Freddie Mac

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**COMMENT OF FREDDIE MAC
ON THE APRIL 13, 1999 NOTICE OF PROPOSED RULEMAKING
ON RISK-BASED CAPITAL
OF THE OFFICE OF FEDERAL HOUSING ENTERPRISE OVERSIGHT**

March 10, 2000

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Glossary of Selected Terms

Act, the .... The Federal Housing Enterprises Financial Safety and Soundness Act of 1992 (the "1992 Act" or the "Act"), Pub. L. No. 102-550

AFS .... Available for Sale

ALMO .... The selected benchmark region (Arkansas, Louisiana, Mississippi, and Oklahoma) and time period (1983-1984)

ANPR .... Advance Notice of Proposed Rulemaking (ANPR) 60 Fed. Reg. 7468 (Feb. 8, 1995)

ANPR Comments .... Freddie Mac comments on the ANPR filed May 9, 1995 ("Freddie Mac's ANPR Comment")

ARIMA .... Autoregressive integrated moving average

ARM .... Adjustable-rate mortgage

CMBS .... Commercial mortgage-backed security

CMT .... Constant maturity Treasury yield

CPI .... Consumer price index

DCR .... Debt coverage ratio is defined as the ratio of net operating income to periodic debt-service payments

DRI .... Data Resources Incorporated

FAS .... Financial accounting standards

FHA .... Federal Housing Administration

GAAP...................... Generally accepted accounting principals

HPI .... House price index

HUD .... U.S. Department of Housing and Urban Development

LIBOR .... London Interbank Offered Rate

LTV......................... Loan-to-value (LTV) ratio is the ratio of the unpaid principal balance of the loan to the value of the underlying property

MSA........................ Metropolitan statistical area

NOI .... Net operating income

NPR1....................... OFHEO's first Notice of Proposed Rulemaking on risk-based capital, 61 Fed. Reg. 29592 (June 11, 1996)

NPR1 Comments ..... Freddie Mac comments on the NPR1, filed June 11, 1996

NPR2 .... OFHEO's second Notice of Proposed Rulemaking on Risk-based Capital, 64 Fed. Reg. 18084 (April 13, 1999) and subsequent revisions announced in OFHEO's "Notice of Availability of Supplemental Information," 64 Fed. Reg. 32828 (June 18, 1999), all of which are contained on OFHEO's web site *http://www.ofheo.gov*

OFHEO .... Office of Federal Housing Enterprise Oversight

OTS .... Office of Thrift Supervision

RBC .... Risk-based capital

REMIC .... Real estate mortgage investment conduit

REO .... Real estate owned
RTI .... Research Triangle Institute
UPB .... Unpaid principal balance
VA .... Department of Veterans Affairs
WSC .... West South Central

I. Introduction and Summary

On April 13, 1999, the Office of Federal Housing Enterprise Oversight (OFHEO) published for comment a Notice of Proposed Rulemaking (NPR2), proposing the second portion of its risk-based capital regulation for Freddie Mac and Fannie Mae (the Enterprises).[1] NPR2 represents a substantial accomplishment in a complex undertaking. In response, Freddie Mac respectfully submits these comments.

Freddie Mac and Fannie Mae serve a fundamental role in the nation's housing finance system. It is therefore vital to homebuyers, mortgage lenders, home builders, real estate professionals and others in the housing industry, as well as to the Enterprises, that OFHEO's final risk-based capital regulation appropriately relate capital to risk, accommodate innovation and operate effectively.

The capital standard uses a stress test to tie capital to risk. With the recommendations Freddie Mac provides here, we believe that OFHEO's stress test will be a state-of-the-art capital regulation. More challenging will be implementing the infrastructure systems and procedures necessary to make the stress test operational. Freddie Mac identifies options to make this implementation accurate, predictable and timely.

Freddie Mac strongly supports a well-implemented risk-based capital standard that will assure the continued flow of mortgage funds to America's families. We are committed to working with OFHEO to achieve this end.

Background

Congress passed the Federal Housing Enterprises Financial Safety And Soundness Act of 1992 (the Act) to modernize the regulatory structure for the Enterprises. The Act created OFHEO and established a minimum capital standard. It also granted OFHEO examination authority and other regulatory tools, similar to those of the federal banking regulators, to assist OFHEO in its effort to supervise Enterprise safety and soundness and to address regulatory concerns promptly. The most innovative feature of the Act is its risk-based capital standard.

Unlike the ratio-based capital standards for other regulated financial institutions, the Act establishes a risk-based capital standard that requires Freddie Mac and Fannie Mae to hold sufficient capital to withstand ten years of specific, severely adverse economic conditions. The statutory stress test incorporates the Enterprises' major risks (interest-rate risk and credit risk) and adds another 30 percent to the capital requirement to account for management and operations risk. Addressing the risks of the Enterprises in an integrated and comprehensive manner, the stress test is the most robust, dynamic and rigorous capital standard in the industry.

Freddie Mac has strongly supported the efforts of OFHEO to develop and implement the capital standard required by the Act. Based on years of experience using stress tests in our business operations, Freddie Mac submitted extensive comments to OFHEO in earlier

[1] 64 Fed. Reg. 18084 (Apr. 13, 1999).

stages of the rulemaking process. Freddie Mac also provided detailed information about our business and risk management systems as OFHEO developed the proposed regulation.

An effort of this importance requires considerable thought and development which are reflected in the proposed regulation and the comment process. Freddie Mac appreciates the opportunity to provide these comments.

Fundamental Principles

In evaluating the proposed regulation, Freddie Mac has been guided by four principles.[2]

The risk-based capital test must be consistent with the Act

The final risk-based capital regulation must be implemented in a manner that is consistent with the Act and its purpose.

The risk-based capital test must appropriately tie capital to risk

The purpose of the risk-based capital standard is to tie capital to the actual risks the Enterprises take as these risks change over time. A capital requirement that is too low would not provide assurance that the Enterprises would remain financially sound; a capital requirement that is too high would impose unnecessary costs on the Enterprises and the families whose homes they finance. A capital standard that requires sufficient capital to withstand the severe conditions specified in the Act provides assurance that the Enterprises will continue to meet their vital missions. Because of the delicate balance that must be struck, extraordinary care must be taken to ensure that required capital is appropriately linked to risk through the stress test.

The risk-based capital test must be operationally workable

OFHEO must be able to apply the risk-based capital standard to classify the Enterprises on a quarterly basis in a way that is accurate, predictable and timely. Accordingly, the infrastructure of systems and procedures used to apply the stress test must be fully operational and of the highest quality. In addition, the application of the stress test must be flexible due to the dynamic nature of the two business organizations and their systems and technology. Moreover, for the Enterprises to conduct their capital planning and comply with the regulation, they must be able to anticipate the amount of capital required by the stress test and incorporate it into their business processes.[3] This, too, requires application of a capital test that is accurate, predictable and timely.

[2] These core principles were articulated by Freddie Mac's Chairman and CEO, Leland C. Brendsel, in remarks on March 25, 1999 and are shared by OFHEO. Speaking to the Mortgage Bankers Association of America's Washington Leadership Conference on March 6, 2000, OFHEO Director Armando Falcon said, "I wholeheartedly agree with all four of these goals [be consistent with the law, be operationally workable, accommodate innovation and tie capital to risk]. OFHEO has shared those objectives from the beginning and I am confident that the final rule will meet those goals."

[3] *See* Remarks of Mark Kinsey, Acting Director, OFHEO, before the Women in Housing and Finance Monthly Luncheon at 3 (March 31, 1999) (asserting risk-based capital test "can't be a black box. It has to be something that the Enterprises can use to anticipate what their capital requirements will be.")

The risk-based capital test must accommodate innovation

The Enterprises have long histories of introducing innovation that reduces risk and costs, and expands markets to new homebuyers and renters. To build on this track record in an ever-changing mortgage market, the Enterprises must be able to anticipate the regulatory capital treatment of new activities and products. If the capital treatment applied to new mortgage or funding instruments is uncertain or inappropriate, it could stifle innovation that benefits America's families.

Organization of Comment

OFHEO depicted its risk-based capital stress test graphically, distinguishing between the "stress test" components and "infrastructure" components. OFHEO illustrated these components as shown in *Exhibit 1*:[4]

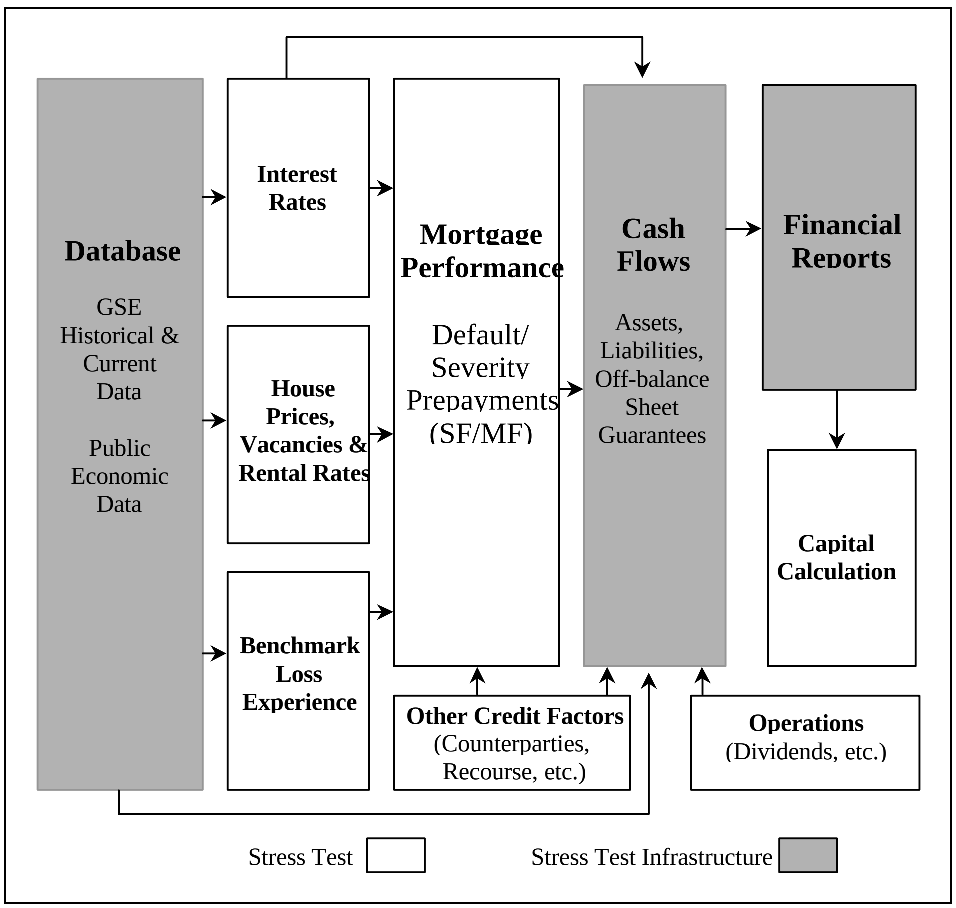

Exhibit 1: OFHEO's Illustration of the Risk-Based Capital Stress Test

The stress test components are depicted in the unshaded boxes. They relate capital to risk based on the requirements of the Act. The infrastructure components are shaded gray. These components do not relate capital to risk. They "make the stress test operational"[5] by establishing a mechanism for assembling data, generating cash flows and projecting

[4] NPR2 at 18089; 1998 OFHEO Annual Report to Congress at 7.
[5] NPR2 at 18089.

financial statements over the stress period. In addition to the stress test and infrastructure components, OFHEO sets forth in general terms the procedures it will use to generate a capital classification for the Enterprises on a quarterly basis.

Freddie Mac believes that this is a logical way to understand this complex undertaking. Accordingly, we have organized our comments based on three categories: (1) the stress test components; (2) the infrastructure; and (3) the reporting and classification and other procedures.

Summary of Recommendations

Freddie Mac engaged in a rigorous effort to replicate the results achieved by OFHEO when OFHEO applied the stress test to Freddie Mac's book of business in the second quarter of 1997 — an effort that has taken thousands of hours in testing, technical reviews and analysis. As a result of this effort, we reached three broad conclusions:

Stress test components: The stress test components, which comprise the bulk of the proposed regulation, reflect a comprehensive effort to tie capital to risk consistent with the Act. The Act specifies certain elements of the stress test and provides that others be chosen by the Director on the basis of their consistency or reasonable relation to the elements specified in the Act. Although Freddie Mac believes that the framework proposed by OFHEO is sound, a number of changes are essential to align capital to risk as envisioned in the Act. Although the recommended changes are extensive, Freddie Mac believes that the goal of a robust, dynamic and rigorous stress test is well within reach.

Infrastructure: The infrastructure that will make the stress test operational is not fully specified in the regulation. However, we believe we have a general understanding of OFHEO's proposed approach, and we have significant concerns about whether OFHEO's infrastructure could be made operationally workable in a reasonable period of time. One option for a faster and more effective implementation is for OFHEO to specify standards for the infrastructure to be used by the Enterprises to run OFHEO's stress test models. OFHEO would verify compliance with those standards on a regular basis. OFHEO could specify key requirements of the infrastructure now. As its systems develop, OFHEO could consider whether its regulatory needs would be better met by specifying more of the infrastructure.

Reporting and classification procedures: The reporting and classification procedures are also is not fully specified in the proposed regulation. To apply the stress test to the Enterprises for the second quarter of 1997, OFHEO followed a process under which the Enterprises reported instrument-level data to OFHEO. OFHEO then applied the stress test, reported the results to the Enterprises and sought to reconcile results with each Enterprise. This process has not proven to be accurate, predictable or timely. Accordingly, Freddie Mac recommends that OFHEO modify the reporting and classification process so that it parallels the process already in place under the minimum capital rule. We recommend that OFHEO establish procedures under which the Enterprises would be required to report to OFHEO the stress test results with all supporting documentation. The documentation would include a complete description of any new activities and instruments and a proposed risk-based capital treatment for them. OFHEO would evaluate that report for accuracy and classify the Enterprises accordingly.

Freddie Mac's specific recommendations are summarized below.

Stress test components

Benchmark loss experience

OFHEO selected the four-state region of Arkansas, Louisiana, Mississippi and Oklahoma during the period 1983-1984 (ALMO) as the benchmark.[6] Freddie Mac concurs with OFHEO's methodology and selection of ALMO as the benchmark. However, we believe that OFHEO must make corrections to the benchmark data before it can quantify accurately the benchmark loss experience. Without such data adjustments, the benchmark loss experience is overstated and does not "reasonably relate" the stress test credit losses to the benchmark loss experience. We believe that OFHEO can make the recommended data adjustments without repeating the benchmark selection process. Therefore, Freddie Mac recommends that the benchmark data be re-weighted to better reflect the credit loss experience of all four states in the region and that missing data be treated appropriately.

Stress test economic environment

Treasury yield curve. The stress test subjects the Enterprises to both increasing and decreasing interest-rate scenarios, and the capital requirement is based on the scenario that requires more capital. OFHEO has proposed that the Treasury yield curve be flat in the up-rate scenario and steeply upward sloping in the down-rate scenario. A flat yield curve over an extended period of time is inconsistent with historical data, which indicate that the yield curve is normally upward sloping and that it will quickly return to its normal shape following an interest-rate shock. In addition, a flat yield curve overstates the costs of refunding short-term debt, artificially increases the discount rate used to determine the stress test requirement for management and operations risk, produces unrealistically low predictions of prepayments and misstates the value of an Enterprise's basis swaps. Therefore, Freddie Mac recommends that the long-run average shape of the yield curve be used in both the up-rate and the down-rate stress tests.

Non-Treasury interest rates. OFHEO proposes to project stress period yields of 19 non-Treasury interest rates using complex time-series ARIMA models.[7] Freddie Mac believes that ARIMA models are not well-suited to project these interest rates because the models do not fit historical data well. As a result, OFHEO's proposed approach for modeling non-Treasury interest rates could mask or exaggerate actual risks. In addition, the proposed ARIMA models would be difficult to incorporate into Enterprise capital management and compliance systems and would hamper Enterprise innovations. Therefore, Freddie Mac recommends that non-Treasury interest rates be based on the average spread between those rates and their corresponding Treasury rates over the past two years.

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[6] The terms "benchmark" and "benchmark loss experience" are not used in the Act. These are terms used by OFHEO in its risk-based capital proposals, and by Freddie Mac throughout this Comment, to mean the region and time period that meet the worst-case regional credit loss specifications in the Act. *See, e.g.*, NPR2 at 18090-91.

[7] ARIMA is an abbreviation for Autoregressive Integrated Moving Average.

Enterprise borrowing rates. OFHEO proposes to add a 50 basis point risk premium to Enterprise borrowing rates during the final nine years of the stress test. Freddie Mac believes that no relevant historical data support such an additional charge. In fact, Freddie Mac's analysis of historical data suggests that past increases in Enterprise borrowing costs associated with credit events have been accompanied by comparable increases in other interest rates and have disappeared within two years. Accordingly, OFHEO's proposed risk premium substantially overstates stresses to the Enterprises. In addition, the proposed risk premium is inconsistent with other elements of the proposed stress test. Therefore, Freddie Mac recommends eliminating the 50 basis point risk premium.

Single-family house price scenario. Freddie Mac concurs with OFHEO's methodology to "season" mortgage loans during the stress test using the single-family house price index that most closely represents average house price behavior in the benchmark. Freddie Mac further agrees that the single-family house price index should be used to calibrate the single-family default and severity statistical models to the benchmark experience. However, Freddie Mac disagrees with OFHEO's proposed approach for measuring the dispersion of house prices around that average. OFHEO's method can result in widely different loss rates for mortgages in different parts of the country for reasons unrelated to risk. Furthermore, Freddie Mac disagrees with OFHEO's inflation adjustment to house prices in the up-rate stress test, which adjustment results in credit losses in the up-rate stress test greater than credit losses in the down-rate stress test. Therefore, Freddie Mac recommends using the dispersion from the benchmark experience to project defaults — the same dispersion OFHEO used to calibrate the default and severity models to the benchmark experience. This would subject mortgages from different parts of the country to the same stress. In addition, Freddie Mac recommends that the inflation adjustment be increased to recognize that the up-rate stress test, in which the interest-rate shock is permanent, is necessarily an inflationary environment.

Multifamily economic environment. OFHEO faces a substantial challenge in developing an appropriate stress test environment for multifamily mortgages, due primarily to the lack of data in the benchmark about rental income, vacancy rates and property values. As a result, OFHEO relies upon various assumptions to generate a stress test environment for multifamily mortgages. Freddie Mac agrees with OFHEO's definition of stress test rent and vacancy rates because they adequately represent the benchmark experience and, in combination with the multifamily behavioral models, tie capital to risk. However, Freddie Mac disagrees with OFHEO's property-value index because it does not credibly represent a stressful multifamily experience, especially in the down-rate scenario. In addition, Freddie Mac recommends that OFHEO rely on actual net operating income for individual properties collected by the Enterprises to define starting values for the stress test.

Mortgage performance and commitments

Single-family mortgage performance. OFHEO proposes three statistical models — default, severity and prepayment – to predict single-family mortgage performance during the stress period. OFHEO calibrates the single-family default and severity models to the benchmark loss experience without addressing data problems. The mismeasurement of risk is particularly large for low-downpayment mortgages which could discourage such lending. OFHEO does not calibrate the prepayment model. OFHEO's approach is fairly successful in specifying mortgage performance in the down-rate stress test but not in the up-rate stress test. In particular, OFHEO's prepayment model underpredicts prepayments in the up-rate scenario due to the lack of reliable historical data on mortgage performance in rising interest-rate environments. Freddie Mac recommends that OFHEO correct the data issues associated with the benchmark before calibrating the default and severity models. We recommend several refinements to better distinguish the default risks of different mortgage products. In addition, we suggest simplifying the severity model. We also recommend that OFHEO adjust the prepayment model by increasing prepayments in the up-rate stress test.

Multifamily mortgage performance. Freddie Mac believes that, given the lack of reliable data on multifamily loan performance, a simpler, statistically based approach to assessing multifamily mortgage risk that reflects an underwriting perspective is preferable to OFHEO's proposed econometric approach. The underwriting approach would explain credit losses in terms of simple, observable mortgage risk characteristics, such as debt-coverage ratios (DCRs) and loan-to-value (LTV) ratios, in a way that is consistent with how an underwriter would assess risk. Furthermore, Freddie Mac believes that the limitations in the underlying data compel OFHEO to evaluate the reasonableness of multifamily capital requirements by comparing them with external benchmarks. Freddie Mac recommends adoption of a default model that depends on observable mortgage characteristics, including original LTV, current DCR (from property-level Enterprise inspection data) and balloon payment risk. In addition, Freddie Mac recommends that prepayments and loss severity be based on simple rules.

Commitments. The proposed treatment of mortgage purchase commitments results in a risk-based capital requirement that is much greater than the current minimum capital requirement. The high capital requirements for commitments could lead to changes in Enterprise business practices. The proposed approach also does not recognize the effect of credit enhancements on mortgages delivered under commitments. Freddie Mac recommends that the treatment of commitments include credit enhancements based on Enterprise experience in the six months preceding the stress test.

Counterparty credit risk

Freddie Mac receives cash flows from a variety of contracts and investments, including mortgage credit enhancements, derivative contracts and investments in non-Freddie Mac securities. OFHEO proposes a haircut approach to discount expected counterparty cash flows during the stress test. The proposed haircuts are extremely large and bear little relationship to an Enterprise's risks. The proposed haircuts would encourage the Enterprises to reduce reliance on counterparties for risk management and funding activities, thereby increasing the cost of these activities and, as a consequence, increasing mortgage interest rates to borrowers. Therefore, Freddie Mac recommends that the haircuts be reduced significantly to reflect expected counterparty performance. We also recommend that the capital required for counterparty credit risk be internally consistent with that required for mortgage credit risk.

Enterprise operations

Refunding. During the stress test, the Enterprises periodically will have excess cash to invest or will need to refund maturing debt. OFHEO proposes that the Enterprises invest excess cash in short-term instruments and issue short-term debt when a cash shortfall arises during the stress period. This highly simplified approach tends to overstate risks in the up-rate scenario because it does not recognize the different refunding strategies that an Enterprise would use in a rising interest-rate environment. Freddie Mac recommends that a refunding mix of 20 percent short-term and 80 percent non-callable long-term debt be used in the up-rate scenario and 80 percent short-term and 20 percent callable long-term debt be used in the down-rate scenario to better reflect the Enterprises' refunding behavior.

Administrative expenses. Administrative expenses constitute a relatively small portion of Freddie Mac's total expenses, but a disproportionately large component of Freddie Mac's capital requirement. In addition, administrative expenses vary unreasonably between the up-rate and down-rate stress tests. These results stem from OFHEO's overly simplified modeling approach that treats all administrative expenses as variable costs. Therefore, Freddie Mac recommends that administrative expenses be specified in terms of a fixed-cost component and a variable-cost component and that administrative expenses related to new business development be eliminated because the stress test assumes there is no new business.

Dividends. OFHEO proposes that an Enterprise pay dividends on preferred stock at the stated coupon rate so long as the Enterprise meets its minimum capital requirement and pay dividends on common stock for only the first year of the stress period. If earnings are positive and increasing, the common stock dividend rate is the average percent of earnings paid out over the prior four quarters; if earnings are flat or negative, the dividend amount is the dollar amount paid in the prior quarter. Freddie Mac generally agrees with OFHEO's proposal. However, changes in an Enterprise's form of capital distributions could affect its capital requirement disproportionately to actual changes in risk. Therefore, Freddie Mac recommends that the dividend rate on common stock be fixed at the industry average percentage of earnings.

Settlement of derivatives. During the stress period, the Enterprises periodically will have to make decisions regarding the settlement of certain derivative securities, such as futures contracts. OFHEO's proposal does not address issues associated with such settlements. Freddie Mac recommends a series of simple rules to govern Enterprise behavior with respect to derivative settlements in the up-rate and down-rate scenarios.

Calculation of the risk-based capital requirement

In calculating the amount of capital the Enterprises have during the stress period, OFHEO distorts the assessment of capital and risk by using a discounting procedure that implicitly assumes that losses from management and operations risk occur at the start of the stress period. Freddie Mac recommends that the discounting procedure be eliminated from the calculation of required capital.

Infrastructure

The Act requires OFHEO to classify the Enterprises on a quarterly basis through the application of the risk-based capital regulation. Additionally, for the Enterprises to conduct their capital planning and comply with the regulation, they must be able to anticipate the amount of capital required by the stress test and incorporate it into their business processes. Therefore, the infrastructure systems (database, cash flow and accounting systems) used to apply the risk-based capital stress test must meet a level of accuracy, predictability and timeliness that corresponds to production standards.

Standards for production systems are very high. They require extensive testing, user manuals, and fully documented computer code and controls. If the infrastructure system used to apply the stress test meets these high standards, OFHEO could have the ability to classify the Enterprises in a timely fashion and to take prompt corrective action if an Enterprise fails to meet its risk-based capital requirement. In addition, the Enterprises could have the ability to anticipate their capital requirements and incorporate the risk-based capital stress test into their business operations and processes. In contrast, if production standards are not met, classifications may be late, erroneous and invalid, and the Enterprises would be unable to anticipate their capital requirements. In short, the regulation would be operationally unworkable.

One option for ensuring that the infrastructure systems used to apply the stress test meet production-quality standards would be for OFHEO to upgrade, test and fully document its current infrastructure systems. Based on our experience attempting to replicate OFHEO's published stress test results for the second quarter of 1997 and our experience in developing similar systems, we believe this process would take several years to accomplish.

Another option would be to adapt existing, production-quality Enterprise systems that perform comparable functions (*e.g.*, forecasting earnings). The Enterprises would use these systems to apply OFHEO's risk-based capital stress test, subject to OFHEO's strict, verifiable performance standards and any other necessary specifications. We expect that this process could be accomplished within a year. OFHEO could specify key requirements of the infrastructure now. As its systems develop, OFHEO could consider whether its regulatory needs would be better met by specifying more of the infrastructure. We believe this approach would enable the Director to implement an operationally workable final regulation in a reasonably short time frame.

Procedures

Reporting and classification

The proposal does not fully specify the process to be used by OFHEO in making a quarterly capital classification for the Enterprises. Given Freddie Mac's experience to date, however, it appears that OFHEO contemplates a process in which: (1) the Enterprises report data to OFHEO; (2) OFHEO applies the stress test and reports the result to the Enterprises; (3) OFHEO and the Enterprises then seek to reconcile results. The stress test applied by OFHEO to the Enterprises' second quarter 1997 book of business demonstrated that this process is not operationally workable. The reconciliation process proved to be time-consuming, inefficient and unnecessarily focused on issues that bear little or no relationship to the Enterprises' safety and soundness. Freddie Mac recommends that OFHEO adopt the approach used under the minimum capital rule. Under that process, the Enterprises would be required to report stress test results and risk-based capital calculations in their quarterly reports to OFHEO, and OFHEO would classify the Enterprises based on those reports, unless OFHEO determines that the Enterprise has made an error, or otherwise failed to apply the regulation correctly. Furthermore, Freddie Mac recommends that the final regulation provide OFHEO with discretion to classify an Enterprise as adequately capitalized if the Enterprise meets its minimum capital requirement and quickly remedies a failure to meet risk-based capital requirement.

New activities

OFHEO recognizes that the risk-based capital regulation must accommodate innovation and change. Nonetheless, the proposed regulation does not specify fully how new activities will be treated in practice. The regulation appears to suggest that new activities will be given "an appropriately conservative treatment"[8] pending a final determination by OFHEO. This standard provides little guidance to the Enterprises as to how new activities will be treated for risk-based capital purposes and could be interpreted in a manner that will stifle innovation. Accordingly, Freddie Mac recommends that, in their quarterly reports, the Enterprises document any new activities or instruments and a proposed capital treatment. OFHEO would review and assess the proposed treatment for reasonableness and consistency with the Act and accord the new activity the proposed treatment unless and until OFHEO amends the regulation to incorporate a different treatment.

Anomalies

Because the proposed risk-based capital stress test is a relatively untested regulatory tool, Freddie Mac is concerned that under unforeseen circumstances it may produce aberrant or anomalous results. Freddie Mac believes that OFHEO should prepare for such a possibility by providing a mechanism in the regulation to override the stress test in the face of irrational or absurd outcomes. Freddie Mac recommends that in the event an anomaly produces a facially absurd result, the Enterprises be afforded an opportunity to document the proposed anomaly and propose an appropriate response to it, subject to review and approval by OFHEO. Freddie Mac further recommends that OFHEO make clear its authority to suspend the risk-based capital regulation pending adoption by OFHEO of a suitable and appropriate response to the anomaly.

Amendments

OFHEO has authority to initiate additional rulemakings to amend the final risk-based capital regulation. Changes to the specifications of the stress test diminish its value as a means of monitoring changes in risk over time and make it difficult for the Enterprises to engage in capital planning. Moreover, amendments are likely to have cascading effects on many other parts of the regulation. Freddie Mac recommends that OFHEO refrain from amending the regulation to incorporate *de minimis* improvements and that it amend the regulation only when consistent with OFHEO's safety and soundness mandate.

[8] NPR2 § 3.11(b).

Reporting procedures

To improve the operational workability of the reporting and classification process, the proposed regulation should omit the requirement that the quarterly risk-based capital reports be submitted 30 days after the end of the quarter and provide instead that the Director retains discretion to specify due dates for quarterly capital reports; that an Enterprise must re-file a risk-based capital report for a prior period only when an adjustment in data might cause a change in the Enterprises' capital classification; and that the contents of the quarterly reports shall be specified only by the Director of OFHEO.

One-year transition period

Freddie Mac recommends that OFHEO make clear that during the one-year transition period, when the risk-based capital test has no regulatory effect, an Enterprise may make a capital distribution without OFHEO's prior approval provided the Enterprise is in compliance with the minimum capital requirement.

APA considerations

OFHEO has stated that, after it reviews comment on the proposal, it will consider whether to re-propose or to issue a final regulation. Re-proposal bears consideration. Re-proposal would eliminate the possibility that the Enterprises and other interested parties will be deprived of the opportunity to comment on unanticipated choices and judgments made by OFHEO in response to the comments submitted in response to NPR2. Moreover, solicitation of public input on a near-final proposal could improve the final regulation. The comment period could be appropriately brief, and could even shorten the time to a final regulation.

II. The Stress Test

The Act requires the Director of OFHEO to issue a final risk-based capital regulation that contains "specific requirements, definitions, methods, variables and parameters used under the risk-based capital test and in implementing the test (such as loan loss severity, float income, loan-to-value ratios, taxes, yield curve slopes, default experience, and prepayment rates)."[9] In general the term "stress test" refers to the components illustrated in the unshaded boxes in *Exhibit 1* that are either specified by the Act or included in OFHEO's regulation.

The Act provides that when applied to an Enterprise, the test shall determine the amount of capital an Enterprise would need to maintain positive capital during a ten-year period in which the following stresses occur:

- Mortgage credit stresses are "losses . . . at a rate of default and severity . . . reasonably related to the rate of severity that occurred in [those] contiguous areas of the United States containing an aggregate of not less than five percent of the total population [that] for a period of not less than two years, experienced the highest rates of default and severity of mortgage losses."[10]

- Interest rate stresses are either: (1) a decline in the ten-year constant maturity Treasury (CMT) yield to the lesser of 600 basis points below the average yield during the preceding nine months or 60 percent of the average yield during the preceding three years, but in no case to a yield less than 50 percent of the average yield during the preceding nine months; or (2) an increase in the ten-year CMT yield to the greater of 600 basis points above the average yield during the preceding nine months or 160 percent of the average yield during the preceding three years, but in no case to a yield greater than 175 percent of the average yield during the preceding nine months — whichever would require more capital for the Enterprise.[11]

- Other Treasury yields are to change relative to the ten-year CMT yield "in patterns and for durations that are reasonably related to historical experience and are judged reasonable by the Director."[12]

- Mortgage credit stresses must be adjusted for the effects of inflation if the ten-year CMT yield is assumed to increase by more than 50 percent over the average yield during the preceding nine months.[13]

The Act further specifies that the Enterprise will not conduct new business during the stress period, except that "[a]ny contractual commitments of the enterprise to purchase

[9] The Act § 1361(e)(2).
[10] *Id.* at § 1361(a)(1).
[11] *Id.* at § 1361(a)(2).
[12] *Id.* at § 1361(a)(2)(D).
[13] Id. at § 1361(a)(2)(E).

mortgages or issue securities will be fulfilled."[14] The characteristics of those mortgages must be "consistent with the contractual terms of such commitments, recent experience, and the economic characteristics of the stress period."[15]

The Act also directs that losses or gains on "[o]ther activities," including interest rate and foreign exchange hedging activities, "shall be determined by the Director, on the basis of available information, to be consistent with the stress period."[16] Stress period characteristics, other than those specified, must be determined on the basis of available information, to be "most consistent with the stress period."[17]

Finally, the Act provides that the amount of total capital that an Enterprise must hold is the amount of capital determined applying the stress test, plus an additional 30 percent to provide for management and operations risk.[18]

The following sections discuss the components of the stress test as proposed by OFHEO in NPR2. These components include the benchmark loss experience, the stress test economic environment, mortgage performance, commitments, counterparty credit risk, Enterprise operations, and the calculation of the risk-based capital requirement.

[14] *Id.* at § 1361(a)(3)(A).
[15] *Id.*
[16] *Id.* at § 1361(a)(4).
[17] *Id.* at § 1361(b)(2).
[18] *Id.* at § 1361(c)(2).

A. Benchmark Loss Experience

OFHEO selected the four-state region of Arkansas, Louisiana, Mississippi and Oklahoma during the period 1983-1984 (ALMO) as the benchmark.[19] Freddie Mac concurs with OFHEO's methodology and selection of ALMO as the benchmark. However, we believe that OFHEO must make corrections to the benchmark data before it can quantify accurately the benchmark loss experience. Without such data adjustments, the benchmark loss experience is overstated and does not "reasonably relate" the stress test credit losses to the benchmark loss experience. We believe that OFHEO can make the recommended data adjustments without repeating the benchmark selection process. Therefore, Freddie Mac recommends that the benchmark data be re-weighted to better reflect the credit loss experience of all four states in the region and that missing data be treated appropriately.

Background

OFHEO must establish a risk-based capital standard based on an economic stress test.[20] In the stress test, an Enterprise must withstand simultaneously severe credit conditions and extreme interest rate movements — an up-rate and a down-rate scenario — during a ten-year period ("the stress period").[21] The credit risk component of the stress test subjects each Enterprise to large, sustained credit losses on mortgages that the Enterprise owns or guarantees throughout the United States and requires OFHEO to "reasonably relate" the nationwide stress test credit losses to a regional loss experience. In so doing, the Act requires OFHEO to identify a historical worst case regional credit loss experience in accordance with statutory requirements (the "benchmark" or the "benchmark loss experience.")

Specifically, the Act requires OFHEO to identify a benchmark with the highest rate of default and severity of mortgage losses experienced during a period of at least two consecutive years in contiguous areas of the United States that together contain at least five percent of the total U.S. population, in comparison with such rates of default and severity of mortgage losses in other such areas of the U.S. for any period of such duration.[22] In addition, the Act directs OFHEO to "take into account appropriate distinctions among mortgage product types, differences in seasoning and any other factors that the Director [of OFHEO] deems appropriate."[23]

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[19] The terms "benchmark" and "benchmark loss experience" are not used in the Act. These are terms used by OFHEO in its risk-based capital proposals, and by Freddie Mac throughout this Comment, to mean the region and time period that meet the worst-case regional credit loss specifications in the Act. *See, e.g.*, NPR2 at 18090-91.

[20] The Act §1361(a).

[21] *Id.*

[22] *Id.* at § 1361(a)(1).

[23] *Id.* at § 1361(b)(1). The Act defines "mortgage product type" as a classification of one or more mortgage products, "as established by the Director" which have similar characteristics to certain listed "products" and adds "any other characteristics as the Director may determine." *Id.* at § 1361(d)(2). The Act also defines "seasoning" to mean the change over time in the ratio of the unpaid principal balance of a mortgage to the value of the property securing the mortgage as determined in accordance with an index that meets certain statutory requirements of reliability and public availability. The Act § 1361(d)(1).

OFHEO must make many decisions concerning methodology and assumptions when establishing the stress test. In making such decisions, Congress intended that OFHEO choose methodologies recognized as valid by experts and, to the extent possible, make assumptions that are historically based and internally consistent.[24] Experts familiar with data issues know that numerous biases, such as selection bias and missing data bias, typically must be corrected before a data sample can be appropriately used.[25]

Proposal

In NPR1,[26] OFHEO requested public comment on its proposed selection of a benchmark (region and period) and on its estimation of the benchmark loss experience. OFHEO selected the benchmark using historical loan level data from each Enterprise based on mortgages originated from 1979 to 1993.[27] When selecting a benchmark, OFHEO made a number of simplifying assumptions in order to rank the vast number of possible region/year combinations and to manage the range and complexity of mortgage data. For example, OFHEO explains that it analyzed only losses on mortgages purchased or guaranteed by the Enterprises in determining the worst regional credit loss rate. Moreover, rather than examining all types of Enterprise-owned or guaranteed mortgages, OFHEO selected only data on standard,[28] single-family mortgages that the Enterprises purchased without recourse. In so doing, OFHEO excluded data on other types of mortgages.[29]

In support of its choice of standard single-family mortgage data, OFHEO emphasized the preponderance of such loans in the Enterprises' portfolios, the homogeneity of the loans and the fact that this loan data was available from both Enterprises in all regions.[30] OFHEO interpreted "year" as the year in which loan was originated and used only data on loans purchased by an Enterprise within twelve months of origination.[31] In support of this approach in NPR1, OFHEO cited industry practice and noted data limitations of the exposure year approach. In order to facilitate comparisons of data in different origination

[24] *See* H.R. Rep. No 206, 102d Cong., 1st Sess. 65 (1991)("House Report")("The Committee understands that in developing the test, the Director will have to make many decisions concerning methodology and assumptions. The Committee intends that any methodology chosen be generally recognized by experts as valid and that any assumptions employed be, to the extent possible, historically based and internally consistent. Further, the Committee intends that all such assumptions and methodology be developed through the notice and comment rulemaking process.")

[25] *See e.g.*, Paul Biemer, Research Triangle Institute, *Comments on the OFHEO NPR Regarding Estimation of Default , Severity and Loss Rates* (1996) (the "RTI Report").

[26] OFHEO's initial notice of proposed rulemaking, 61 Fed. Reg. 29592 (June 11, 1996) (NPR1).

[27] NPR1 at 29600.

[28] OFHEO determined to use only Enterprise data on first lien, 30-year, fixed rate conventional mortgages secured by single-family, one unit, detached, owner-occupied dwellings. NPR1 at 29597.

[29] In NPR1, OFHEO explains that its data selection, "excludes other types of loans such as adjustable rate and balloon mortgages and loans secured by other property types such as multi-unit and two-four unit structures, condominiums, Planned Urban Developments (PUDs) and cooperatives." NPR1 at 29600-01. This approach also excluded data on adjustable rate mortgages and seasoned mortgages purchased by the Enterprises and on Enterprise-quality mortgages that the Enterprise did not purchase.

[30] *Id.*

[31] *Id.* at 29602.

years, OFHEO used ten-year default and severity rates.[32] OFHEO concluded that states were the most logical and efficient geographic unit from which to construct and compare benchmark regions and, therefore, defined "contiguous areas" as all areas within a state or group of two or more states sharing common borders.[33]

Mortgage loss rates are the product of default and severity rates.[34] For any group of defaulted loans, OFHEO defined the "severity rate" as the aggregate losses on those loans divided by the aggregate original principal balance of all loans in the group. For purposes of ranking the state/year combinations for severity, OFHEO calculated Real Estate Owned (REO) financing costs associated with properties acquired through foreclosure using the average from 1982 though 1992 of the 12-month Federal Agency constant maturity yield.[35]

After considering thousands of alternatives,[36] OFHEO identified ALMO as the benchmark.[37] Once OFHEO identified the ALMO benchmark, it used the same selection of Enterprise data to estimate a benchmark credit loss experience. In NPR1, OFHEO estimated a benchmark loss rate of 9.4 percent.[38] OFHEO acknowledged that this rate far exceeds the typical loss rate, noting that the aggregate loss rate for the 48 states and the District of Columbia for all origination years from 1979 through 1985 was 2.1 percent.[39]

Discussion and Recommendations

In establishing a benchmark loss experience OFHEO first needed to develop a selection methodology and to make certain assumptions in order to identify a benchmark out of thousands of possible alternatives. After identifying a benchmark, OFHEO needed to estimate the benchmark credit losses in order to "reasonably relate" the stress test credit losses to this baseline benchmark loss experience.

In response to NPR1, Freddie Mac commented that ALMO could be a suitable benchmark if certain adjustments to the benchmark data were made. Moreover, we agreed with OFHEO that the historical Enterprise data used by OFHEO is probably the most reliable source of data on which to identify the benchmark. We concluded that OFHEO's methodology for selecting the benchmark was reasonable and appropriate in accomplishing this complex and time-consuming task. However, as discussed in our NPR1 comment, it is clear that OFHEO's initial benchmark loss estimation was affected by missing data, OFHEO's assumptions related to this missing data, data errors and other data-related issues.

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[32] *Id.* at 29602-03.
[33] *Id.* at 29597-98.
[34] OFHEO explains that although it had what it considered a sufficient amount of severity data, it did not have such data on all defaulted loans. *Id.* at 29598.
[35] *Id.* at 29597 and 29603, n. 40. We note that OFHEO later used a different methodology for calculating such costs when developing its severity model.
[36] *Id.* at 29597.
[37] *Id.* at 29598.
[38] *Id.*
[39] *Id.* The estimated loss rate in NPR1 is four to five times worse than any nationwide experience.

An unbiased baseline benchmark is necessary to calibrate OFHEO's statistical models of mortgage performance and to reasonably relate the stress test credit losses to the benchmark loss experience.[40]

We recommend that OFHEO take into account certain data concerns and biases and make appropriate adjustments as described below. Our analysis of the proposed stress test in NPR2 supports our earlier conclusions in our NPR1 Comment. Without adjustments to correct bias, the calibration of OFHEO's proposed models of mortgage performance is affected and the benchmark loss experience is overstated.

Re-weight data to reflect entire benchmark loss experience

The Act requires that the benchmark region be a "contiguous area" containing not less than five percent of the total population of the United States.[41] OFHEO met this requirement when it selected ALMO as the benchmark. However, OFHEO essentially estimated the benchmark loss experience on only two of the four states of ALMO.

OFHEO's method of weighting the benchmark data when selecting the benchmark uses actual Enterprise purchases of mortgages in ALMO. This method implicitly weights the data by purchase volume. Using purchase volume creates bias in the benchmark loss experience in two ways: 1) the distribution of Enterprise purchases of standard mortgages across the benchmark states is quite different from the distribution of originations of standard mortgages across the benchmark states and 2) the performance of mortgages significantly varies across the four benchmark states.

In the data set used by OFHEO to estimate the benchmark loss experience only a small portion of the loans are from Arkansas and Mississippi. The data set principally (89 percent) reflects the loss experience in only two states (Oklahoma and Louisiana). Therefore, the benchmark data, if not adjusted, is based principally on two states containing only 3.2 percent of the U.S. population and not on the entire benchmark region of ALMO. Moreover, the Oklahoma and Louisiana credit loss experience was significantly worse than the loss experience of Arkansas and Mississippi.

We recommend that OFHEO weight the Enterprise data for each of the ALMO benchmark states by the number of conventional mortgages originated in that state when estimating the credit loss experience for the entire benchmark.

[40] RTI Report, *supra*, at 4-14.
[41] The Act § 1361(a)(1).

Use Freddie Mac swap data as a proxy for missing Fannie Mae swap program data

Freddie Mac and Fannie Mae have two types of mortgage purchase programs — a cash program and a swap program. Freddie Mac collected and recorded historical loan level data for the benchmark period on both its cash and swap programs. Fannie Mae collected and recorded historical data for the benchmark period only for mortgages purchased under it cash program.

For purposes of identifying the benchmark, OFHEO responded to this missing data by basing Fannie Mae's loss rate only on Fannie Mae's cash program performance. In other words, OFHEO assumed that Fannie Mae loans purchased under the "swap" or "MBS" program behaved identically to Fannie Mae loans purchased under their "cash" program. In fact, Freddie Mac's experience suggests that, at that time, swap program loans performed significantly better than cash program loans.[42] The performance difference may have been due to different types of lenders. OFHEO's treatment of the missing Fannie Mae data creates bias when estimating the credit losses in the benchmark.

We recommend that OFHEO compare mortgages purchased under Fannie Mae's swap program with mortgages purchased under Freddie Mac's swap program. Therefore, we recommend that OFHEO look to the performance of mortgages purchased under Freddie Mac's swap program as a proxy for missing data on Fannie Mae swap-program mortgages.[43]

Adjust for missing Fannie Mae pre-1987 severity data

OFHEO lacks loss severity data on Fannie Mae REO properties sold prior to 1987 because Fannie Mae did not collect or record such data. In addressing this missing data in its benchmark identification process, OFHEO assumed that missing pre-1987 Fannie Mae loss severity data were similar to Fannie Mae's post 1987 severity data for REO properties. While it may be appropriate for OFHEO to make this assumption for purposes of identifying the benchmark, this assumption introduces bias into OFHEO's estimate of benchmark credit losses.

OFHEO's assumption significantly overstates loss severities. Based on Freddie Mac data we know that there is a significant difference between the loss severities of Freddie Mac's REO sales before and after 1987. House prices began a declining trend in the early 1980s which continued through the latter part of the 1980s. Mortgages that did not default until 1989 or 1990 were likely to have a greater property loss than loans that defaulted soon after origination.

We recommend that OFHEO adjust for the missing Fannie Mae severity data, in accordance with Table 1 of the RTI Report, before drawing inferences about the severity experience for mortgages in the benchmark.[44]

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[42] *See* RTI Report, *supra*, at 8. While this difference in performance was true at that time, today loan performance in the swap and in the cash programs is similar.
[43] *Id.*
[44] *See* RTI Report, *supra*, at 12

Adjust for Fannie Mae's loss rates due to factors unrelated to credit risk

As discussed in Freddie Mac's NPR1 Comment, we have reservations about the validity of the Fannie Mae loss rates in ALMO for the 1983-1984 originations. Fannie Mae's credit losses are 70 percent higher than Freddie Mac's credit losses. This huge disparity strongly suggests that those Fannie Mae credit losses are the result of bad data or factors unrelated to generic credit risk such as the disproportionate effect of a few outlier sellers.

We recommend that OFHEO consult with Fannie Mae on those loss rates and then make appropriate adjustments before estimating the experience of mortgages in the benchmark time and region.

Recommended adjustments do not require a new benchmark selection

In NPR1, OFHEO selected the ALMO benchmark but did not make adjustments to correct data bias before it estimated the benchmark loss experience. Data adjustments such as those recommended by Freddie Mac are recognized by experts. We believe these adjustments do not require OFHEO to go back through the arduous and time-consuming process of benchmark identification. OFHEO recognized implicitly that it could make adjustments to the benchmark data when it used one methodology to calculate asset (REO) funding costs in ranking the regions for loss severity in NPR1 and another methodology when it modeled severity.

There is no reason to expect that the recommended adjustments for data bias would be substantially different for another possible region. Any region that OFHEO could have selected pursuant to its methodology is likely to have been an outlier or atypical region with data problems or quirks requiring adjustment. Moreover, there is no reason to expect that the unbiased credit loss rates for the worst regions would vary by large amounts — there would be only marginal differences. Any such marginal difference would be far less than the difference between the benchmark loss rate that OFHEO has initially identified and the more accurate benchmark loss rate that would result from the adjustments. Further, if after correcting for the identified biases, another region appeared to have a slightly higher loss rate, it is likely that the new benchmark would have additional data biases not already identified. Thus, it is reasonable for OFHEO to select the benchmark based on available uncorrected data and then to make corrections before applying the benchmark.

B. Stress Test Economic Environment

The risk-based capital standard of the Act requires that the Enterprises hold capital sufficient to withstand ten years of extreme economic conditions in terms of mortgage credit risk and interest-rate risk. The credit risk component of the stress test assumes that the worst credit losses ever experienced in a region occur nationally. The interest-rate risk component tests both extreme increases and decreases in rates; whichever requires more capital is used. On top of capital required to withstand these stresses, the Act requires additional capital to cover management and operations risk. Specifically, the capital required for management and operations risk is 30 percent of the capital required for interest-rate risk and credit risk.[45] Capital required to withstand the stress tests is that amount of capital required to cover losses net of gains over the ten years such that total capital is never negative over the ten-year period.

The Act specifies the exact behavior of the ten-year constant maturity Treasury (CMT) yield over the ten-year stress period for both the up-rate stress (when interest rates rise) and the down-rate stress (when interest rates decline).[46] The interest-rate shocks depend on the current level of rates and the recent behavior of interest rates. Generally speaking, the yield on the ten-year CMT may rise by as much as 600 basis points in the up-rate stress test and fall by as much as 600 basis points in the down-rate stress test. The interest-rate shocks occur over the first year of the stress period and the new level of rates is then maintained over the remaining nine years. The Act specifies that other Treasury yields will change relative to the ten-year CMT "in patterns and for durations that are reasonably related to historical experience and are judged reasonable by the Director [of OFHEO]."[47] The Act does not specify the behavior of non-Treasury interest rates.[48] Instead, the Act requires that characteristics of the stress period not specified by the Act be determined by OFHEO on the basis of available information to be *most consistent with* the stress period.[49]

The Act specifies that credit losses on mortgage loans be *reasonably related to* those experienced in a contiguous region making up at least five percent of the U.S. population.[50] The Act further requires that credit losses be reduced to account for the higher level of expected inflation when interest rates increase by more than 50 percent.[51] Higher inflation would affect credit losses through property values. As property values rise with inflation, the probability that a mortgage will default declines and the loss experienced by an Enterprise in the event a mortgage defaults also declines. Thus, stress test credit losses depend on economic factors such as house prices which affect single-

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[45] The Act § 1361(c)(2).
[46] *Id*. at § 1361(a)(2).
[47] *Id*. at § 1361(a)(2)(D).
[48] Treasury rates and non-Treasury rates — including, *e.g.*, Enterprise borrowing rates and mortgage rates — are necessary to determine the cash flows of financial instruments in the Enterprises' portfolios over the ten-year simulation.
[49] The Act § 1361(b)(2).
[50] *Id*. at § 1361(a)(1). *See also Benchmark Loss Experience*.
[51] *Id*. at § 1361(a)(2)(E).

family mortgage performance and rent and vacancy rates which affect multifamily mortgage performance.

The following sections discuss the factors that make up the stress test economic environment as proposed in the NPR2. They include interest rates and property values; specifically, the Treasury yield curve, non-Treasury interest rates, Enterprise borrowing rates, single-family house prices, the dispersion of single-family house prices, and multifamily rents and vacancies.

i. Treasury Yield Curve

The stress test subjects the Enterprises to both increasing and decreasing interest-rate scenarios, and the capital requirement is based on the scenario that requires more capital. OFHEO has proposed that the Treasury yield curve be flat in the up-rate scenario and steeply upward sloping in the down-rate scenario. A flat yield curve over an extended period of time is inconsistent with historical data, which indicate that the yield curve is normally upward sloping and that it will quickly return to its normal shape following an interest-rate shock. In addition, a flat yield curve overstates the costs of refunding short-term debt, artificially increases the discount rate used to determine the stress test requirement for management and operations risk, produces unrealistically low predictions of prepayments and misstates the value of an Enterprise's basis swaps. Therefore, Freddie Mac recommends that the long-run average shape of the yield curve be used in both the up-rate and the down-rate stress tests.

Background

The Act sets two interest rate scenarios based on the movements of the ten-year CMT yield. Instead of specifying the shape of the yield curve during the stress period, the Act requires that other Treasury yields "change relative to the ten-year CMT yield in patterns and for durations that are reasonably related to historical experience and are judged reasonable by the Director."[52]

The shape of the Treasury yield curve is an important stress test parameter because it significantly affects an Enterprise's capital requirement generated by the stress test.[53] The Act gives specific guidance on the shape of the yield curve, requiring that it be reasonably related to historical experience.[54]

While the shape of the Treasury yield curve can affect an Enterprise's capital in many ways, four effects of the yield curve shape are highly significant. First, the shape of the yield curve affects funding costs associated with replacement of short-term debt. Specifically, if the yield curve is assumed to be flat, short-term debt that matures during the stress period must be replaced at a higher rate than if the yield curve had a typical upward slope.[55] Second, the shape of the yield curve affects OFHEO's discounting calculations, which in turn, affects the capital that the Enterprises must hold for management and operations risk. Third, the shape of the yield curve affects assumed prepayment rates. In general, a flatter yield curve will slow predicted prepayments,

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[52] The Act § 1361(a)(2)(D).
[53] OFHEO notes that the security yields not specified in the Act "will have potentially substantial and pervasive effects on the Enterprises during the stress period." NPR2 at 18146.
[54] The Act § 1361(a)(2)(D).
[55] The yield curve is said to slope upward when short-maturity CMT yields are lower than the longer-maturity CMT yields, *e.g.*, when the three-month yield is less than the one-year CMT yield, which in turn is less than the ten-year yield, and so on. Historically, the yield curve is generally observed to be upward sloping. A common explanation for this phenomenon is that investors usually have shorter investment horizons and require a premium to hold longer-term bonds. This premium results in long-term yields being higher then short-term yields on average.

distorting estimates of future Enterprise cash flows. Finally, a flat yield curve will overstate or understate the risks associated with an Enterprise's "basis swaps."

Proposal

NPR2 proposes that the CMT yield curve should be flat across all maturities in the up-rate scenario[56] and be steeply upward sloping (from short maturities to long maturities) in the down-rate scenario.[57] For both scenarios, the yield curve adjusts from the level just preceding the stress period to the proposed shape over the first 12 months of the stress period in equal monthly increments. NPR2 explains that OFHEO "based its selection of yield curves on an examination of historical data on Treasury yields,"[58] adding that "[t]he pattern of relatively flat yield curve slopes after interest rate increases and steep yield curve slopes after interest rate decreases is consistent with the data."[59]

Discussion

Proposed yield curves are not reasonably related to historical experience

The historical record contains no instances of shocks to the ten-year CMT rate that are as severe or as permanent as those specified by the Act. The maximum increase in the ten-year CMT yield over any 12 month period between 1977 and 1999 is 45 percent, far less than the 75 percent increase generally required by the Act. The maximum decrease observed during any 12 month period between 1977 and 1999 is 36 percent, in comparison to the 50 percent decrease generally required by the Act. Accordingly, our review of historical data reveals nothing directly comparable to either stress scenario.

While OFHEO recognizes that "[a]t no time during the past 40 years have ten-year CMTs changed as greatly as required by the stress test,"[60] it specifies the path of the yield curve in the up-rate and down-rate scenarios based on the analysis of yield curve data from 1956 to 1996. As an example, NPR2 provides an analysis of the slope of the curve between six-month and ten-year CMT yields. In its effort to adhere to the letter of the Act, OFHEO analyzes changes in rolling nine-year averages of the ten-year CMT yield relative to the preceding nine-month average and compares these changes to rolling nine-year averages of the 6-month CMT yield relative to the ten-year CMT yield. This comparison leads OFHEO to conclude that in the up rate stress test the six-month CMT yield and the ten-year CMT yields should be equal (*i.e.*, the yield curve should be flat).

There are two obvious difficulties with this analysis. First, the 1959 to 1996 sample has only four independent nine-year periods. Consequently, rolling nine-year averages (of which there are many) do not provide much additional information.[61] Second, it is generally misguided to project a path of the yield curve based on the analysis of nine-year averages because paths, by definition, are dynamic, while averages are static. Averaging smoothes

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[56] NPR2 § 3.3.3.3.2.
[57] *Id.* at § 3.3.3.3.1.
[58] *Id.* at 18147.
[59] *Id.* at 18148.
[60] *Id.*
[61] This difficulty is acknowledged by OFHEO. *Id.* at n.148.

over the dynamics in time series data and thereby discards precisely the information that is most relevant for specifying a path.

Given this lack of a direct historical precedent, it is necessary to employ careful dynamic economic analysis to infer what is reasonably related to historical experience. Freddie Mac commissioned a study[62] by a leading scholar on interest rates, Professor John Campbell of Harvard University, to examine the probable behavior of the yield curve based on the historical evidence given the stress paths of the ten-year CMT yield as defined by the Act.[63] The econometric analysis reported in the study concludes that large and permanent interest rate shocks as specified in the Act would have little impact on the long-run shape of the yield curve. The Campbell Study indicates that while one might expect temporary narrowing of the spread between the long and short end of the yield curve in the first year of the up-rate scenario, the yield curve would revert rapidly to its long-run shape, which is upward sloping.[64] The study suggests that a flat or inverted yield curve is not the normal shape and that the yield curve would not take such a shape following a large and permanent shock to the ten-year CMT rate.

Table 1 and *Chart 1* below show the average shape of the yield curve over the period 1980 to1999.[65]

Maturity	1 mo.	2 mo.	3 mo.	6 mo.	1 yr.	2 yr.	3 yr.	5 yr.	10 yr.	20 yr.	30 yr.
Average CMT-Yields 1980 -1999	6.69	6.98	6.95	7.05	7.64	8.05	8.22	8.47	8.74	---	8.89
Historical Shape (Yield/10-year CMT)	0.77	0.80	0.79	0.81	0.87	0.92	0.94	0.97	1.00	1.01[66]	1.02
Shape Proposed in Up-Rate NPR2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Shape Proposed in Down-Rate NPR2	0.68	0.72	0.74	0.77	0.80	0.87	0.90	0.95	1.00	1.06	1.03

Table 1: Long-Run Average and Proposed Shape of CMT Yield Curve [67]

[62] "The Yield Curve and Proposed Stress Tests for Freddie Mac" (1998), by John Campbell, Otto Eckstein Professor of Applied Economics, Harvard University (the "Campbell Study"). The Campbell Study is attached as *Appendix 3*.

[63] *See* H.R. Rep. No 206, 102d Cong., 1st Sess. at 65 (1991) ("House Report") "The Committee intends that any methodology chosen be generally recognized by experts as valid and that any assumptions employed be, to the extent possible, historically based and internally consistent."

[64] *See* cover letter from John Campbell, dated May 5, 1998, summarizing the Campbell Study (attached as *Appendix 3).*

[65] The average yield curve was obtained by averaging CMT yields of each of the following maturities: one-month, two-month, three-months, six-months, one-year, two-years, three-years, five-years, ten-years and 30-years.

[66] This ratio was interpolated because the 20-year CMT yield is not a continuous series from 1980-1999. The Treasury stopped issuing 20 year bonds in 1986 and the series is unavailable between 1986-1993. Because of this discontinuity, we chose to interpolate the 20 year/10 year ratio. See the Federal Reserve's website for details (http://www.federalreserve.gov/releases/H15/data.htm).

[67] The information in *Table 1* was provided by Data Resources Incorporated (DRI).

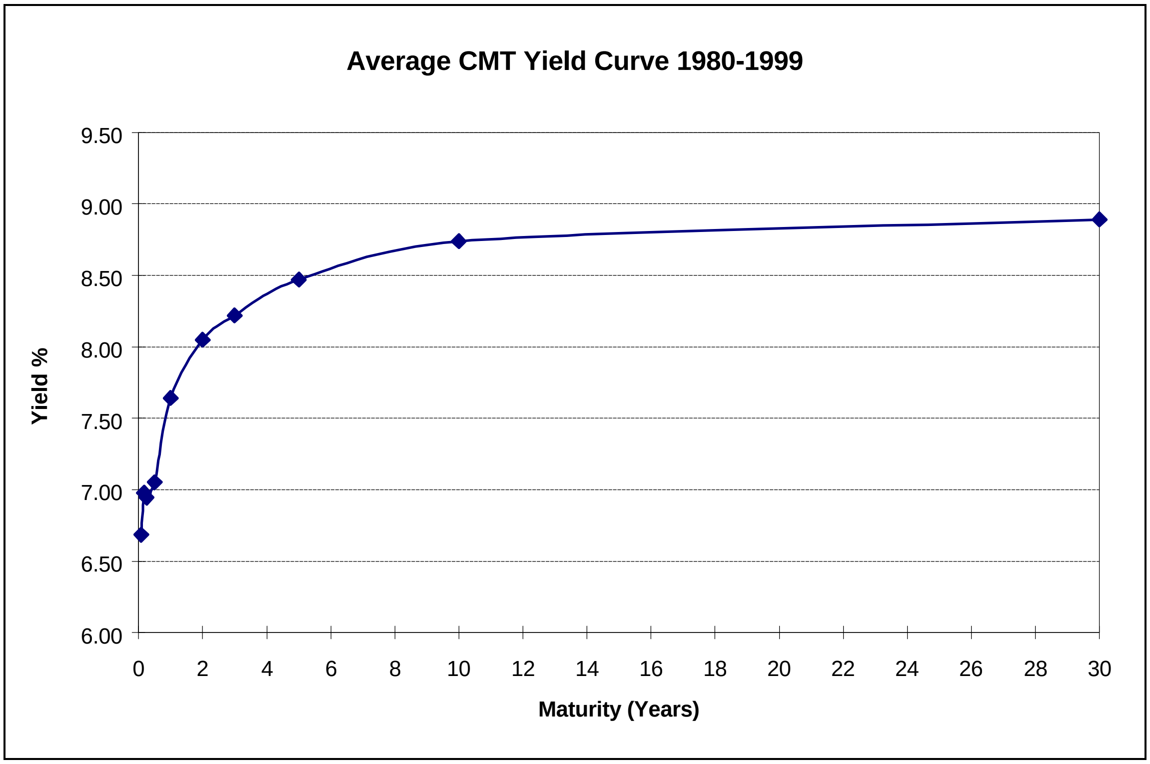

Chart 1: Average Yield Curve 1980-1999

In view of the evidence and the analysis provided by Professor Campbell, Freddie Mac believes that the yield curve would revert to its long run average shape following large interest-rate shocks. OFHEO's proposed flat yield curve in the up rate stress test represents an extremely unlikely prediction of yield curve behavior that cannot be said to be "reasonably related to historical experience." The shape of the proposed yield curve in the down-rate scenario, while somewhat more reasonable, is steeper than historical experience would predict.

A flat yield curve in the up-rate stress test imposes capital requirements unrelated to risk

By adopting an inaccurate assumption about the shape of the yield curve in the up rate scenario, OFHEO subjects the Enterprises to artificial stresses that affect their capital requirements in a manner unrelated to their actual risks. The proposed approach mismeasures risk in four principal areas. First, a flat yield curve assumes that short-term debt will be replaced at a higher interest rate than would exist under a more probable upward sloping yield curve, thereby distorting estimates of an Enterprise's refunding costs. Second, an assumed flat yield curve results in a higher discount rate than an upward sloping yield curve, directly increasing an Enterprise's capital requirement for management and operations risk. Third, a flat yield curve results in slower prepayments in the up-rate scenario and consequently distorts estimates of cash flows that the Enterprises will receive during the stress test. Finally, a flat yield curve assumption tends to misestimate the value of an Enterprise's basis swaps. Each of these difficulties associated with the flat yield curve assumption is discussed in greater detail below.

Refunding costs

A flat yield curve in the up-rate scenario is likely to overstate the costs that an Enterprise would actually face when refunding its short-term debt. As an example, suppose that at the start of the stress test, an Enterprise has short-term debt that is due to mature one year in the future. Further suppose that one year into the stress test, the ten-year CMT yield is 12 percent. If the yield curve is assumed to be flat, the maturing short term debt will be replaced at 12 percent plus the specified spread for the Enterprise's funding rate. On the other hand, if the yield curve is assumed to have a typical long-run upward slope, the short-term CMT rate would be 9.8 percent. Thus, an assumption of a more reasonable yield curve slope produces a more realistic estimate of actual funding costs.

Discount rates

A flat yield curve assumption produces a higher discount rate in the up-rate scenario than would an upward sloping yield curve, which would require an Enterprise to hold more capital to cover its management and operations risk. NPR2 uses the six-month CMT as a basis for the discount rate in months where an Enterprise is characterized as a net investor[68] for purposes of calculating its risk-based capital requirement.[69] Specifically, OFHEO sets its discount factor for such months as follows:

$$monthly\ discount\ factor = \left[1 + \frac{(1 - Effective\ Tax\ Rate) \times 6\ month\ Treasury\ yield}{2}\right]^{\frac{1}{6}}$$

A flat yield curve will produce a higher discount rate in comparison to an upward sloping yield curve because, with a flat curve, the six-month Treasury yield will equal the ten-year CMT yield.

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[68] In general, an Enterprise is a net investor when its net cash flow is positive; it is a net borrower when its net cash flow is negative.

[69] NPR2 § 3.12.3.

In months where an Enterprise is characterized as a net borrower, NPR2 uses the six-month Federal Agency Cost of Funds as the basis for the discount rate.[70] Specifically, the discount factor for such months is:

$$monthly\ discount\ factor = \left[\frac{1+(1-Effective\ Tax\ Rate)\times\left(\frac{6\ month\ Federal\ Agency\ Cost\ of\ Funds}{2}\right)}{1-\left[(1-Effective\ Tax\ Rate)\times .00025\right]}\right]^{\frac{1}{6}}$$

where the factor .00025 (2.5 basis points) represents the Enterprise's administrative costs of issuing short term debt when it is a net borrower.

Because the six-month Agency Cost of Funds is tied to movements in the six-month Treasury yield, a flat yield curve assumption should result in a higher discount rate compared to an upward sloping curve.[71] The higher the discount rate, the lower is the discounted value of the future projected capital. The capital that an Enterprise must hold for management and operations risk is directly related to the difference between starting capital levels and future projected levels. Thus, the assumption of a flat yield curve artificially increases an already conservative requirement for management and operations risk.

Prepayments

In general, a flat yield curve slows down expected prepayment rates. When yield curves are flat, a homeowner might expect rates to remain stable or decrease and might delay prepaying an existing mortgage and obtaining a new one. On the other hand, when yield curves are upward sloping, a homeowner might expect rates to rise and will be more likely to prepay an existing mortgage and take out a new mortgage. Furthermore, if the yield curve is upward sloping, adjustable rate mortgages with lower initial rates are available, providing a further incentive for homeowners to prepay existing mortgages. Accordingly, prepayment rates are likely to be unrealistically low with a flat yield curve. Assuming prepayments that are too low distorts the measure of the risk in a mortgage portfolio. For example, interest-only strips would gain too much value in the up-rate stress test and principal-only strips would lose too much value. Again, the unrealistic flat yield curve assumption distorts the actual risks that an Enterprise faces in the up-rate scenario and violates the general principal that capital should be tied to risk.

Basis swaps

A basis swap is a swap in which an Enterprise makes or receives payments depending on how much the yield curve deviates from expectations. This type of swap allows an Enterprise to swap one floating rate for another based on a notional amount. For example, an Enterprise may agree to pay the floating six-month CMT rate plus a spread at six-month intervals and receive the floating ten-year CMT rate on a notional amount of $100 million. The payments exchanged under such a swap are sensitive to the slope of the yield curve, and

[70] *Id. at* 18299-300.

[71] There is, of course, a small amount of uncertainty associated with this conclusion because it is possible for the six-month Federal Agency Cost of Funds to become decoupled from the six-month Treasury yield.

by assuming a slope of the yield curve different from historical averages, OFHEO's proposal misestimates the value of a yield curve basis swap.

If the yield curve is assumed to be flat (or flatter than expected), then the difference between the short rate and the long rate is expected to be zero (or smaller than expected) and the value of the basis swap described above will be significantly negative.[72] Because the average shape of the yield curve is upward sloping and the stress scenario assumes a flat yield curve, this basis swap will be undervalued. Alternatively, a swap to receive the floating six-month CMT rate and to pay the floating ten-year CMT rate will be overvalued. Depending on the swap terms, a flat yield curve will over- or under-state risks.

Recommendation

Freddie Mac recommends that the yield curve retain its long run average historical shape during the course of the both the up-rate and down-rate stress tests. The slope of the yield curves in both the up-rate and down-stress tests should be based on the following table of historical averages.

Maturity	1 mo.	2 mo.	3 mo.	6 mo.	1 yr.	2 yr.	3 yr.	5 yr.	10 yr.	20 yr.	30 yr.
Recommended Slope	0.77	0.81	0.81	0.82	0.89	0.93	0.95	0.97	1.00	1.01	1.02

Table 2: Recommended Shape of Treasury Yield Curve (as Ratio of 10-Year CMT Yield)

In summary, while we express our concern regarding the proposed shape of the yield curve in NPR2, we agree with the proposal that the yield curve should move to this shape from pre-stress period levels in equal monthly increments over the first 12 months of the stress period. As the Act does not have the ten-year CMT rate move after month 12, the shape of the yield curve should not change after month 12 either.

The Campbell Study, based on analysis of historical experience, suggests a more complicated dynamic that would depend in part on the shape of the yield curve before the start of the stress period. However, given that the Act specifies that the ten-year yield does not change after the first 12 months of the stress test, it is a reasonable simplification to assume the same about the other yields. A more complicated specification, where the yield curve was sometimes steeper and sometimes less steep during the stress period, would not better capture risk. Furthermore, such a complication would limit the ability of the Enterprises to forecast their capital requirements.

[72] The value of the swap depends not only on the expected difference between the two rates in the future but also on their relative volatilities.

ii. Non-Treasury Interest Rates (Spreads)

OFHEO proposes to project stress period yields of 19 non-Treasury interest rates using complex time-series ARIMA models.[73] Freddie Mac believes that ARIMA models are not well-suited to project these interest rates because the models do not fit historical data well. As a result, OFHEO's proposed approach for modeling non-Treasury interest rates could mask or exaggerate actual risks. In addition, the proposed ARIMA models would be difficult to incorporate into Enterprise capital management and compliance systems and would hamper Enterprise innovations. Therefore, Freddie Mac recommends that non-Treasury interest rates be based on the average spread between those rates and their corresponding Treasury rates over the past two years.

Background

A significant portion of the Enterprises' asset and liability payments are based on non-Treasury interest rates, such as the London Interbank Offered Rate (LIBOR) and Agency Cost of Funds.[74] These interest rates are integral to the Enterprises' cash flows, and any comprehensive stress test of the financial soundness of the Enterprises must make assumptions concerning the behavior of such non-Treasury rates during the stress period. An inaccurate specification of non-Treasury rates could result in a distorted assessment of an Enterprise's exposure to changes in interest rates and mortgage credit risks.

Because the Act only specifies interest rate shocks to the ten-year CMT during the stress period,[75] it was necessary for OFHEO to project interest rates that are relevant to the businesses of the Enterprises. The Act requires that OFHEO determine unspecified characteristics of the stress test (such as non-Treasury interest rates) consistently with the stress period, on the basis of available information.[76] As described below, NPR2 proposes to project non-Treasury interest rates through the use of ARIMA models.

On October 1, 1999, Freddie Mac provided Preliminary Comments on OFHEO's Proposed Approach to Projecting Non-Treasury Interest Rates (Preliminary Comments). The Preliminary Comments, which are attached as *Appendix 2* to this Comment, contain an extensive analysis of the proposed use of ARIMA models, concluding with a recommendation that OFHEO replace the ARIMA approach with a two-year rolling average to project differences between non-Treasury and Treasury interest rates. The Preliminary Comments are summarized in the following paragraphs. However, Freddie Mac hereby incorporates by reference all of the Preliminary Comments into this Comment. In addition, Freddie Mac presents at the end of this section a further comment and recommendation not included in the Preliminary Comment concerning historical data sources used to project non-Treasury interest rates.

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[73] ARIMA is an abbreviation for Autoregressive Integrated Moving Average.

[74] While Freddie Mac and Fannie Mae are not agencies of the Federal government and are, in fact, private, shareholder-owned corporations, we conform to market and industry conventions in this Comment by referring to the Enterprises' borrowing rates as the "Agency Cost of Funds."

[75] *See* the Act § 1361(a)(2).

[76] *Id.* at (b)(2).

Proposal

NPR2 proposes to project stress period levels of yields on non-Treasury interest rates and indices by applying 19 separate ARIMA time series models, one for each interest rate. An ARIMA model projects a non-Treasury interest rate for each month of the stress period based on information such as the historical average for that interest rate and recent month-to-month changes in that interest rate. On any given date, the ARIMA model projections use the recent history of an interest rate, plus its longer term historical patterns, to specify how that interest rate might behave in a stress test initiated on that date.

NPR2 explains the ARIMA models would estimate values during the stress period based on historical percent spreads to yields on Treasuries of comparable maturities. NPR2 further explains that such ARIMA models "capture the average historical relationships between specific [Treasury] and non-Treasury interest rates."[77]

Discussion

ARIMA models are poor predictors of non-Treasury interest rates

As discussed in depth in the Preliminary Comments, the proposed use of ARIMA models is poorly suited to the objective of projecting non-Treasury interest rates during the stress period. Accordingly, an ARIMA modeling approach does not meet the statutory obligation that non-specified stress period characteristics be consistent with the characteristics specified in the Act and does not adequately tie capital requirements to risk.

To summarize some of the observations made in the Preliminary Comments, many of the ARIMA models do not fit historical data well, in part because some historical data exhibit changes in behavior that ARIMA models cannot capture, and in part because the proposed ARIMA methodology ignores relationships among different interest rates. Furthermore, the ARIMA models in many instances will introduce errors into interest-rate projections. These errors exist because OFHEO's proposed ARIMA models miss important changes that occurred in the behavior of non-Treasury interest rates in the 1980s, as well as because the proposed models extrapolate recent interest rate trends by assuming that these trends will persist for the ten-year stress period. These errors ultimately can produce erratic changes in an Enterprise's capital requirement that are unrelated to risk.

Additional errors are introduced because the proposed ARIMA processes consider each non-Treasury rate separately, leading to predicted relationships among rates that are haphazard, counter-factual and highly sensitive to small variations in individual rates. A stress test that relies on these projected rates is likely to generate estimates of significant and arbitrary gains or losses, distorting basis risk and other types of risk.

Implementation difficulties

Freddie Mac observes in the Preliminary Comments that the proposed ARIMA models would hinder incorporation of the capital requirement into the capital management and compliance systems of an Enterprise. Freddie Mac's principal objections are summarized below.

[77] NPR2 at 18149.

First, fluctuations in the capital requirements resulting from the proposed ARIMA models would be difficult to predict, verify and explain. Because the ARIMA models will cause the stress test to include arbitrary gains and losses that have no discernible relationship to an Enterprise's true interest rate and mortgage credit risks, forecasting and managing capital would be extremely difficult.

Second, the use of ARIMA models would make capital requirements overly sensitive to data discrepancies. ARIMA models can be extremely sensitive to the level of precision of the historical data that is used in the models. If the available data are not accurate — as is true for a significant amount of the historical data that would be used to project the 19 non-Treasury interest rates — the estimation and projection of the ARIMA models will not be reliable. This unreliability further contributes to the difficulties that an Enterprise would have forecasting and managing its capital requirements under the proposed approach.

Finally, the coefficients for the ARIMA models in the proposed approach would have to be re-estimated each quarter. The quarterly re-estimation represents a significant task and would consume resources at both OFHEO and the Enterprises that could be better employed at monitoring and managing risk. In addition, any instability in stress test results that is induced by the re-estimation process would further complicate the process of verifying and explaining capital requirements.

Accommodating innovation

In the Preliminary Comments, Freddie Mac describes how NPR2's proposed approach for projecting non-Treasury interest rates would hamper innovation to the extent that either Enterprise introduces a product that references a rate not currently included among the 19 rates specified. Under such circumstances, an Enterprise would be unable to gauge the effect of such new product on capital requirements until OFHEO studied and published a lag structure for the new rate's ARIMA model. In addition, OFHEO would have to commence a rulemaking procedure to amend its capital rules to add the new rate. These results adversely affect the Enterprises' business and are contrary to OFHEO's stated goals that the stress test be "flexible enough to address innovation."

Recommendation

Freddie Mac recommends that OFHEO project stress-period non-Treasury interest rates using a simple two-year rolling average method rather than using ARIMA models. This technique is described in greater detail in the Preliminary Comments. The two-year rolling average method produces less erratic interest rate projections — and, hence, less erratic capital requirements. However, this method should not, on average, either increase or decrease an Enterprise's required capital in comparison to the ARIMA method. Some additional advantages of the two-year rolling average method in comparison to the proposed ARIMA approach include:

- It is in accord with the requirements of the Act in as much as non-Treasury interest rate projections will be consistent with the specified characteristics of the stress period.
- It is simpler and less costly to implement — both for OFHEO and for the Enterprises — yet it achieves a comparable state of refinement with less distortion of risk.

- It would better accommodate innovation.
- It is not sensitive to software choices.
- It would reduce OFHEO's documentation challenges by reducing the likelihood that rulemaking amendments would be necessary.
- It is preferable to any attempt to refine the ARIMA models, which would be likely to exacerbate implementation problems without better tying capital to risk.

Additional discussion and recommendation

Since preparing the Preliminary Comments, Freddie Mac has conducted further analysis on the appropriate methodology for determining non-Treasury interest rates. As a result of this analysis, Freddie Mac would like to offer the following additional comments concerning the use of historical data sources.

Any approach for projecting interest rates that relies on historical information by necessity requires access to accurate and reliable historical data sources.[78] In the case of certain interest rates, satisfactory data are readily obtainable. However, historical data concerning other interest rates — particularly rates that have limited applications outside of the activities of the Enterprises — are inconsistent in terms of quality and availability.[79]

The use of inaccurate or unreliable data in the projection of interest rate spreads can distort substantially the Enterprises' capital requirements. It would be impossible, of course, to project a non-Treasury interest rate during the stress test to the extent that historical data concerning that rate is no longer available.

In order to resolve these data issues, Freddie Mac recommends that OFHEO should develop requirements for the stress test to ensure that only reliable and relevant historical interest rate data are used — irrespective of the methodology that OFHEO selects to project non-Treasury interest rates during the stress period. Freddie Mac tracks certain critical rate spreads — such as the LIBOR-Agency spread — very carefully, using actual transaction prices in instances where information from third-party sources is likely to be inaccurate or unreliable. We believe that OFHEO should be as careful in specifying sources for historical non-Treasury indices. In addition, OFHEO should take care to ensure that calculations of spreads between a non-Treasury interest rate and a Treasury interest rate are done so that the two series are calculated in the same manner (*e.g.*, either using monthly averages for both or month end rates for both, but not a combination).

Furthermore, Freddie Mac recommends that OFHEO develop a process to provide back-up historical data on non-Treasury interest rates to be used in the event that data concerning such rates are no longer available from their normal sources. Ideally, this process should simply require that the Enterprises rely on historic interest rate data from commonly

[78] Freddie Mac's proposed two-year averaging approach for projecting non-treasury interest rates also requires accurate and reliable historical data sources. Accordingly, these comments are relevant even if OFHEO replaces its proposed ARIMA approach with another methodology that also relies on historical data.

[79] For example, Data Resources Incorporated (DRI), a well regarded source of interest-rate data, recently stopped providing Agency Cost of Funds data.

available and accepted sources, such as the Federal Reserve. In instances where such information is not available, each Enterprise should be permitted to rely on its own data sources and tabulations, subject to adequate back-up documentation and verification by OFHEO. We would be pleased to work with OFHEO and to provide any additional information that OFHEO might need to implement these recommendations.

iii. Enterprise Borrowing Rates

OFHEO proposes to add a 50 basis point risk premium to Enterprise borrowing rates during the final nine years of the stress test. Freddie Mac believes that no relevant historical data support such an additional charge. In fact, Freddie Mac's analysis of historical data suggests that past increases in Enterprise borrowing costs associated with credit events have been accompanied by comparable increases in other interest rates and have disappeared within two years. Accordingly, OFHEO's proposed risk premium substantially overstates stresses to the Enterprises. In addition, the proposed risk premium is inconsistent with other elements of the proposed stress test. Therefore, Freddie Mac recommends eliminating the 50 basis point risk premium.

Background

A risk premium is an addition to borrowing rates that develops in capital markets when lenders perceive additional risks associated with particular borrowers or categories of borrowers. NPR2 proposes to add a 50 basis point risk premium to Enterprise borrowing costs during the final nine years of the stress period. This risk premium is intended to account for the increased borrowing costs that the Enterprises would experience as lenders perceive that stressful conditions have made Enterprise debt inherently riskier. By increasing the Enterprises' borrowing costs during the stress period, the proposed risk premium increases the amount of capital that an Enterprise must have at the start of the stress period.

Proposal

NPR2 states, "The stress test adds a 50 basis point credit spread to the federal agency cost of funds index to project Enterprise borrowing costs for the last nine years of the stress period."[80] To justify this additional charge, NPR2 indicates that, following one year of stressful conditions, "market values of the Enterprises' assets, liabilities, and derivatives contracts would fully reflect the effects of the interest rate shock and some of the credit quality deterioration of the stress test."[81] The proposal further notes that "[i]nvestors would be aware of these changes in market value and adjust their evaluations of the Enterprises' financial health accordingly."[82]

OFHEO explains the proposed 50 basis point risk premium by noting both that the Enterprises likely would be subject to dividend restrictions for the final nine years of the stress period and that Fannie Mae and the Farm Credit System experienced borrowing risk premiums during financial crises during the 1980s.[83] However, NPR2 also acknowledges that "[a]fter one year of stress test conditions, the Enterprises might appear strong based on accounting measures of earnings and net worth."[84]

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[80] NPR2 § 3.3.3.5.
[81] *Id*. at 18149.
[82] *Id*.
[83] *Id*. at 18149-50.
[84] *Id*. at 18149.

Discussion

The proposed risk premium, which applies only to Enterprise borrowings for the final nine years of the stress period, is not consistent with empirical evidence and is not consistent with the operation of capital markets. As proposed, the risk premium is inconsistent with other components of the stress test and does not effectively tie an Enterprise's capital requirement to its actual risk exposure. In sum, the proposed risk premium is an arbitrary addition to the interest rate shocks specified by the Act and should not be included as part of the stress test.

The proposed risk premium is not "most consistent with the stress period based on historical information"

Because it is not a specified stress in the Act, NPR2's proposed 50 basis point risk premium is an additional characteristic of the stress period that, pursuant to the Act should be "determined by the Director, on the basis of available information, to be most consistent with the stress period."[85] The historical record, however, contains little evidence to predict the precise characteristics of any risk premium that might develop. We can state with a high degree of certainty, however, that the historical record does not support a risk premium with the characteristics proposed by OFHEO.

OFHEO's proposal overstates Enterprise risks because it ignores long run historical correlations between interest rates

OFHEO's justification for its proposed risk premium relies on examination of Enterprise borrowing costs (in terms of the Agency-Treasury spread) under stressful conditions. However, there is a strong positive relationship between Enterprise borrowing rates and other interest rates relevant to Enterprise businesses (such as CMT yields and LIBOR rates) that OFHEO fails to consider. This historical correlation cannot be ignored, because it relates directly to Enterprise cash flows during the stress period and has a significant impact on the stresses that an Enterprise would actually experience. To the extent that an Enterprise enters into swaps where it pays a fixed rate and receives the floating LIBOR rate, a widening of the LIBOR-Agency spread would actually reduce Enterprise stress. Accordingly, OFHEO's consideration of the historical behavior of Enterprise borrowing rates in isolation is likely to overstate significantly the impact of any increases in such rates under stressful conditions.

Chart 2 shows monthly rates for three-month, six-month and one-year CMT yields, Agency Cost of Funds and LIBOR over the period 1980 to 1999. The Chart illustrates the very close relationship between all nine data series. CMT yields, Agency Cost of Funds and LIBOR move in a well-synchronized manner over the long run,[86] notwithstanding occasional and temporary deviations from this behavior.

[85] The Act § 1361(b)(2).

[86] This type of synchronized long run behavior of time series is known as "cointegration." *See* R.F. Engle and C.W.J. Granger, eds., *Long Run Economic Relationships* (1991). Our formal statistical tests indicate that for each maturity, CMT yields, Agency Cost of Funds and LIBOR rates are cointegrated. In other words, the three-month CMT yields, Agency Cost of Funds and LIBOR move together; similarly, the three six-month series move together and the three one-year series move together as well.

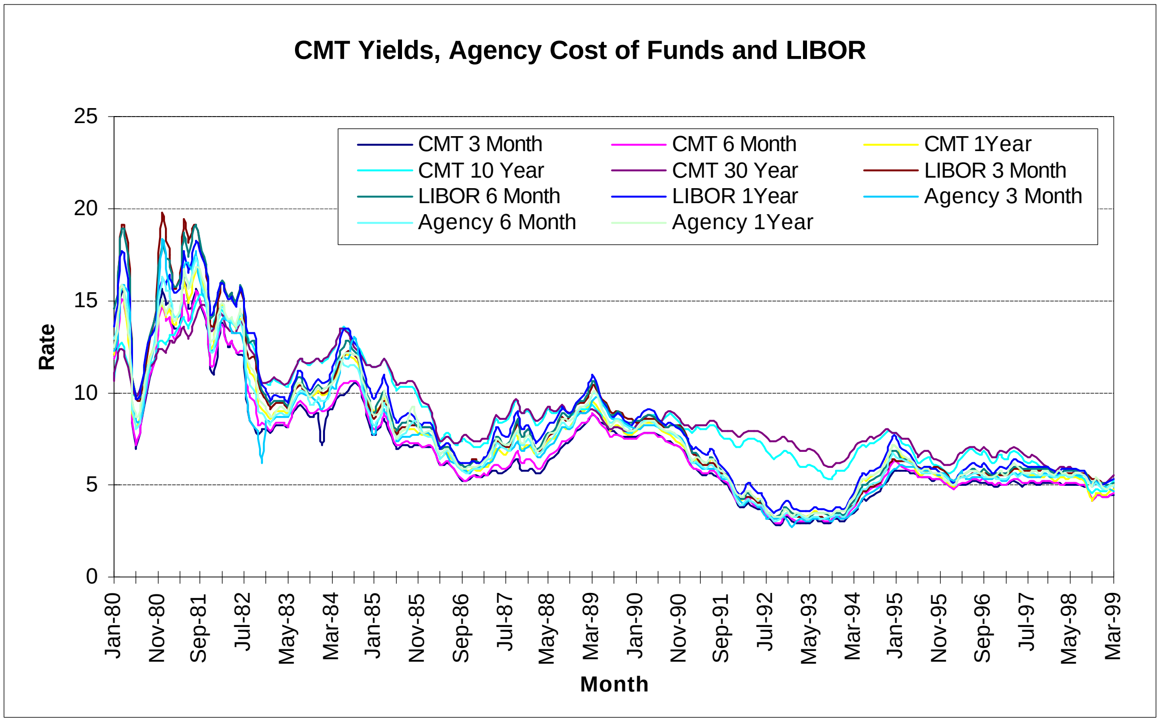

Chart 2: CMT Yields, Agency Cost of Funds and LIBOR 1980-1999

	3 Month	6 Month	12 Month
CMT	+48	+45	+46
Agency Cost of Funds	+50	+50	+50
LIBOR	+63	+62	+54
LIBOR–Agency Spread	+13	+12	+4

Table 3: Agency-LIBOR Long-Run Relationship

Table 3 shows the estimated long-run relationships between CMT yields, Agency Cost of Funds and LIBOR rates of different maturities over the period 1980 to 1999.[87] In each case, when Agency Cost of Funds increase by 50 basis points, LIBOR rates increase by more that 50 basis points, causing the LIBOR-Agency spread to widen. For example, a 50 basis point increase in the six-month Agency Cost of Funds is associated with a 62 basis point increase in the six-month LIBOR rate (*i.e.*, the six-month LIBOR rate increases by more than the Agency Cost Funds and the LIBOR-Agency spread *widens* by 12 basis points).

This Table demonstrates that there is no historical support for a 50 basis point increase in the Agency Cost of Funds with no concomitant increase in CMT yields and LIBOR rates.

[87] These relationships were estimated by Johansen's maximum likelihood method. *See* S. Johansen, "Statistical Analysis of Cointegration Vectors," in R.F. Engle and C.W.J. Granger, eds., *Long Run Economic Relationships* (1991).

This widening of the LIBOR-Agency spread would actually decrease stress on a well-hedged Enterprise. Notably, OFHEO's proposed 50 basis point risk premium will often cause Enterprise borrowing rates to be materially more than the LIBOR — an event that would be completely inconsistent with our comprehensive analysis of historical data.

In summary, a careful examination of the historical long run relationships embedded in the data makes a powerful case against an isolated 50 basis point shock to Agency Cost of Funds alone.[88] Our examination and analysis strongly suggest that a 50 basis point shock to Agency Cost of Funds must simultaneously affect other interest rates. One reason for this synchronized behavior in interest rates is that they are all affected by a common factor, such as the overall economic outlook. Accordingly, OFHEO's proposed imposition of a risk premium applying only on Enterprise borrowing costs presumes the existence of a stress that cannot be supported by historical evidence and requires the Enterprises to hold capital for risks that they are unlikely ever to experience.

Historical data do not support a nine-year risk premium

OFHEO's proposed risk premium for the second year through the tenth year of the stress test is inconsistent with the evolution of spreads. We have analyzed historical data and reached a conclusion that a shock to Enterprise borrowing rates largely disappears within a year and decays to virtually zero in two years. We apply a "vector error correction model" that permits analysis of the length of time it takes for a shock to move through a dynamic system before the system returns to its long-run equilibrium. Using the data from *Table 3* above, *Chart 3* shows the speed of convergence to equilibrium (or the "persistence profile") of the six-month LIBOR rate and the six-month CMT yield following a shock to the six-month Agency Cost of Funds.[89] Notably, all return to their long-run equilibrium within two years of a shock to the six-month Agency Cost of Funds. The implication of this analysis is that the effect of a shock will not last forever, and the system will return close to equilibrium within two years. The results are similar for three-month and 12-month maturities. Accordingly, OFHEO's proposal of a risk premium that persists for nine years cannot be supported by any comprehensive analysis of historical data.

[88] Ignoring long run relationships between levels of interest rates and focusing directly on spreads results in a misspecified econometric model. Such a model results in biased and inconsistent estimates of the dynamics in the system of interest rates and should be treated with skepticism. *See* R.F. Engle and C.W.J. Granger, "Cointegration and Error Correction: Representation Estimation and Testing" in R.F. Engle and C.W.J. Granger, eds., *Long Run Economic Relationships* (1991).

[89] This analysis is based on M.H. Peraran and Y. Shin, "Cointegration and Speed of Convergence to Equilibrium," *Journal of Econometrics* (Mar. 1996).

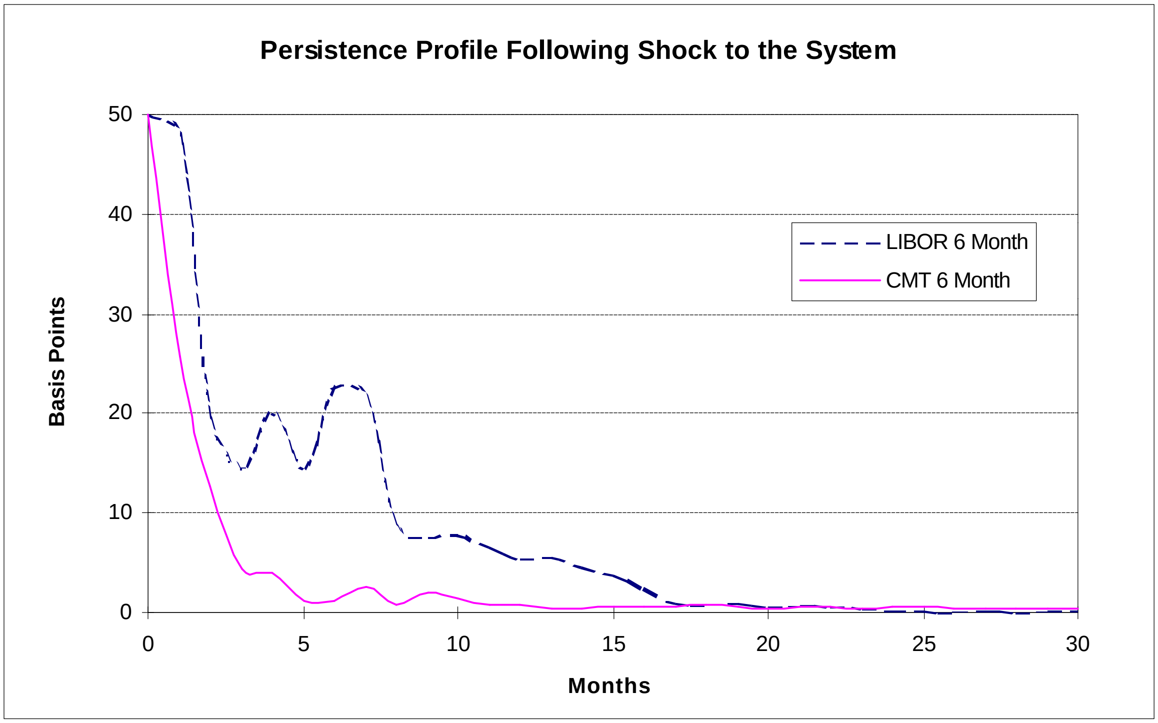

Chart 3: Persistence Profile of LIBOR Rate and CMT Yield

Fannie Mae historical data do not support the proposed risk premium

To support its proposed risk premium, OFHEO cites the increased borrowing costs that Fannie Mae experienced during financial crises of the 1980s. This example, however, is not as directly applicable as it might appear at first glance.

	1980	1981	1982	1983	1984	1985	1986	1987
Bal. Sheet Assets	$58,015	$61,681	$73,109	$78,500	$87,895	$99,188	$99,795	$103,655
MBS	$0	$717	$14,450	$25,121	$36,215	$54,987	$97,174	$139,960
Minimum Capital Required	$1,450	$1,545	$1,893	$2,076	$2,360	$2,727	$2,932	$3,221
Equity Capital	$1,310	$1,080	$953	$1,000	$918	$1,009	$1,182	$1,811
Deficit	($140)	($465)	($940)	($1,076)	($1,442)	($1,718)	($1,750)	($1,410)
Percent Deficit	-10%	-30%	-50%	-52%	-61%	-63%	-60%	-44%

Table 4: Minimum Capital Requirement Applied to Fannie Mae 1980-1987[90]

The relevance of Fannie Mae's experiences during the 1980s is reduced substantially by the fact that Fannie Mae was seriously undercapitalized for its risks and had no meaningful safety and soundness regulation. At the times that OFHEO cites as examples, Fannie Mae was substantially below the minimum capital standards that apply to the Enterprises today. *Table 4* shows financial data for Fannie Mae from 1980 to 1987 and indicates how the

[90] Department of the Treasury, 1990 Report on GSE's, p A82.

company would have fared if the current minimum capital standards were in effect in the 1980s.

The minimum capital requirement was established for the Enterprises in 1992[91] and hence did not apply to Fannie Mae during its periods of financial distress. While a risk premium might be appropriate when an Enterprise is seriously undercapitalized as measured by the minimum capital requirement, the Enterprises generally should remain in compliance with minimum capital requirements throughout the stress period. Accordingly, there should be substantial doubt about whether a risk premium would develop.

In addition, any risk premiums that emerged during the 1980s pre-date many of the Enterprise's substantial risk-management refinements over the past two decades. An example is provided in the General Accounting Office's 1990 report to Congress on government-sponsored enterprises.[92] GAO indicates that the duration of Fannie Mae's portfolio in 1984 was 29 (*i.e*., Fannie Mae's portfolio would have lost 29 percent of its value given an instantaneous upward shock of 100 basis points to the yield curve).[93] Fannie Mae's portfolio had become much less sensitive to a similar shock by 1989 — it would have lost six percent for a 100 basis point upward shock to the yield curve.[94] This example illustrates the degree to which the Enterprise's risk management had developed over time. These improvements should not be ignored in assessing debt costs of Enterprises in stresses that might occur in the future.

Furthermore, Fannie Mae's experiences during the 1980s occurred prior to the establishment of OFHEO. OFHEO has significant powers to ensure the financial safety and soundness of the Enterprises, including the ability to appoint a conservator if an Enterprise's capital levels drop below critical levels.[95] OFHEO's existence should provide additional comfort to investors that a risk premium would not develop.[96] Perceptions of the risk of Enterprise default should be substantially less during the proposed stress period conditions than they were in the 1980s, when Fannie Mae had little capital for its risks.

Finally, a close examination of Fannie Mae's experience in the early 1980s shows that while its borrowing costs relative to the six-month Treasury yield did widen by 110 basis points over the period of the stress, LIBOR spreads increased by approximately 145 basis points at the same time, resulting in a net *increase* in LIBOR-Agency spreads of 35 basis points. As noted above, the LIBOR-Agency spread is as important to forecasting an Enterprise's earnings as the Agency-Treasury spread. Accordingly, a more comprehensive analysis of rate relationships during the 1980s suggests that the interest-rate environment actually

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[91] *See* the Act § 1362.
[92] U.S. General Accounting Office, *Government Sponsored Enterprises: The Government's Exposure to Risk* (1990).
[93] *Id*. at 39.
[94] *Id*.
[95] The Act § 1367.
[96] The inclusion of a risk premium in the proposed stress test in effect amounts to an assertion that investors will question OFHEO's abilities to prevent the Enterprises from defaulting on their obligations under stressful conditions.

moved to one that *decreased* stress for an Enterprise that had hedged its exposure substantially through interest-rate swaps.

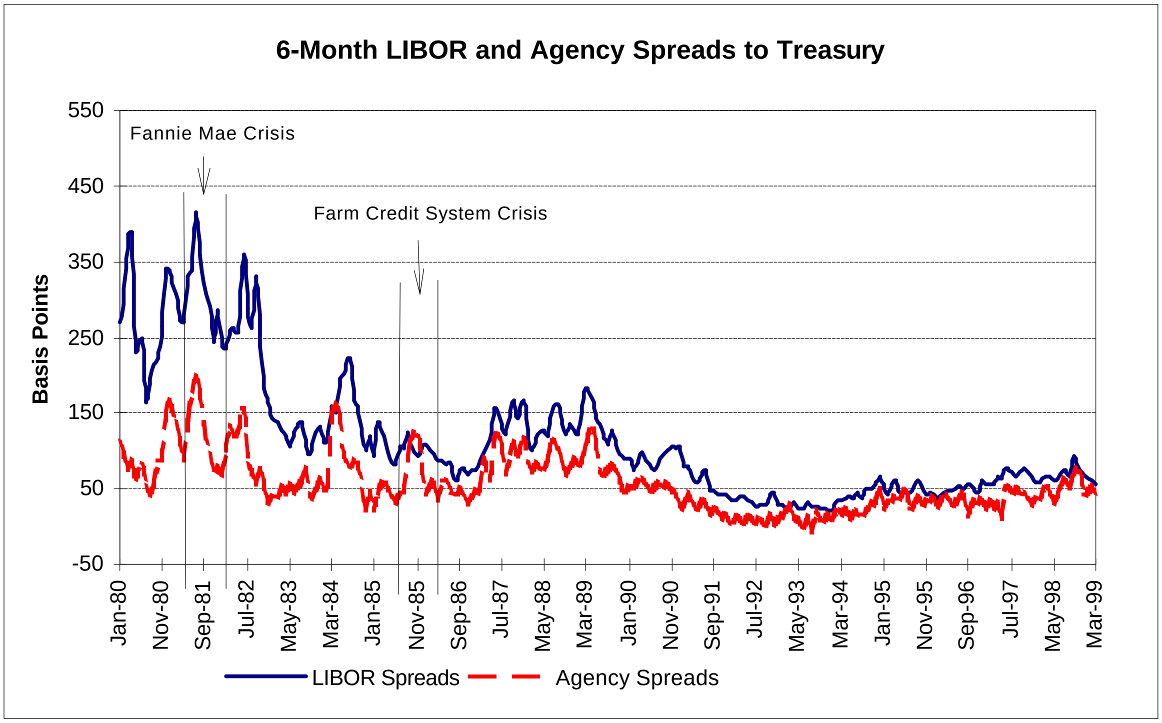

Chart 4: 6-Month LIBOR and Agency Spreads to Treasury 1980-1999

Farm Credit historical data do not support the proposed risk premium

Enterprise borrowing rates, which are historically lower than LIBOR rates, increased relative to LIBOR rates in the late 1980s when the Farm Credit System experienced severe financial distress, resulting in a narrower LIBOR-Agency spread. However, it is likely that this narrowing was due principally to increased liquidity in the LIBOR market. Despite this narrowing of spreads, Enterprise borrowing rates generally remained lower than LIBOR rates throughout the period. As has been noted, OFHEO's proposed 50 basis point risk premium will often cause Enterprise borrowing rates to be materially more than LIBOR rates.

The proposed risk premium is inconsistent with other elements of the stress period

Without the support of relevant historical information, there is little basis for asserting that the risk premium proposed in NPR2 is "most consistent with the stress period." In addition, several elements of the proposed risk premium are inconsistent with other elements of the stress test.

The proposed risk premium is inconsistent with the proposed haircuts

The proposed risk premium is inconsistent with the haircuts on counterparty cash flows proposed elsewhere in NPR2.[97] Implicit in OFHEO's haircut proposal is an assumption of declining overall economic conditions so severe that risk premiums should develop on virtually all spreads related to credit quality. Even the reduced haircut charges recommended by Freddie Mac in this Comment[98] are consistent with significant overall economic distress and the emergence of risk premiums on all spreads.

The proposed risk premium is inconsistent with methods to project non-Treasury interest rates

Any gradual widening of spreads that may occur as the Enterprises entered difficult financial environments (in essence, a risk premium) would be captured substantially through the mechanism used to project non-Treasury interest rates during the stress period.[99] If OFHEO adopts Freddie Mac's proposed methodology for establishing non-Treasury interest rates during the stress period, the prediction of Agency Cost of Funds, as well as other non-Treasury rates, will be based on a 24-month moving average of the most recent months. In the event of a stressful path, the 24-month moving average will automatically and smoothly capture any concomitant increase in the Agency Cost of Funds.

The proposed risk premium is inconsistent with how the Enterprises would operate during the stress period

If a risk premium were to develop in the manner suggested by OFHEO, an Enterprise would continue to have the option of borrowing at rates at least as attractive as LIBOR by using collateralized repurchase agreements. One year into the stress period, the Enterprises would have several hundred billion dollars of unpledged assets. Rather than issuing debt at the elevated rates proposed in NPR2, the Enterprises would have the ability to pledge these assets to borrow at LIBOR rates or better.

In addition, when an Enterprise has surplus cash, the proposed risk premium creates an incentive to repurchase debt rather than invest the surplus in one-month maturity assets that yield the six-month Treasury rate, as required in NPR2.[100] There would be no rational reason for an Enterprise to pay a premium rate on its debt while simultaneously earning an unusually low rate on its surplus. Accordingly, OFHEO's proposed reinvestment rule represents an illogical assumption concerning Enterprise behavior if a 50 basis point risk premium is in effect.

The proposed risk premium does not tie capital requirements to risk

Predicting linkages to many of the variables that might directly affect the emergence of a risk premium — that is, tying the risk premium to actual risk — can present formidable challenges for the design of a stress test. Rather than attempting to predict the precise characteristics of any risk premium that might emerge during the stress test, OFHEO simply

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[97] NPR2 § 3.6.
[98] *See Counterparty Credit Risk.*
[99] *See Non-Treasury Interest Rates (Spreads).*
[100] NPR2 § 3.10.3.1(c).

adopts a risk premium with arbitrarily assigned characteristics. For the reasons discussed below, OFHEO's approach leads to capital charges that have no reasonable relationship to the actual risks that the Enterprises would be experiencing during the stress test.

The proposed risk premium is not tied to an Enterprise's financial condition

At a minimum, any estimate of a risk premium must include some consideration of the initial financial health of an Enterprise in order to make a reasonable prediction of when a premium might develop. NPR2 makes no such consideration. Instead, it proposes to commence the risk premium in the thirteenth month of the stress test in all situations — an approach that would apply this additional stress correctly only by coincidence. Under virtually any other circumstance, the 50 basis point add-on is likely to distort the actual risk exposures of the Enterprises and will impose capital charges that have little relationship to actual risks.

As an example, consider an Enterprise that is highly skilled at managing interest-rate risk and that has hedged its exposure to the point that it could still absorb substantial interest rate shocks after the first year of the stress test. There is no reason to expect that this Enterprise would suddenly experience a risk premium in month 13 of the stress test. NPR2, however, would impose exactly the same borrowing charge on such an Enterprise as it would impose on another Enterprise that suffers significant capital depletion very early in the stress test. The resulting capital charge does not accurately account for the risk exposure of either Enterprise.

The proposed risk premium would increase substantially the cost of funding mortgages with synthetic long-term debt

An Enterprise may find it convenient to issue short-term floating rate debt and convert it into long-term fixed rate debt by entering a swap contract. The resulting funding, known as synthetic long-term debt, is often used as a substitute for direct long-term debt depending on market opportunities. The proposed risk premium of 50 basis points affects the cost of issuing direct long-term debt relative to its synthetic counterpart. Because the short-term debt component of synthetic long-term debt is subject to the additional 50 basis point charge when it is refunded, synthetic debt becomes less attractive. This add-on alone results in approximately a four percent capital charge against synthetic long-term debt. This capital charge would be supplemented by the counterparty risk capital charge associated with the interest rate swap component. The sum of capital charges is far out of proportion to any additional risk that the use of synthetic long-term debt creates. In fact, the use of such debt diversifies the Enterprise's funding sources and actually is risk reducing. By imposing its proposed risk premium, the Enterprises would move from synthetic long-term debt to higher cost funding. Eventually these higher costs would result in higher mortgage rates.

Recommendation

In view of the above considerations, Freddie Mac believes that OFHEO's proposed 50 basis point add-on to Enterprise borrowing costs has no historical justification and imposes an arbitrary additional stress that is not consistent with the Act. In fact, a comprehensive analysis of historical data suggests that a properly implemented risk premium (*i.e.*, one that also considers concomitant increases in other rates, among other factors) actually could decrease the stresses imposed on a well-hedged Enterprise. Given the significant doubt about whether or when a risk premium might develop during the stress period, the considerable complexity associated with modeling and incorporating a properly specified risk premium and the substantial possibility that a properly specified risk premium would decrease stress levels, Freddie Mac recommends that OFHEO eliminate its proposed risk premium completely.[101]

[101] If OFHEO believes that it must include a risk premium in the stress test, it is essential that it specify a premium that is consistent both with historical evidence and with the other components of the stress test. At a minimum, such a risk premium should add risk premiums to other relevant interest rates and phase-in the premium at a point when an Enterprise might actually experience an increase in its borrowing costs (*e.g.,* when the Enterprise stops paying preferred stock dividends). As is indicated in the text, however, a properly specified risk premium is likely to decrease overall stresses on the Enterprises during the stress period.

iv. Single-Family House Price Scenario

Freddie Mac concurs with OFHEO's methodology to "season" mortgage loans during the stress test using the single-family house price index that most closely represents average house price behavior in the benchmark. Freddie Mac further agrees that the single-family house price index should be used to calibrate the single-family default and severity statistical models to the benchmark experience. However, Freddie Mac disagrees with OFHEO's proposed approach for measuring the dispersion of house prices around that average. OFHEO's method can result in widely different loss rates for mortgages in different parts of the country for reasons unrelated to risk. Furthermore, Freddie Mac disagrees with OFHEO's inflation adjustment to house prices in the up-rate stress test, which adjustment results in credit losses in the up-rate stress test greater than credit losses in the down-rate stress test. Therefore, Freddie Mac recommends using the dispersion from the benchmark experience to project defaults — the same dispersion OFHEO used to calibrate the default and severity models to the benchmark experience. This would subject mortgages from different parts of the country to the same stress. In addition, Freddie Mac recommends that the inflation adjustment be increased to recognize that the up-rate stress test, in which the interest-rate shock is permanent, is necessarily an inflationary environment.

Background

Original equity, amortization of the loan balance and house price movements over time determine the amount of equity borrowers have in their single-family homes at any point in time. Decreases in house prices lead to a decrease in the value of a borrower's property relative to the unpaid balance of the mortgage, or to an increase in a borrower's loan-to-value ratio (LTV). LTV at the time of default is a major determinant of loss severity. The higher the LTV ratio, the less likely the Enterprise is to recover the full amount of the unpaid principal on the mortgage loan when the home is sold. In addition, LTV affects both the probability that a loan will default in the first place and the probability that a loan will prepay.[102] Low LTV mortgages are less likely to default because the borrower has a significant equity stake in the home. High LTV mortgages are less likely to prepay because the borrower may not qualify for refinancing.

LTV is only observed directly when a single-family mortgage is originated. Current LTV — which incorporates the effect of house price movements on borrower equity over time — must be estimated. A house price index (HPI), which measures average house price growth rates for a geographic area (*e.g.*, a nation, state or Census division) can be used to update LTVs. Because not all homes appreciate at the same rate within a geographic area, some measure of dispersion of growth rates around the average might also be used.[103] The greater the dispersion around a given average house price growth rate, the

[102] To prepay a loan such as a mortgage is to pay off its balance before it reaches maturity.

[103] Dispersion around the average might grow over time — a process known as diffusion — as homes depreciate at different rates. Some homeowners may not keep up with basic maintenance and repair, for example, while their neighbors not only maintain their properties but also build additions. The more time

greater the probability of default and the higher the credit losses, since a higher proportion of loans lose equity. For the same reason, greater dispersion results in lower prepayment rates.

Three requirements of the Act pertain to the behavior of house prices in the stress test. First, the Act requires OFHEO to "take into account appropriate distinctions among types of mortgage products, differences in seasoning of mortgages, and any other factors the Director considers appropriate."[104] The Act defines "seasoning" as the change in the LTV ratio over time as determined in accordance with a HPI that meets statutory standards of quality and public availability.[105] Thus, the Act requires OFHEO to distinguish among mortgages at the start of the stress test by recognizing the effect of past house price movements since origination on borrower equity. It also suggests that LTV is an appropriate distinguishing characteristic throughout the stress test simulation. To take LTV into account in defining the performance of different mortgages in the stress test, OFHEO would need to determine the future house price behavior (of the ten-year stress test) as well. This is, in fact, what OFHEO proposes to do.

Second, the Act requires OFHEO to "reasonably relate" rates of default and loss severity (credit losses) in the stress test to the benchmark loss experience.[106] One way to reasonably relate credit losses of existing mortgages to the benchmark loss experience is to simulate the performance of those mortgages through the same house price experience as the loans of the benchmark region (ALMO). As long as current LTV or the probability of negative equity is included as a determinant of rates of mortgage default and severity, then credit losses will be driven, in part, by the changes in borrower equity brought about by the ALMO house price environment.

Third, the Act requires OFHEO to adjust credit losses in the up-rate stress test to reflect higher inflation whenever the ten-year CMT increases by more than 50 percent from the average yield during the nine months preceding the stress period ("mandatory adjustment threshold").[107] This mandatory inflation adjustment in the up-rate stress test is statutory recognition that house price inflation lowers current LTV ratios on mortgage loans and thereby reduces credit losses. This statutory provision also acknowledges the positive relationship between permanently higher interest rates and inflation.

The Act gives OFHEO considerable discretion in specifying the inflation adjustment. The Act does not restrict OFHEO from adjusting credit losses when interest rates do not meet the mandatory adjustment threshold. Moreover, the Act requires OFHEO to determine the characteristics of the stress period "on the basis of available information, to be most consistent with the stress period."[108] Therefore, OFHEO also has the authority to make a discretionary adjustment that reduces credit losses for inflation, even when interest rates

that passes, the greater the opportunity for these differences in depreciation to arise — thus, the greater the dispersion in house price growth rates.

[104] The Act § 1361(b)(1).

[105] *Id*. at § 1361(d)(1).

[106] *Id*. at § 1361(a)(1).

[107] *Id*. at § 1361(a)(2)(E).

[108] *Id*. at § 1361(b)(2).

do not meet the threshold, especially when such an adjustment would be "most consistent" with the stress period.

Proposal

In NPR2, OFHEO addresses the three requirements of the Act discussed above as follows. First, OFHEO takes account of seasoning by recognizing the effect of both past and future house price behavior and amortization payments on borrower equity.[109] OFHEO updates LTV ratios from the loan origination date to the start of the stress test using the most recent HPI published by OFHEO, the same HPI proposed as part of NPR1, which captures past average changes in property values by Census division.[110] OFHEO continues to take account of seasoning in the stress test simulation by updating LTVs using house price growth rates from the benchmark experience. The current LTV (or similar measure, in the case of the loss severity model) together with a measure of house price dispersion enter into the default, prepayment and severity models as key determinants of mortgage performance.[111] The standard deviation (dispersion) of house price growth rates around the mean HPI value for a given Census division depends on the age of the mortgage, is different for each Census division and is re-estimated every quarter for each Census division along with the HPI.[112] Thus, in the stress test simulation, OFHEO uses house price growth rates from the benchmark regional experience and the current estimate of the

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[109] NPR2 §§ 3.4, 3.5.2.3.2.3 and 3.5.3.3.3.1. House price movements affect the underlying value of the borrower's property (the denominator of the LTV ratio) and amortization affects the amount of unpaid principal (the numerator of the LTV ratio).

[110] NPR2 § 3.5.2.2(e) and NPR1 at 29592, 29615-17. The "most recent HPI" may not be consistent with the model specifications in NPR2 § 3.5.2.3.2.3 and NPR2 § 3.5.3.3.3.1. These models require HPI values for the "start of the stress period." However, OFHEO typically publishes the HPI for a given quarter with a delay of two months, which is too late for use in the stress test. For example, if the Enterprises had been required to run the stress test for fourth quarter of 1999 by the end of January 2000, they would have had to rely on the third quarter of 1999 HPI, because the fourth quarter of 1999 HPI was not yet available.

[111] Current LTV and dispersion — measured by the standard deviation of house price growth rates — enters into the single family default and prepayment models through the PNEQ variable (probability of negative equity). NPR2 § 3.5.2.3.2.3. $PNEQ_q = N[\ln(LTV_q)/\sigma_{d,q}]$ where N(.)=cumulative standard normal distribution function, ln(.)=natural logarithm, $LTV_q = UPB_q*(HPI_{d,O}/HPI_{d,q})$, $\sigma_{d,q}$ =standard deviation of house price growth rates around the $HPI_{d,q}$ value, $HPI_{d,q}$ =house price index for Census division d in quarter q, and $HPI_{d,O}$ =house price index for Census division d at loan origination quarter. Current LTV does not enter directly into the severity model, only indirectly as measured by the z-score for the distance between the logarithm of the house price index and the logarithm of the UPB index. NPR2 § 3.5.3.3.3.1. $z_t =[\ln(HPI_{d,q,t})-\ln(b_t)]/\sigma_{d,t}$ where $\sigma_{d,t}$ =standard deviation of house price growth rates for loans in Census division, d, in month t of the stress period, $HPI_{d,q,t}$ =house price index for loan groups in Census division d, originated in quarter q, and defaulting in month t of the stress period, and b_t =the ratio of defaulting UPB in month t of the stress period to original house price (with minimum value of 0.05). The z-score in the severity model is a determinant of the sales proceeds from property disposition. Note that both the HPI — average house price growth rate — as well as the standard deviation of the house price growth rates around the mean (σ) affect defaults, prepayments and severities.

[112] NPR2 § 3.5.2.3.2.3. Dispersion is quadratic in terms of age (a function of age and age squared). $\sigma_{d,q} = (\alpha_d MA_q + \beta_d MA_q^2)^{0.5}$ where α_d ="alpha" volatility parameter for Census division d (from OFHEO HPI Report, most recent quarter), β_d ="beta" volatility parameter for Census division d (from OFHEO HPI Report, most recent quarter), and MA_q =mortgage age (limited to avoid negative diffusion).

diffusion of house price growth rates for each Census division to calculate the probability that a mortgage borrower will have negative equity.

Second, OFHEO addresses the requirement of the Act to "reasonably relate" credit losses on existing mortgages in the stress test to the benchmark loss experience by using a proxy for the ALMO benchmark house price growth rates to update LTVs in the stress test.[113] The changes in LTV brought about by the benchmark house price environment affect mortgage default and severity rates. These rates, in turn, affect credit losses. The proxy for ALMO benchmark house price experience that OFHEO proposes is the HPI series for the West South Central Census division (WSC) for the middle ten years of the 12-year benchmark loss experience (1984-1993).[114] The WSC includes all of the ALMO benchmark states except Mississippi.

Third, OFHEO addresses the mandatory inflation adjustment requirement in the Act by adding an inflation adjustment to the WSC 1984-1993 house price path when the ten-year CMT increases by at least the mandatory adjustment threshold.[115] However, OFHEO does not use its discretion to adjust credit losses when the ten-year CMT increases by less than the mandatory adjustment threshold. In addition, OFHEO limits the inflation adjustment to the difference between the yield on the ten-year CMT that obtains in the stress test and the mandatory adjustment threshold.[116] Moreover, OFHEO back-loads the cumulative inflation adjustment into the last five years of the stress test.[117]

Discussion

Seasoning and other factors of mortgage performance

OFHEO's proposed method for taking into account seasoning involves using the HPI proposed in NPR1 to update LTVs for past house price growth.[118] Freddie Mac's comments on NPR1 expressed our concerns about the proposed HPI.[119] Freddie Mac agrees with OFHEO's reliance on current LTV as an important determinant of single-family mortgage default, prepayment and severity rates. However, Freddie Mac disagrees with OFHEO's proposal to specify that house price dispersion vary by Census division in the stress test simulation. This variation in house price dispersion creates differences in

[113] NPR2 § 3.4.1. OFHEO further attempts to link credit losses on existing mortgages to the credit losses experienced by loans in the benchmark region by including a calibration factor in the default and severity models.
[114] OFHEO used the HPI series for WSC calculated as of the third quarter of 1996. These house price growth rates are published in NPR2 § 3.4.2, Table 3-13. They are corrected on OFHEO's website. OFHEO used the same WSC index from the third quarter of 1996 to calibrate the default and severity models to the benchmark experience.
[115] Thus, the proposed stress test house price environment is given by the WSC 1984-93 HPI for the down-rate stress test and for the up-rate stress test if the ten-year CMT increases by less than the mandatory adjustment threshold. *See* the Act § 1361(2)(C) for the formula that determines the size of the up-rate interest shock.
[116] NPR2 § 3.4.3. (Recall that the yield represented by the mandatory adjustment threshold is 150 percent of the average yield on the ten-year CMT in the nine months prior to the stress period.)
[117] *Id*.
[118] NPR1 at 29615-17.
[119] Freddie Mac's Comment at 2, 13-16.

credit losses, and thus the capital requirement, for otherwise identical mortgage loans originated in different parts of the country. These differences are inconsistent with the intent of the Act to impose the loss experience from a single region on the national portfolios of the Enterprises. In addition, Freddie Mac believes that updating the dispersion estimates every quarter could change the Enterprises' capital requirement from one quarter to the next for reasons unrelated to changes in risk.[120]

Chart 5 shows OFHEO's proposed measures of dispersion by Census division (estimated as of the third quarter of 1996 when the HPI for the benchmark — representing the stress test house price experience — was estimated). Dispersion for all Census divisions grows with the age of the mortgage, with dispersion for some Census divisions growing at a faster rate than for others. Greater house price dispersion increases the probability that a given loan will have negative equity. As a result, a pool of mortgages from the Mid-Atlantic division will have higher credit losses in the stress test than will an identical pool of mortgages from the East North Central division and, therefore, will require more capital. *Chart 6* shows the ten-year credit losses for the down-rate stress test for a newly originated mortgage in each Census division.[121] Credit losses projected for this mortgage would be 21 percent higher if it were originated in the Mid-Atlantic region than in the East North Central region (6.87 percent for the Mid-Atlantic and 5.68 percent for the East North Central).

[120] Updating the HPI every quarter would affect seasoning (changes in the estimate of borrower equity) due to past house price changes but would not affect the house price behavior of the stress test, which is tied to (fixed to) the benchmark experience and does not vary by Census division. Updating the volatility estimates, however, would affect diffusion by Census division for the stress test.

[121] Credit losses are estimated for a fixed-rate 30-year mortgage having an original LTV of 90 percent and a coupon of seven percent. We assume that the yield on the ten-year CMT is 6.5 percent at the start of the stress test and declines to 3.25 percent by the end of the first year of the stress test. The pattern of credit losses across Census divisions is similar for different LTVs and mortgage ages.

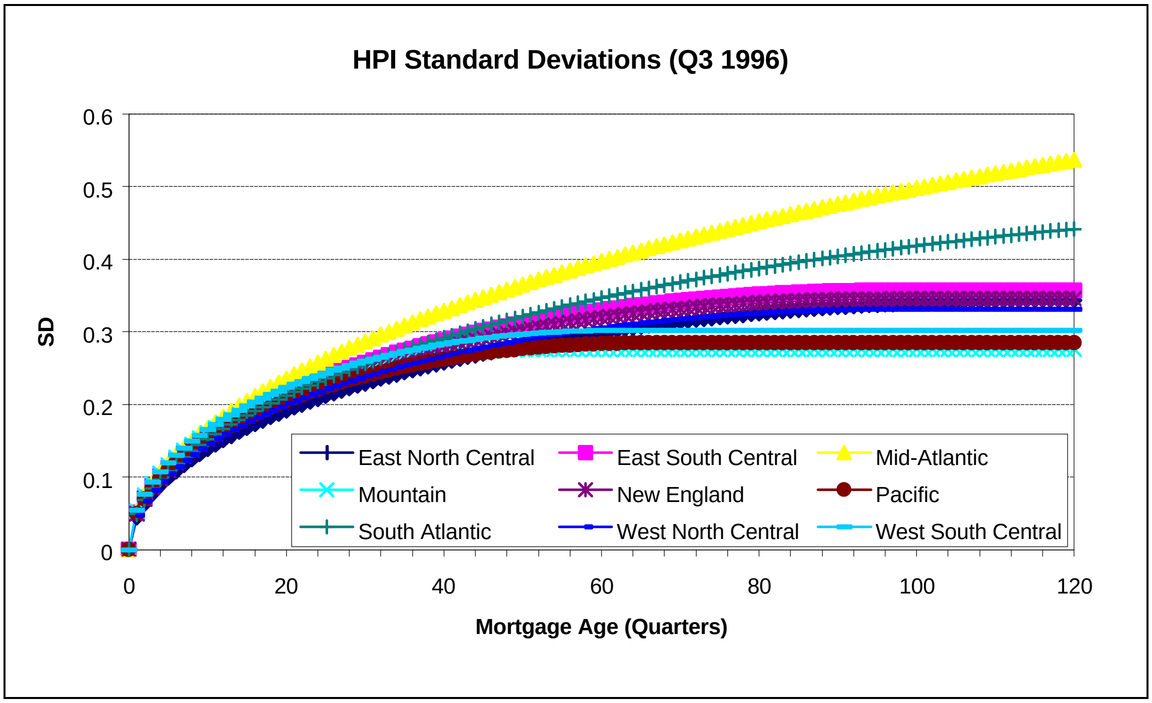

Chart 5: HPI Standard Deviations (Q3 1996)

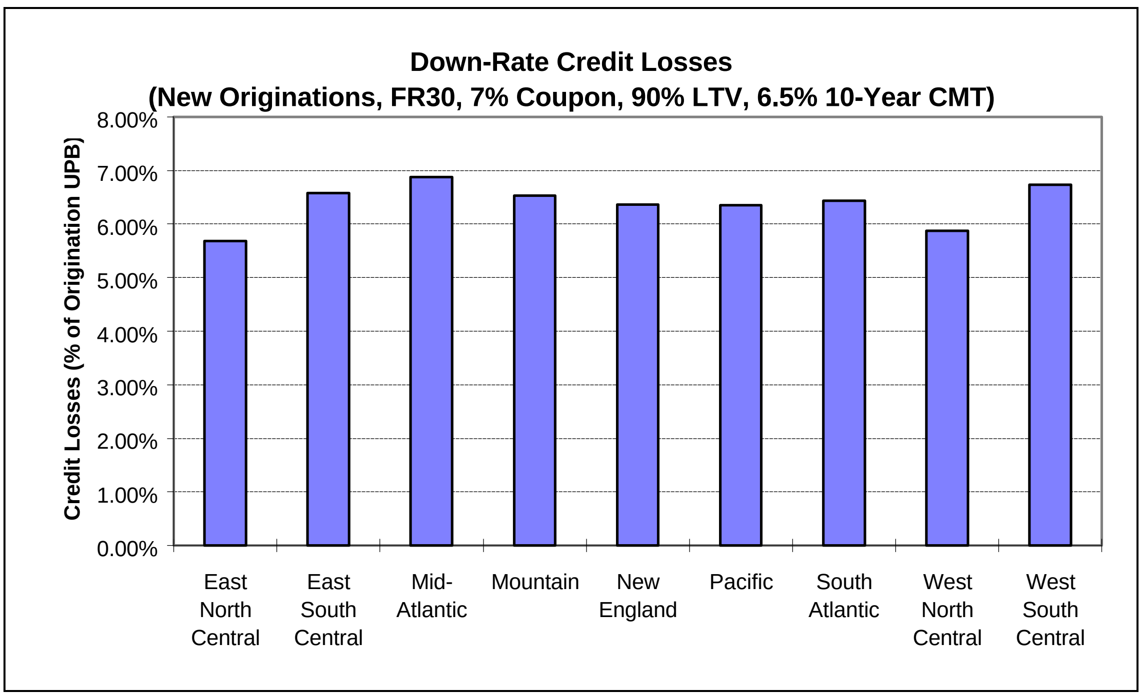

Chart 6: Down-Rate Credit Losses by Region (New Originations)

Capital requirements that vary by Census division are contrary to the intent of the Act. The Act mandates a stress test that imposes a benchmark loss experience from a single region on the national mortgage portfolios of the Enterprises.[122] The proposed stress test is inconsistent with this requirement in that credit losses vary for mortgages that are identical with the exception of their geographic location.

Besides creating a disparity across regions, OFHEO's approach to account for house price dispersion introduces unnecessary instability in Enterprise capital requirements from quarter to quarter as the standard deviation of the HPI is re-estimated every quarter. The impact on credit losses of revising the coefficients on the dispersion equation can be significant. For example, we found that credit losses for a two-year old loan[123] from the Mid-Atlantic division decreased from 8.96 percent to 7.77 percent when we used the dispersion equation estimated as of second quarter 1997 and third quarter 1999, respectively. The resulting variability in quarter-to-quarter capital requirements complicates the task of capital management.

The choice to re-estimate the dispersion coefficients and apply coefficients from different Census divisions has another undesirable consequence. It weakens the connection between the stress test and the benchmark experience on which the default and severity models were calibrated. OFHEO used dispersion estimates from the HPI for the WSC for the third quarter of 1996 to proxy for dispersion in the benchmark loss experience when it calibrated the default and severity models. As noted above, dispersion estimates vary widely by Census division, and tend to change for the same Census division with re-estimation. As a consequence, the dispersion OFHEO proposes for the stress test can differ dramatically from that used to calibrate the default and severity models — an exercise to relate credit losses in the stress test to those in the benchmark.

Relationship to benchmark loss experience

OFHEO's proposed method to reasonably relate credit losses in the stress test to the benchmark loss experience involves, in part, using the WSC 1984-93 HPI in the stress test.[124] Freddie Mac agrees that the 1984-1993 growth rates from WSC HPI as of the third quarter of 1996 is a reasonable proxy for the economic environment of the benchmark (ALMO). The WSC HPI largely captures the magnitude and timing of house price changes experienced by benchmark loans. *(See Chart 7.)*[125] Although the ALMO

[122] The Act § 1361(a)(1).
[123] Again assume a 90 percent LTV, 30-year, fixed-rate mortgage loan with a seven percent coupon in the down-rate scenario as the ten-year CMT falls from 6.5 percent at the start of the stress test to 3.25 percent during the stress test.
[124] As discussed above, the other part of OFHEO's proposed method to tie projected credit losses to the benchmark experience involves the calibration factors included in the single-family default and severity models.
[125] *Chart 7* shows the 1984-93 WSC HPI (as of the third quarter of 1996) that OFHEO published at NPR2 § 3.4.3, Table 3-13, and used in the down-rate stress test. The other index shown is for ALMO for the same period (1984-1993) derived from the Conventional Mortgage House Price Index (CMHPI) published by the Enterprises (also as of the third quarter of 1996). While the estimation differs across the two indices, both apply the "weighted repeat sales" methodology to the same transactions data. *See* "OFHEO House Price Indices: HPI Technical Description" (March 1996) for the details of OFHEO's index construction. *See* "Home Price Index FAQs" at http://www.freddiemac.com/finance/cmhpi/faq.htm for information on CMHPI construction and its similarity to the OFHEO HPI.

index shows a more severe decline in house prices in the first two years of the stress test, the WSC index has an even more dramatic decline between years two and five. Thus, the indices result in similar but not identical credit losses for any given pool of mortgage loans.

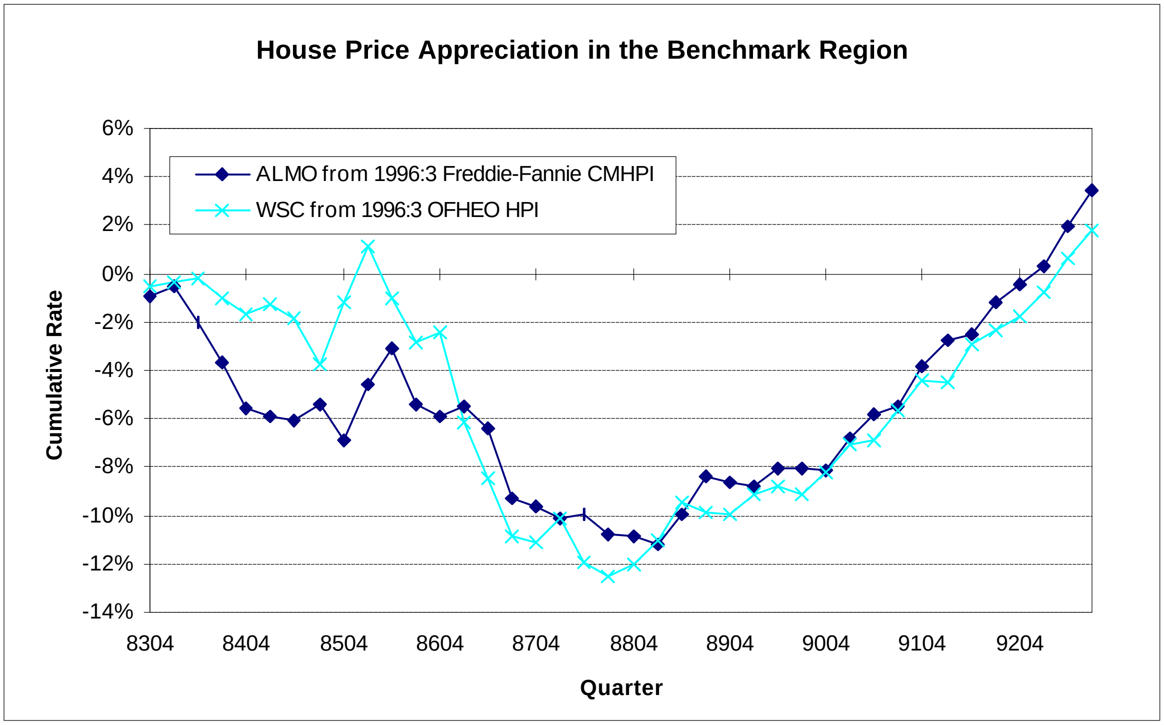

Chart 7: House Price Appreciation in the Benchmark Region

Inflation adjustment in the up-rate scenario

OFHEO's proposed method to adjust credit losses in the up-rate stress test to reflect higher inflation results in an inflation adjustment to the base house price scenario (WSC 1984-1993) that is too little and too late. The proposed inflation adjustment violates the spirit of the Act that suggests that credit losses in the up-rate stress test should be less than in the down-rate test, at least when the ten-year CMT increases by the mandatory adjustment threshold or more. Freddie Mac's stress test results for second quarter of 1997 given by OFHEO show credit losses in the up-rate stress test greater than credit losses in the down-rate test. This is largely due to back-loading the inflation adjustment in the last five years of the stress test, which — as illustrated in the example below — does little to attenuate defaults and losses given the dramatic house price decline in the early years of the stress test. The inflation adjustment proposed by OFHEO is also limited in magnitude to the difference between the yield on the ten-year CMT that obtains in the stress test and the yield represented by a 50 percent increase.[126]

[126] For example, if the general level of interest rates (as given by the ten-year CMT) increased by 75 percent in the stress test, the inflation adjustment would be the difference between the yield given by the 75 percent increase in rates and that given by a 50 percent increase in rates (over the average yield in the preceding nine months).

The proposed inflation adjustment reduces credit losses in the up-rate stress test only for mortgage loans having the lowest borrower equity at the start of the stress test. Credit losses on most loans, however, are higher in the up-rate stress test. *Chart 8* shows, for example, ten-year credit losses for various LTV cohorts for stress test scenarios similar to those of the second quarter of 1997.[127] Credit losses are higher in the up-rate test in spite of the inflation adjustment because prepayments are slower in the up-rate than in the down-rate stress test, allowing more mortgages the opportunity to default. The lateness of the NPR2 inflation adjustment means that many mortgages will default before the adjustment can help borrowers' equity positions, and the mildness of the adjustment means that its effect will be small even for those mortgages that have not yet defaulted.

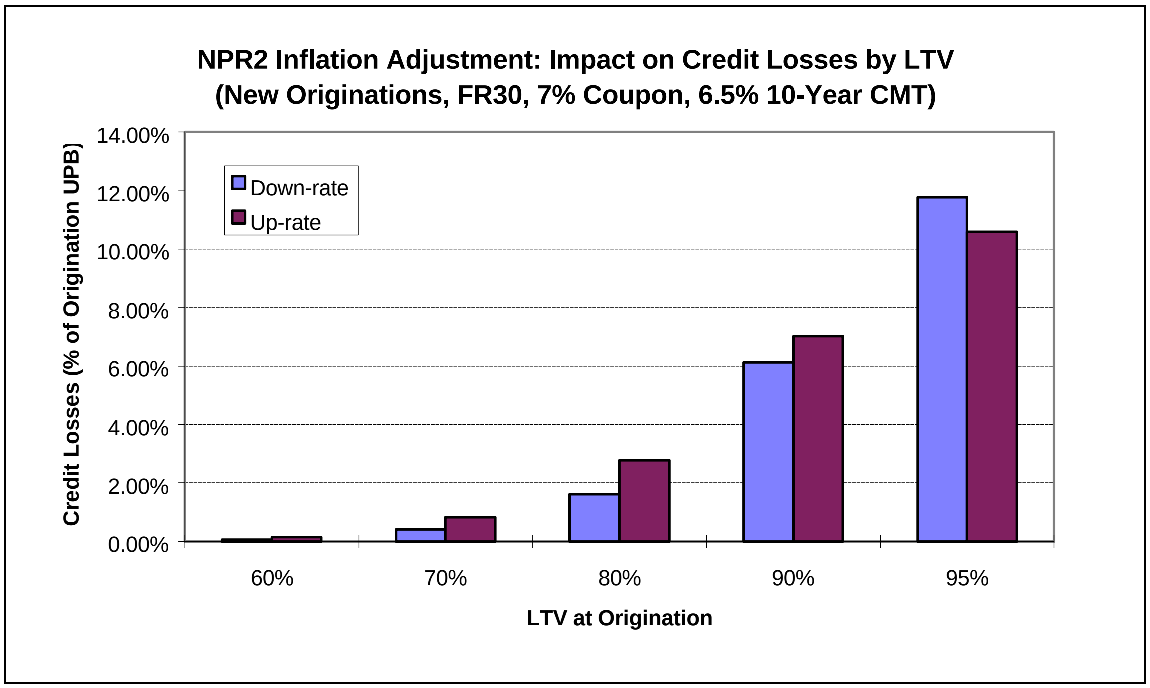

Chart 8: NPR2 Inflation Adjustment: Impact on Credit Losses by LTV

The inadequate inflation adjustment in NPR2 contributes to the excessive stringency of the up-rate stress test. The slow prepayments in the up-rate stress test mean that mortgages have more opportunity to default as they remain in the Enterprises' portfolio. The rising cost of debt to fund such mortgages together with the high credit losses of the benchmark region make the up-rate test more stressful than the down-rate test. Recognizing greater house price inflation, particularly in the early years of the stress test, would better tie capital to risk and meet the mandate of the Act. An up-rate stress test that is too severe would encourage the Enterprises to take on more exposure to falling interest rates.

OFHEO's proposed inflation adjustment is minimal due to its failure to find a clear empirical relationship between interest rates and house price inflation. OFHEO's proposal

[127] The LTV cohorts are newly originated, fixed-rate, 30 year mortgages having a coupon of seven percent at the start of the stress test. The ten-year CMT is assumed to be 6.5 percent at the start of the stress test and increases by 75 percent to 11.4 percent by the end of the first year of the stress test.

is based on the observation that for three five-year periods between 1975 and 1989 house price inflation moved inversely with changes in interest rates, although over longer periods (of ten years or more) house price inflation has moved positively with changes in interest rates.[128] What OFHEO fails to sort out in the empirical data is whether the change in interest rates was due to a change in real interest rates or a change in general inflation.[129] The contractionary monetary policy of the early 1980s increased real interest rates, inducing a recession that eventually brought double digit inflation under control. The recession brought about declines in house price inflation. Conversely, as the real interest rate declined, house price inflation accelerated. The nature of such real interest rates shocks is temporary, never sustained for a long period. Thus, OFHEO's finding that over long periods of time interest rates, general inflation and house price inflation tend to be positively correlated is consistent with real interest rates returning to normal and nominal interest rates largely reflecting inflationary forces.

To expect that interest rates would rise dramatically and permanently with such a lagged and limited inflation response as proposed in NPR2 is highly unrealistic. Freddie Mac hired Michael Darby, Warren C. Cordner Professor of Money and Financial Markets at UCLA to evaluate the relationship between the up-rate interest rate and shock and inflation. Darby's work shows that the economic environment most consistent with the up-rate stress test is an inflationary one brought about by a pre-announced, credible shift toward an expansionary monetary policy.[130] Macroeconomic Advisers, also consulted by Freddie Mac, further shows that such an inflationary environment would result in an acceleration of house price inflation by at least as much as the acceleration in general inflation.[131]

Michael Darby develops the macroeconomic scenario appropriate to the up-rate stress test. Darby rules out the possibility of a real interest rate shock given the permanent nature and size of the shock in the Act. He concludes that the only realistic scenario implied by the interest rate path of the up-rate stress test is a substantial increase in the Federal Reserve System's money growth or inflation target at the beginning of the stress period.[132] Darby goes on to determine the amount of the increase in inflation associated with the large increase in ten-year CMT. He finds that the "correspondingly higher rate of general price inflation" required for implementing the up-rate stress test lies between 75

[128] NPR2 at 18145.
[129] The nominal interest rate is the sum of the real interest rate and the expected inflation rate.
[130] Michael R. Darby, "Consistent Macroeconomic Conditions for a Risk-Based Capital Stress Test" (June 1997), attached as *Appendix 4* to this Comment.
[131] Macroeconomic Advisers, LLC, "House Prices under Alternative Interest Rate Paths" (1999), attached as *Appendix 5* to this Comment.
[132] Darby assumes that the shift in monetary policy is credible and pre-announced so as to minimize the effects on the real economy. He argues that this assumption is conservative because the alternative, typical response to increased money growth is for inflation to rise gradually but faster than interest rates, which would prove less stressful for the Enterprises. He also argues that though conservative, the assumption is consistent with the rapid rise in rates over the first year of the stress period. Darby, *supra*, at 4.

percent and 100 percent of the interest rate increase.[133] Darby demonstrates that the higher rate of general price inflation would occur immediately because the credible, pre-announced shift in monetary policy would, according to macroeconomic theory, result in *de minimis* deviations of actual and expected inflation and hence actual and normal unemployment rates.[134]

Macroeconomic Advisers also studied the economic conditions accompanying a sharp and permanent rise in interest rates as given in the Act. To this end, it used its proprietary dynamic general equilibrium model of the U.S. economy together with a model of the housing market that relates house prices to factors specific to the housing market as well as to general macroeconomic conditions.[135] Like Darby, Macroeconomic Advisers concluded that an increase in the general rate of inflation such that the real interest rate is left relatively unchanged would be most consistent with the up-rate stress test.[136] Specifically, Macroeconomic Advisers calculated that inflation would increase by about 83 percent of the increase in nominal interest rates in the up-rate stress test, a figure within the Darby range of 75 percent to 100 percent.[137] Furthermore, Macroeconomic Advisers concluded that an increase in inflation of 75 percent of the increase in interest rates would be just enough to prevent any change in the real after-tax interest rate. Since it is the real after-tax interest rate that drives housing demand, the real housing market would remain unperturbed: nominal house prices would rise one-for-one with inflation (*i.e.*, equal to 75 percent of the increase in interest rates).[138]

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[133] Thus, if the ten-year CMT increases by 600 basis points, the general inflation rate would increase between 450 basis points and 600 basis points.

[134] Darby, *supra*, at 7.

[135] Macroeconomic Advisers' general equilibrium model is well known. Its housing model is new, however, built in part to help Freddie Mac understand the relationship between interest rates, general inflation rates and house price inflation rates. The salient features of the housing model are as follows: the demand for housing depends on real income and the real rental-equivalent cost of housing services; housing services are produced with land and structures; the supplies of land and structures are fixed in the short-run but can vary positively with their own real price in the long-run; and substitution between land and structures is possible in the production of housing services. House prices are an average of the prices of land and structures, computed by equating the derived demands for each with their supplies. The derived demands depend on seven factors: the real price of structures and land; the expected real price appreciation of structures and land; the general rate of price inflation; depreciation and maintenance costs of structures and land; the nominal after-tax opportunity cost of investing in housing (which is a function of the risk-free rate of return and a risk premium specific to housing); the property tax rate; and tax deductions allowed for mortgage interest and property taxes. How housing values vary in response to changes in interest rates depends on whether the increase in the interest rate is "nominal" or "real" in nature, the long-run responses of the supplies of land and structures, how quickly those supplies adjust towards the new equilibrium, and the extent to which the adjustments are anticipated.

[136] Macroeconomic Advisers ruled out two other potential sources of a sustained rise in the interest rate: faster productivity growth and an increase in the structural budget deficit relative to potential GDP. Macroeconomic Advisers, *supra*, at 5-7.

[137] Macroeconomic Advisers points to the benefits of using a full numerical computable general equilibrium macro model to assess the overall relationship between inflation and nominal interest rates given the complicated interactions in the economy between inflation, the business tax code and foreign capital flows. Macroeconomic Advisers, *supra*, at 11.

[138] Thus, for example, if interest rates increased by 500 basis points, the general inflation rate and the house price inflation rate would both increase by 375 basis points. An increase in inflation of 100 percent

Thus, the Darby and Macroeconomic Advisers studies support immediate house price inflation in the up-rate stress test that would leave real house values unaffected, at a minimum, or cause some real house price appreciation (in the event that general inflation accelerates by more than 75 percent of the increase in interest rates).[139] The acceleration of house price inflation would be relative to the current house price growth rate (typically about three percent per year).

The studies do not support OFHEO's inflation adjustment calculated as the difference between the yield on the ten-year CMT that obtains in the stress test and the mandatory adjustment threshold.[140] In addition, neither study suggests that the inflation adjustment would be appropriate only when interest rates in the up-rate test rise by more than the mandatory adjustment threshold. Darby notes that, given the formulas dictating the size of the interest rate shock in the up-rate scenario, OFHEO can choose not to adjust credit losses to account for higher inflation only in extraordinary cases when current interest rates are high and have been rising.[141] Darby concludes, "exercise of that option would be nonsensical given the assumption that the interest rate increase is maintained for ten years."[142]

These two aspects of the NPR2 inflation adjustment — turning off the inflation adjustment when rates are high and rising and the size limit on the inflation adjustment — lead to instability in the Enterprises' capital requirements. *Chart 9* illustrates the inflation adjustment given by NPR2 that would have obtained over the past 39 years given the

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of the increase in interest rates would, on the other hand, reduce the real after-tax interest rate and increase housing demand. Consequently, real house prices would increase — nominal house price growth rates would exceed inflation and the increase in interest rates. Macroeconomic Advisers, *supra*, at 12-14.

[139] Real house price appreciation means that housing values increase by more than the rate of inflation. Remember that it is nominal house values that matter for mortgage default and severity. Inflation decreases the probability of default because the loan burden, as a percent of the nominal house value, decreases (*i.e.*, LTV ratio decreases). If inflation accelerates by 75 percent of the increase in interest rates (the lower end of the range given by Darby), real interest rates will have increased, but not the real after-tax interest rate that affects housing demand. (The tax advantages of mortgage debt just compensate for the higher real interest rate.) If inflation accelerates by 100 percent of the increase in interest rates (the upper end of the range given by Darby), real interest rates will be unchanged and the real after-tax interest rate that affects housing demand will decline.

[140] If the ten-year CMT increased in the up-rate test by 75 percent from 6.5 percent to 11.4 percent, house price inflation would accelerate by at least 3.6 percent. (Thus, if house prices had been growing at a 3 percent rate, they would grow at a 6.6 percent rate or more in the up-rate stress test.) The inflation adjustment proposed in NPR2, on the other hand, would be zero percent in the first five years and 3.02 percent annually in the second five years.

[141] The Act requires OFHEO to adjust credit losses for inflation when the maximum yield on the ten-year CMT during the stress test exceeds its average during the nine months prior to the stress test by more than 50 percent. The maximum yield during the stress test is the greater of (a) the average during the prior nine months plus 600 basis points or (b) 160 percent of the average for the prior three years. The maximum yield during the stress test is further capped at 175 percent of the nine-month average. If the nine-month average is 12 percent or more and rates have been rising steeply enough, the maximum yield during the stress test will be set to the nine-month average plus 600 basis points according to the rule described above. However, in this case the mandatory adjustment threshold will not be met, because the maximum yield during the stress test will not exceed the nine-month average by more than 50 percent.

[142] Darby, *supra*, at 2.

behavior of the ten-year CMT.[143] In the early 1980s when the ten-year CMT was very high and had been rising, the inflation adjustment would have dropped to zero in the stress test simulation, even though an environment of high and rising rates *per se* would not affect the inflationary assumptions of the stress test scenario.[144] Similarly, the limited amount by which inflation adjusts under the NPR2 formula as the interest rate increase of the stress test approaches 50 percent leads to some volatility in the inflation adjustment. The changes in the Enterprises' capital requirements resulting from such instability in the inflation adjustment would be unrelated to changes in risk.[145] As discussed earlier, these constraints on the inflation adjustment formula are not required by the Act. OFHEO has considerable discretion in defining an inflation adjustment that is most consistent with the stress period and best ties capital to risk.

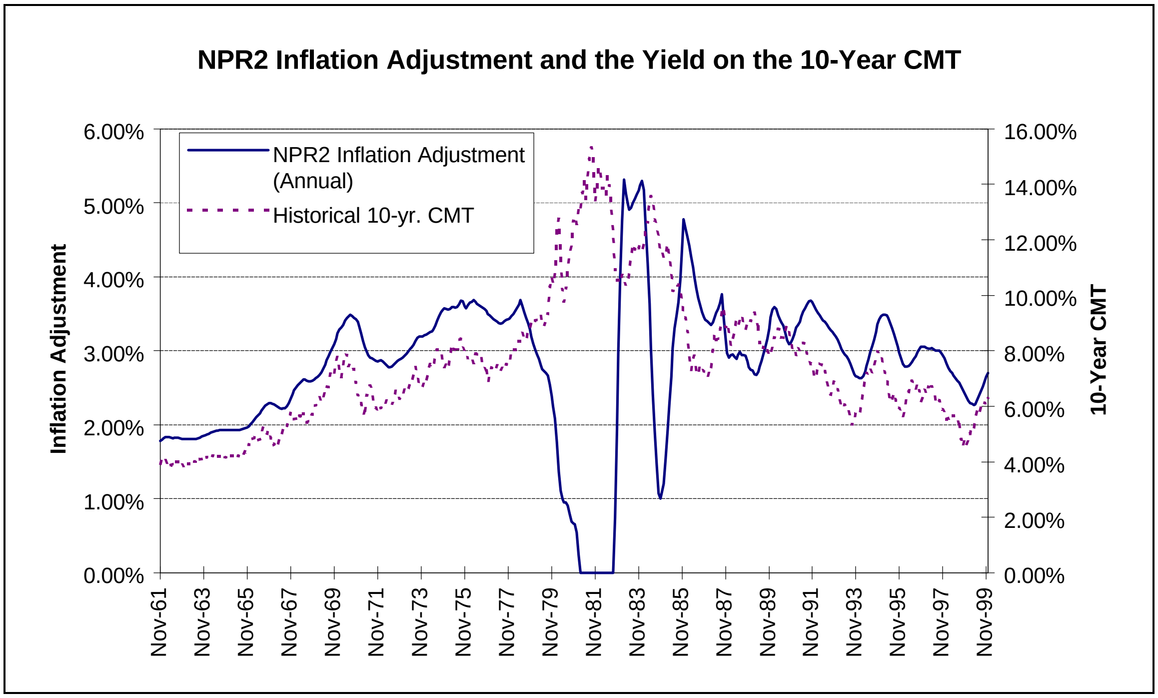

Chart 9: NPR2 Inflation Adjustment and the Yield on the 10-Year CMT

143 The chart does not depict the back-loading of the NPR2 inflation adjustment. Thus, the inflation adjustment shown is the average per year.

144 The environment of very high and rising rates does affect the size of the interest rate shock dictated by the Act. In such cases, the up-rate shock is 600 basis points but less than a 50 percent increase over recent levels. However, there is no reason to think that a 600 basis point shock would not be accompanied by inflation. Note that the interest rate shock of the stress test is usually proportional to the level of the ten-year CMT, causing the inflation adjustment to generally track the level of rates.

145 While the back-loading the NPR2 inflation adjustment attenuates the impact on capital requirements of such instability, that is not a good argument for back-loading. Back-loading is what makes the NPR2 inflation adjustment unimportant for credit losses in the first place.

Recommendations

Seasoning and other factors of mortgage performance

Freddie Mac recommends adopting a single set of dispersion coefficients for all Census divisions that are fixed by regulation, just as house price growth rates are fixed for the stress test. The house price growth rates together with the dispersion coefficients should approximate house price behavior during the benchmark loss experience. This experience will then apply to mortgages of all regions in the stress test, as the Act requires. Specifically, we propose using the house price dispersion coefficients from the third quarter 1996 HPI for the WSC Census division since it is the corresponding HPI that defines the stress test house price path and since the third quarter 1996 HPI and dispersion estimates were used in calibrating the single-family mortgage behavioral models to the benchmark. This approach would have the added benefit of reducing instability in the capital requirement caused by re-estimating the dispersion coefficients every quarter as under the proposed approach.

Relationship to benchmark loss experience

Regarding the use of the WSC 1984-1993 HPI as a proxy for the benchmark house price experience, Freddie Mac recommends keeping that index, calculated as of the third quarter of 1996, to define the economic environment in the down-rate scenario. After all, this was the index used by OFHEO in the calibration of the single-family default and severity models to the benchmark experience.

Inflation adjustment in the up-rate scenario

An inflation adjustment based on the work of Darby and Macroeconomic Advisers would be most consistent with the stress period given by the behavior of the ten-year CMT in the up-rate scenario. Freddie Mac recommended a similar inflation adjustment in its comments on an earlier OFHEO rule-making.[146] In NPR2, OFHEO rejects Freddie Mac's recommendation because "such an approach could result in … very few credit losses in the up-rate scenario." OFHEO further claims that "the recommended approach ... would not have any obvious relationship to the benchmark loss experience."[147]

In consideration of these concerns, Freddie Mac recommends that the inflation adjustment in the up-rate stress test be applied not to current house price growth rates but to the house price growth rates of the benchmark region (WSC 1984-1993), which define the down-rate house price path. Furthermore, Freddie Mac recommends that the inflation adjustment to house price growth rates be only 75 percent of the increase in stress test interest rates but not tied in any way to the mandatory adjustment threshold.

In addition, Freddie Mac recommends that OFHEO apply the inflation adjustment to all up-rate stress test scenarios, even when interest rates increase by less than the mandatory adjustment threshold, to avoid needless volatility in Enterprise capital requirements and to maintain consistency with the events of the stress period. The recommended inflation

[146] Freddie Mac Comment, dated May 9, 1995, on OFHEO's Advance Notice of Proposed Rulemaking (*Freddie Mac's ANPR Comment*) at 45-47.
[147] NPR2 at 18145-18146.

adjustment would better track movements in the ten-year CMT yield as shown in *Chart 10*. Such tracking is appropriate given that the interest-rate shock of the stress test is generally proportional to the level of the ten-year CMT. Thus, when the ten-year CMT is low, the interest rate shock is relatively small and so is the inflation adjustment.

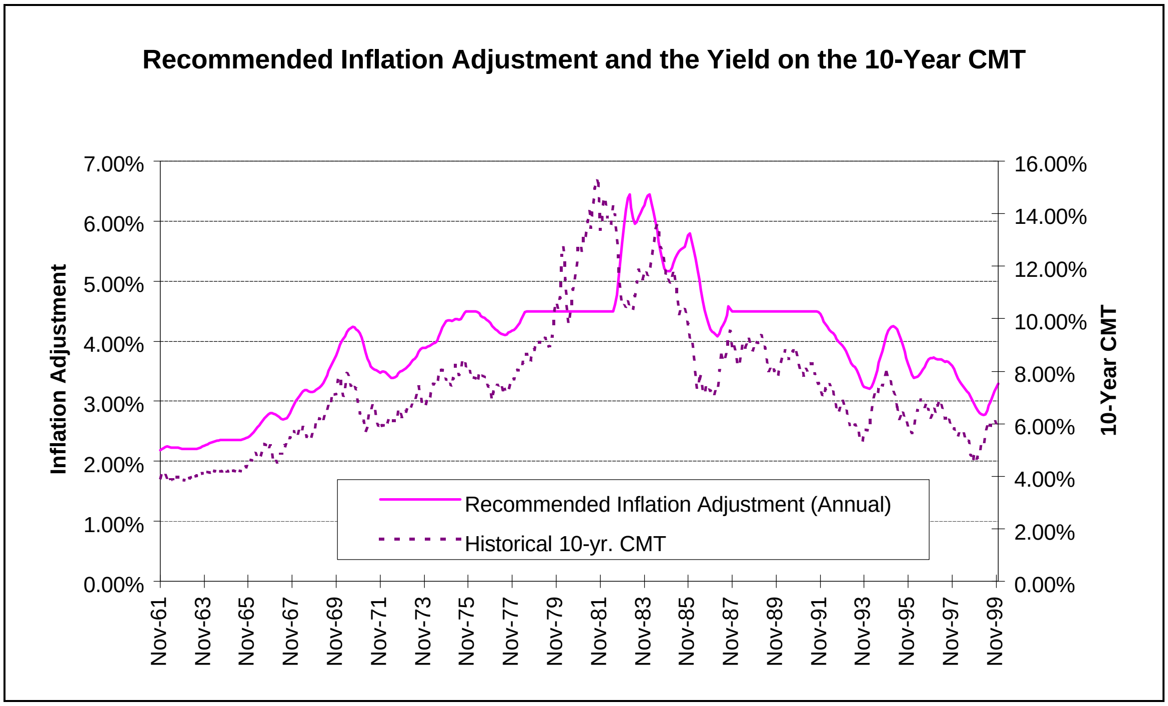

Chart 10: Recommended Inflation Adjustment and the Yield on the 10-Year CMT

The effect of the recommended inflation adjustment would be to lower credit losses in the up-rate stress test relative to the down-rate test, especially for loans with low borrower equity at the start of the stress test. This affect is appropriate given the nature of the inflationary environment in the up-rate stress test. *Chart 11* shows, for example, ten-year credit losses for various LTV cohorts for stress test scenarios similar to those of the second quarter of 1997.[148] Credit losses are reduced significantly for all the mid- to high-LTV loans, not just those with the worst equity position.

[148] As in the corresponding chart above (*Chart 10*), the LTV cohorts are newly originated, fixed-rate, 30 year mortgages having a coupon of seven percent at the start of the stress test. The ten-year CMT is assumed to be 6.5 percent at the start of the stress test and increases by 75 percent to 11.4 percent by the end of the first year of the stress test.

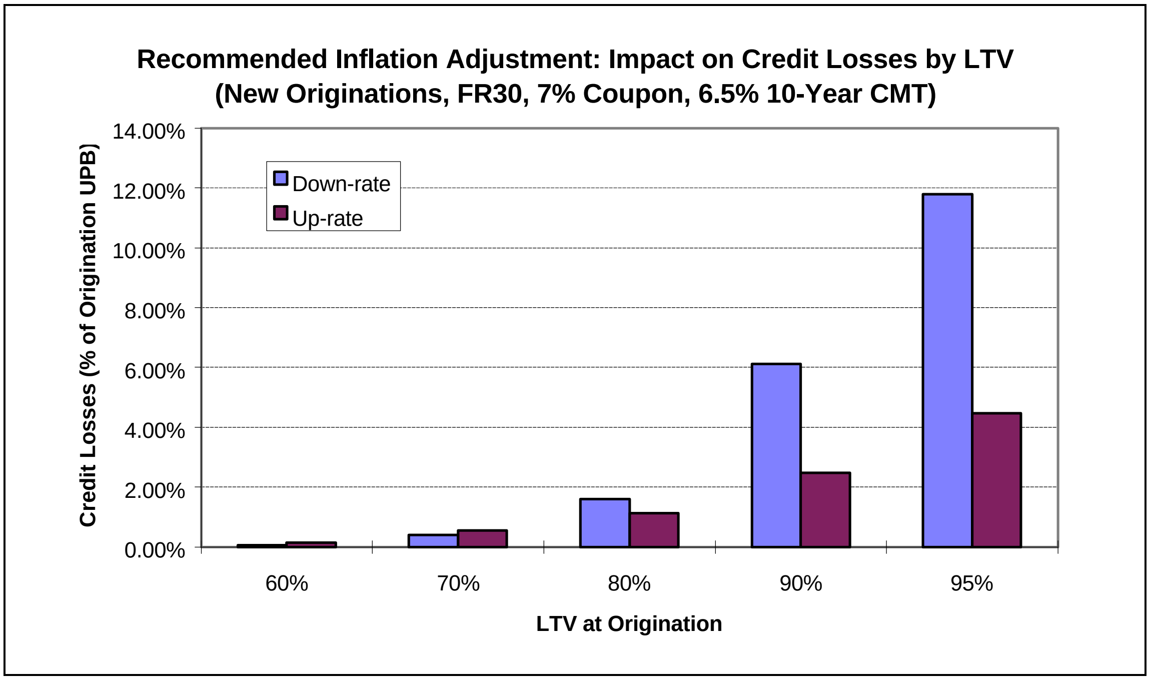

Chart 11: Recommended Inflation Adjustment: Impact on Credit Losses by LTV

Freddie Mac's recommended inflation adjustment has the following advantages:

- The recommended inflation adjustment is most consistent with the stress period as required by the Act.
- The earlier inflation adjustment (for the first five years of the stress period as well as the last five) lowers credit losses in the up-rate stress test to a level "consistent with" credit losses in the down-rate stress test.
- Basing the inflation adjustment on the benchmark house price experience retains the stressfulness of the up-rate credit loss scenario and the relationship to the benchmark experience.
- De-linking the inflation adjustment from the mandatory adjustment threshold increases the stability of the capital requirement and better ties capital to risk.

v. Multifamily Economic Environment

OFHEO faces a substantial challenge in developing an appropriate stress test environment for multifamily mortgages, due primarily to the lack of data in the benchmark about rental income, vacancy rates and property values. As a result, OFHEO relies upon various assumptions to generate a stress test environment for multifamily mortgages. Freddie Mac agrees with OFHEO's definition of stress test rent and vacancy rates Because they adequately represent the benchmark experience and, in combination with the multifamily behavioral models, tie capital to risk. However, Freddie Mac disagrees with OFHEO's property-value index because it does not credibly represent a stressful multifamily experience, especially in the down-rate scenario. In addition, Freddie Mac recommends that OFHEO rely on actual net operating income for individual properties collected by the Enterprises to define starting values for the stress test.

Background

Multifamily mortgage loans differ in many ways from single family mortgage loans and present unique credit risks.[149] In contrast to single-family loans which are often owner-occupied, multifamily loans are commercial loans on properties owned by investors and generally supported by a stream of income generated by the property. Single-family defaults are driven largely by borrower equity. Multifamily defaults are driven by a combination of current debt coverage ratio (DCR), borrower equity and balloon dates. Another important difference between single-family and multifamily loans is the data available to study loan performance. The data on single-family mortgages are abundant, but there are little reliable data on multifamily mortgages. This section focuses on the particular challenges in defining the stress test economic environment for multifamily mortgages, especially those related to data limitations.

Indices of rental income and vacancies play a prominent role in OFHEO's approach to the modeling of multifamily loan performance. The DCR is directly related to these indices. DCR equals the ratio of net operating income (NOI) to the mortgage payment. NOI is rental income net of vacancies and less expenses. Increases (reductions) in DCR reduce (increase) the probability of mortgage default. Property value, a determinant of borrower equity, is not observed (*i.e.*, there are no data available) but is calculated by OFHEO as the product of NOI and a capitalization rate multiplier, which itself is a function of the interest rate. Increases in property values reduce the LTV and decrease the probability of mortgage default; decreases in property values (increases in LTV) have the opposite effect.

The credit risk component of the stress test in the Act does not expressly distinguish multifamily from single family mortgage loans. The Act refers to default and severity rates of "mortgages" during the stress period and requires that OFHEO reasonably relate the stress period credit losses to a historical benchmark loss experience.[150] However, the Act also requires OFHEO to take into account "appropriate distinctions among types of

[149] This is acknowledged by OFHEO. *See, e.g.*, NPR2 at 18120 and 18125.
[150] The Act § 1361(a)(1).

mortgage products, including the distinction between single-family and multifamily loans."[151] The interest rate risk component of the Act requires OFHEO to make a mandatory inflation adjustment to credit losses for large increases in the ten-year CMT yield.[152]

The following discussion focuses upon three aspects of the stress test economic environment for multifamily mortgages. The first is the appropriateness of the stress test economic environment for multifamily loans, which depends upon the linkage of that environment to the benchmark and how well the economic environment, in combination with the multifamily behavioral models, produce results that tie capital to risk. The second is the adjustment for inflation in the up-rate scenario and the third is the approach used by OFHEO to determine starting values for net operating income for "seasoned" loans.

Proposal

OFHEO explains that the stress test simulates mortgage performance (default and severity rates and prepayment levels) under housing market conditions that reflect stresses comparable to those of the benchmark loss experience (ALMO). OFHEO uses four housing market condition variables: house price growth rates, rent growth rates, rental vacancy rates, and multifamily property value growth rates. The latter three variables are used to project multifamily default and prepayment rates. OFHEO constructs its own indices of rents and vacancies for the ALMO region based upon data available from the Institute for Real Estate Management (IREM).[153] OFHEO tried to adjust for deficiencies in IREM data using statistical regression techniques. The resulting stress test scenarios for rents and vacancies are presented in Tables 3-14 and 3-15 of NPR2.[154] OFHEO addresses the mandatory inflation adjustment as required by the Act by adjusting rent growth rates in the up-rate scenario in the same manner as the single-family house price growth rates are adjusted.[155]

Because indices of multifamily property values are not available from any public sources, OFHEO creates property value indices to both estimate the models and define the stress

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[151] *Id.* at § 1361(b)(2). The Act defines "types of mortgage products" as classification of mortgage products with similar characteristics as determined by OFHEO's Director, including properties that are owner-occupied versus investor-owned or those with 1-4 dwelling units versus more than 4 dwelling units or "any other characteristics of the mortgage as the Director may determine." *Id.* at § 1361(d)(2). In addition, the Act defines "seasoning" as the change over time in the ratio of the unpaid principal balance of a mortgage to the value of the property by which such mortgage loan is secured as determined by an index that meets statutory criteria of quality and public availability. *Id.* at §1361(d)(1).

[152] *Id.* at § 1361(a)(2)(C).

[153] In contrast, OFHEO uses geographic specific indices of rent and vacancy rates from government sources for purposes of estimating the default and prepayment models. Rent growth rates are from the residential rent component of the consumer price index (CPI) which is produced by the U.S. Bureau of Labor Statistics. Vacancy rates are from the rental vacancy rate series (H-111) produced by the Bureau of the Census. These indices are available for the metropolitan area or Census region, but not for ALMO. OFHEO states that the CPI residential rent index is not available for ALMO and the H-111 state vacancy rate series is not available for the appropriate time period (1984-85). NPR2 at 18215.

[154] NPR2 at 18239-40.

[155] *Id.* at § 3.4.3. *See also Single-Family House Price Scenario.*

test scenario.[156] As mentioned above, OFHEO measures property value (P) as the product of NOI and a capitalization rate multiplier (C): $P_t = NOI_t\ C_t$.[157] The value of the capitalization rate multiplier at the time of origination (C_0) is the ratio of the original purchase price to NOI at origination (NOI_0). The capitalization rate multiplier changes inversely with the changes in the level of the ten-year CMT yield (i_{10}).[158] As such, property values in the stress test can change substantially as the ten-year CMT changes.

In addition to defining the economic conditions of the stress period for multifamily mortgages, OFHEO had to determine the starting values of NOI for "seasoned" loans.[159] The average value of NOI for a seasoned loan at the start of the stress test period equals NOI at origination times a net income multiplier. The net income multiplier is given by $I_0 = (1 - 2.15(V_0 - 0.0621))$, where V_0 is the rental vacancy rate at the start of the stress test. The value of I_0 for a seasoned loan is NOI at the time the loan was originated updated by the BLS rent indices appropriate to the age and geographic location of each mortgage. The value of V_0 is the Census vacancy index appropriate to the geographic location of each mortgage in the year in which the stress test begins.

Discussion

Unfortunately, the procedures used by OFHEO to define the stress test environment for single-family mortgages are not possible for multifamily mortgages. There are two reasons for this. First, the number of multifamily defaults in the benchmark region is quite small, which makes it virtually impossible to calibrate closely a statistical model to the benchmark experience.[160] Second, as noted above, precise historical indices of multifamily property values are not readily available for ALMO or, in fact, for any part of the nation.

As a result, the multifamily statistical model and the stress test environment must rely upon other economic variables.

We evaluate how well OFHEO's specification of the stress test economic environment for multifamily mortgages is tied to the ALMO experience and how well the economic environment together with the multifamily behavioral models produce results that tie capital to risk. Our evaluation is tempered by recognition of the substantial difficulties associated with the statistical modeling of multifamily mortgage performance.

Due to lack of multifamily data, the tie to ALMO is weak

Because there are few (only 13) multifamily mortgage defaults in the benchmark time-period, multifamily loan performance is tied to ALMO exclusively by the three housing

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[156] *See, e.g.*, NPR2 at 18125 ("there is not enough data available for OFHEO to develop its own price index and the only known price indices blend many commercial property types, have small numbers of observations and are national in scope").
[157] *Id.* at §§ 3.4 and 3.5.4.2.4.
[158] For example, during the stress test $C_t = (1 + 0.23{*}di_{10}/i_{10})C_0$, where di_{10} is the percentage difference between the ten-year CMT at origination and period t of the stress test.
[159] Seasoned loans are loans that are not new originations and are typically more than one year old.
[160] *Id.* at 18144.

market condition variables: rents, vacancies and multifamily property values.[161] Even for these variables, the tie to ALMO is tenuous owing to data limitations. Although the data on ALMO vacancy rates are plentiful and reliable, data on ALMO rents are lacking (and OFHEO's proxy is questionable) and data on property values are not available. The resulting stress test economic scenario for multifamily is described and evaluated below.

First, the vacancy rate scenario is quite stressful. The average vacancy rate in the stress test is 10.5 percent (with a peak vacancy rate of 13.2 percent) compared with a national average of 7.20 percent over the 1984-1993 ALMO time period (with a peak vacancy rate of less than eight percent). This is similar to the relative stressfulness of the single-family house price scenario *(Chart 12).*

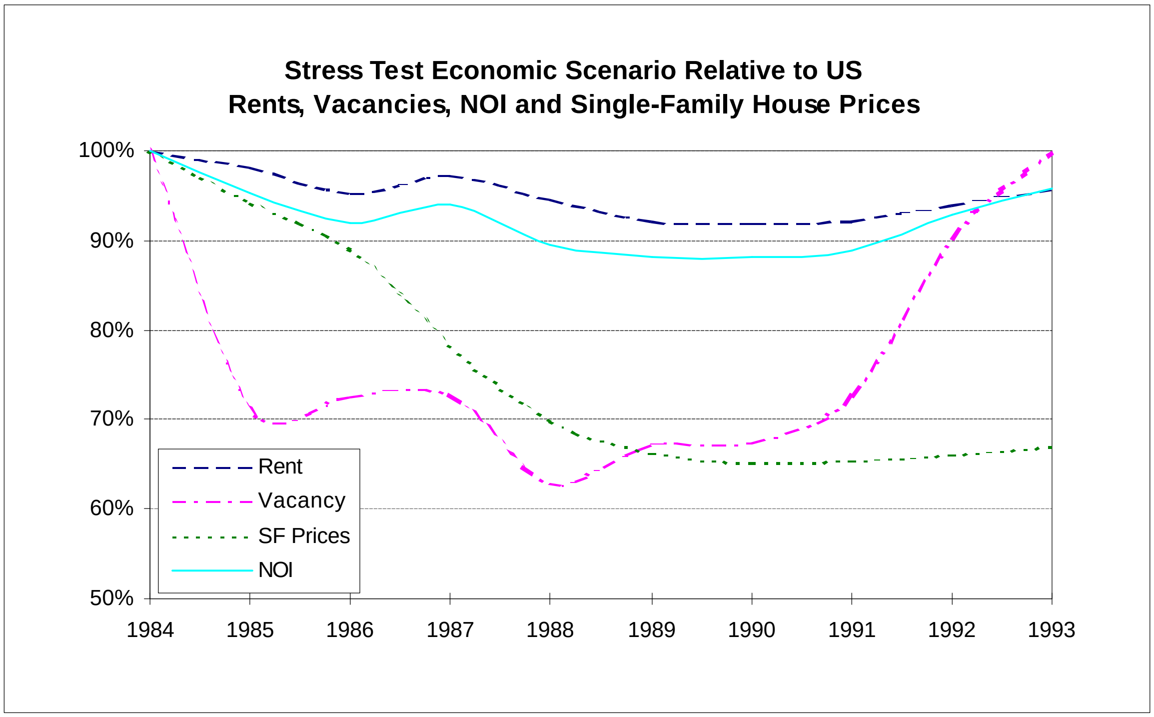

Chart 12: Stress Test Economic Scenario Relative to US (1984-1993)

Second, the rental price scenario is mild. Rents grow by 42 percent over the entire stress period in the down rate scenario, which is close to the national average growth rate in the residential rent component of the Consumer Price Index (CPI) for the nation for the period 1984-1993 (*Chart 12*).[162]

[161] In other words, there are not enough data to calibrate the multifamily default model to ALMO defaults, which is not the case for the calibration of the single-family models. Therefore, OFHEO ties only the model inputs to ALMO — to the extent it can — with the expectation that the model outputs (defaults) would be closely related to ALMO.

[162] We believe this outcome is produced, in part, by OFHEO's reliance upon a regression model to link the IREM data to the CPI data. Such an approach has a tendency to generate a predicted series that is smoother than the true underlying data. For example and in an extreme case, the predicted value of the dependent variable in a regression in which the dependent variable bears no relationship to the independent variable is the estimate of the constant term. More generally, the lower the explanatory power

Third, we believe the scenarios for the rental income and the vacancy rate combine to produce a severe environment for the cash flow available to multifamily properties during the stress test. Our conclusion is based upon two indices of cash flow we construct using the rent and vacancy scenarios for ALMO and for the whole country. Each index measures the growth in maximum rental income available to the property, less vacancies, as such it is a proxy for property net operating income. The ALMO-based index of NOI is eight percent lower than a national index of NOI (*Chart 12*). At the trough, the ALMO index is about 12 percent less than the national index.

Finally, the property value scenario is implausible and volatile. Here the tie to the benchmark experience is quite weak as we explain below. OFHEO's constructed property value index tends to increase substantially in the down-rate scenario and decrease substantially in the up-rate scenario.[163] Although precise historical indices of multifamily property values are not available for many markets, especially for the ALMO region, our review of available information suggests that declines in property value, not increases, best characterize multifamily housing markets suffering severe stress. For example, the indices of multifamily properties produced in a 1997 article by Follain and Calhoun show substantial declines in Texas and Florida during the portions of the 1980s when parts of those multifamily housing markets were in steep decline due to tax reform, oil price declines and the S&L crisis.[164] The CB Richard Ellis National Real Estate Index also shows property value declines in a number of metropolitan areas that experienced high vacancy rates.[165]

In addition, the implied index of multifamily property values is difficult to support in comparison to the treatment of single-family house prices. Although single-family house prices decline by about 12 percent before returning to nearly their starting position level at the end of the stress period, multifamily house prices can *rise* by 50 percent in the down-rate scenario. In the up-rate scenario, multifamily house prices decline substantially more than single-family house prices.

An important source of the volatility of the property value index is OFHEO's equation for the capitalization rate multiplier, which we believe is seriously flawed. Recall that the property value index (P_t) is the product of OFHEO's estimate of net operating income (NOI_t) and the capitalization rate multiplier (C_t). The capitalization rate multiplier increases as interest rates decline and decreases as interest rates rise. A 50 percent decline

of the regression, the lower the variation in the predicted variable relative to the independent variable. Indeed, our analysis of the regression used by OFHEO to generate the rent scenario indicates that the predicted series is less volatile than the underlying IREM data. So, to the extent that the IREM data actually represent the true ALMO experience, the OFHEO rental income stress scenario underestimates the ALMO experience.

[163] The exact change in property values depends on circumstances prior to the start of the stress test. Property values can rise (LTVs decline) by 50 percent or more during the down rate scenario; large decreases in the up-rate scenario are also possible.

[164] James R. Follain and Charles Calhoun, "Constructing Indexes of the Price of Multifamily Properties Using the 1991 Residential Finance Survey," *Journal of Real Estate Finance and Economics*, at 235-255 (1997).

[165] *CB Richard Ellis National Real Estate Index*, 353 Sacramento St., San Francisco, CA 94111.

in interest rates can generate a double-digit increase in property values. While the appropriate relationship between the capitalization rate multiplier and the level of nominal interest rates is complex and difficult to estimate, especially with the limited data available, a properly specified multiplier should incorporate a distinction between nominal interest rates and expected inflation. OFHEO's multiplier does not.

In sum, the property value scenarios, especially the down-rate scenario, are inconsistent with observed multifamily property values in stressful markets, quite different than the scenarios for single-family house prices and difficult to explain. Furthermore, the capitalization rate multiplier used by OFHEO to construct its indices of property values is incompletely specified and estimated with inadequate data.

Proposed inflation adjustment is modest

OFHEO includes an adjustment of the rent series in the up-rate scenario to take account of the expected positive correlation between the level of nominal interest rates and inflation of the general price level. The procedure underlying the adjustment is the same as that for single-family and is described in the section on *Single-Family House Price Scenario*. As explained in that section, the small inflation adjustment proposed by OFHEO for single-family house prices is inconsistent with the up-rate scenario. This argument applies equally well to rents; that is, nominal rent growth rates would rise at or near the rise in the general inflation rate. This relationship is supported by the empirical evidence: the growth rates in the residential rent component of the CPI and the CPI less shelter grew by very similar amounts between 1984 and 1998 (63 versus 56 percent).

Some housing economists have also provided theoretical evidence to support the idea that real (inflation-adjusted) rent may grow faster than the rate of inflation of the general price level.[166] Their analysis focuses upon the relationship between the response of the equilibrium level of rent to an increase in the general inflation rate.

The connection between the two lies in the tax treatment of investments in rental property. Specifically, the depreciation allowance for rental housing is a nominal amount (*i.e.*, straight line depreciation) that is invariant to the level of inflation, so higher rates of inflation reduce the value of this allowance, all else equal. As a consequence, investors in rental housing will likely increase rents by more than the rate of inflation of the general price level to compensate for the lower value of the depreciation allowance.

Although empirical evidence is insufficient to assign a precise relationship between nominal rent and the underlying inflation rate, rents are likely to grow as fast, if not faster, than the rate of inflation of the general price level.

NOI starting values for the seasoned loans can be improved

The process used by OFHEO to "season" loans relies upon indices of rents and vacancies rather than on the actual changes in the rents and vacancies of the properties. This can cause serious measurement error if the changes at the property level are much different

[166] Follain and Ling discuss this issue, review the relevant literature, and provide evidence about its impact in Follain, James R., and David C. Ling, "Another Look at Inflation, Taxes and Tenure Choice," 16(3) *American Real Estate and Urban Economics Association Journal* (1988) at 207-229.

than those generated by the indices. In fact, a recent study indicates that 80 to 95 percent of the variance in the annual growth rate of rents around the national mean at the unit level is explained by fluctuations at the unit level, not variations in the Metropolitan Statistical Area (MSA) average rent growth.[167] Rather than relying on such indices, OFHEO could begin to use more reliable information collected by the Enterprises. Specifically, both Enterprises now collect annual inspection data about each multifamily property as a way of managing the risk of their multifamily portfolios. These data include the current and best estimate of the NOI generated by the specific property.

Recommendations

We offer several recommendations to the issues we discussed above.

Maintain the scenario for vacancies and rents

We support OFHEO's proposed stress scenario for the vacancy rate. It portrays an appropriately stressful economic environment for multifamily mortgages and bears the closest relationship of any element of the multifamily economic environment to the ALMO experience.

The proposed stress test scenario for rent is less closely tied to ALMO than is the proposed vacancy scenario. Judged independently of other aspects of the stress test, the rent scenario should be more severe in the down-rate scenario. Also, the adjustment for inflation in the up-rate scenario should be larger and approximate the increase in the underlying rate of inflation implied by the up-rate scenario. However, specific recommendations to change this element of the stress test for multifamily cannot be made outside of the context of the overall treatment of multifamily mortgages. Specifically, increasing the severity of the down-rate rental price scenario alone is not enough to generate appropriate credit losses for multifamily mortgages with OFHEO's proposed statistical models. Therefore, the solution we suggest to improve the overall stress test for multifamily includes adjustments to the statistical model but no changes to the scenarios for rents and vacancies. Solutions that call for changes to both the statistical model and the scenario for rents are also possible. However, a solution that accepts the statistical model we suggest and a more severe rent scenario would no longer tie risk-based capital requirements to risk for multifamily loans.

Do not update property values and LTV ratios during the stress test

We strongly recommend dropping the property value index from the specification of the stress test economic environment for multifamily and reliance on that index to update property values (and loan to value ratios) during the stress test. Although including an accurate measure of the current loan to value ratio would improve the performance of a multifamily mortgage model, including an imprecise measure yields few benefits. In our view, OFHEO's constructed index is based upon inappropriate methods and data and generates results that are indefensible. The statistical model we propose below relies

[167] Follain, James, David Kogut, and Michael Marschoun, "Analysis of the Time-Series Behavior of Multifamily Rents," Paper presented at the 2000 Meetings of the American Real Estate and Urban Economics Association, Boston.

instead on the DCR, which we believe to be a critical determinant of multifamily mortgage performance.

Use Enterprise inspection data for starting values of NOI for seasoned loans

We recommend that OFHEO not model starting values of NOI for seasoned loans. Both Enterprises devote considerable resources to collecting and analyzing financial information about each property underlying their multifamily mortgage portfolio. Included in what we call the inspection data set is an annual assessment of the NOI generated by each property. These data provide more precise estimates of the starting values of NOI than the methods and indices OFHEO proposed.

C. Mortgage Performance

The risk-based capital standard of the Act requires OFHEO to "reasonably relate" the stress test credit losses — mortgage default rates and severity rates — to the identified benchmark loss experience.[168] In addition, the Act requires OFHEO to determine prepayment experience in the stress period "on the basis of available information, to be most consistent with the stress period."[169] Moreover, the Act requires OFHEO to "take into account appropriate distinctions among types of mortgage products, differences in loan seasoning and any other appropriate factors in developing the stress test."[170]

OFHEO uses statistical models estimated on historical mortgage performance data of the Enterprises to sort out the contribution of various mortgage risk factors and the economic environment on mortgage defaults, prepayments and loss severities. These models are then used to predict prepayments and credit losses in the stress test scenarios defined by the economic conditions of the benchmark. OFHEO explains that it chose to develop statistical models for mortgage performance instead of applying default, prepayment and loss severity rates directly from the benchmark experience for several reasons.[171] First, OFHEO notes that the benchmark loss experience does not include all relevant loan products and risk classes to allow direct application of benchmark loss rates to the Enterprises' current portfolios. In contrast, statistical models estimated on large data sets can differentiate mortgage performance across a wide range of products and still allow the performance of each product to be related to the benchmark experience, by simulating the effect on mortgage performance of the benchmark economic environment, for example. Second, OFHEO points out that statistical models allow one to extrapolate mortgage performance to out-of-sample events — events that have never occurred, such as the sustained adverse interest rate scenarios of the stress tests. Third, OFHEO argues that statistical models are the best way to address the multiple requirements of the Act.

Freddie Mac generally agrees with OFHEO's statistical modeling approach for single-family mortgages. The abundance of data on single-family mortgage performance in falling interest rate environments allows statistical models to adequately quantify the causes of mortgage default and prepayment and accurately predict mortgage performance of the Enterprises current portfolios in the down-rate stress test.[172] Extrapolation of model results to the extreme interest-rate shock of the up-rate stress test, however, should be done with caution given the lack of historical mortgage performance data relating to rising interest rate environments. For a similar reason, we believe that statistical models

[168] The Act § 1361(a)(1).
[169] *Id*. at § 1361(b)(2).
[170] *Id*. at § 1361(b)(1). Single-family and multifamily mortgages are considered different types of mortgage products. *Id*. at § 1361(d)(2). "Seasoning" is defined by the Act to mean the change in a mortgage's loan-to-value ratio over time. *Id*. at § 1361(d)(1).
[171] See NPR2 at 18119.
[172] In addition, calibrating the models to the benchmark loss experience provides a further reality check on model results in a down-rate environment.

for multifamily should inform but not solely determine the risk-based capital requirements for multifamily mortgages. The paucity of precise multifamily data precludes the use of highly structured econometric models that can be successfully deployed in the single-family mortgage area. In sum, the reasonableness of the statistical model results should be evaluated in light of the extreme conditions of the stress test and the out-of-sample nature of the predictions of stress test mortgage behavior.

A statistically based modeling approach together with some reality checks for reasonableness of out-of-sample predictions can produce mortgage behavioral models that reasonably tie capital to risk. Once reached, however, this delicate balance should not be upset by re-estimating the models frequently as new data become available. This is because out-of-sample predictions will not be improved with new data from normal economic environments. In fact, small changes in model coefficients that might reasonably occur with an additional year's worth of data can produce undesirably large changes in capital requirements once model outcomes are extrapolated to the extreme environments of the stress test. In most cases, these changes would reflect no new information on mortgage performance within the extreme scenarios.

The following sections discuss and evaluate the statistical models of default, prepayment and loss severity that OFHEO proposes to predict single-family mortgage performance and multifamily mortgage performance in the stress test. We evaluate how well the proposed models achieve the requirements of the Act, tie capital to risk and are operationally workable and make recommendations based on that analysis.

i. Single Family Mortgage Performance

The stress test simulates the performance of an Enterprise's current mortgage portfolio under extreme interest rate scenarios and the worst historical regional credit loss experience.[173] In order to predict single-family mortgage performance[174] during the stress test OFHEO specifies statistical models[175] for mortgage defaults, loss severity, and prepayment. Rates of default and loss severity are captured by the models through the timing and magnitude of credit losses, given specific loan characteristics and the economic circumstances affecting such loans.[176] Prepayment is a key determinant of net interest income and also affects credit losses through its effects on the timing and rates of default. All three mortgage performance components ultimately affect Enterprise cash flows.

The Act requires that the credit risk component of the risk-based capital stress test include rates of mortgage default and severity.[177] In addition, OFHEO must determine prepayment experience in the stress period "on the basis of available information to be most consistent with the stress period."[178] The term "stress period" in the Act means the ten-year period of the stress test during which an Enterprise simultaneously must withstand severely adverse credit conditions and extreme interest rate movements as specified by the Act.[179]

In developing stress test credit losses, the Act requires OFHEO to identify a historical worst case regional credit loss experience (the benchmark loss experience).[180] OFHEO then must "reasonably relate" the Enterprises' current portfolios to the identified benchmark loss experience.[181] In addition, the Act requires OFHEO to "take into account appropriate distinctions among types of mortgage products, differences in loan seasoning and any other appropriate factors in developing the stress test."[182]

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173 The Act § 1361(a)(1).

174 Mortgage performance is not a term used in the Act. The term is used by OFHEO in NPR2 and its earlier rulemakings to facilitate discussion of rates of default, severity and prepayment. *See, e.g.*, NPR2 at 18117-18.

175 These models are essentially sets of equations specified by OFHEO in NPR2.

176 OFHEO also describes loss severity as the net cost to the Enterprise of a loan default. *See* NPR2 at 18139.

177 The Act §1361(a)(1).

178 *Id*. at § 1361(b)(2).

179 *Id*. at § 1361(a).

180 *Id.* at §1361(a)(1). *See* also *Benchmark Loss Experience.*

181 *Id.*

182 *Id.* at §§ 1361(b)(1) and (d)(1) and (2). The Act defines "type of mortgage product" as "a classification of one or more mortgage products, as established by the [OFHEO] Director, which have similar characteristics …[such as whether the property is multifamily; whether the interest rate is fixed or adjustable; the priority of the lien on the property securing the mortgage; the term of the mortgage; whether the property is owner-occupied or investor-owned; amortization of the unpaid balance and]… any other characteristics of the mortgage, as the Director may determine." *Id.* at (d)(2). The Act defines "seasoning" to mean "the change over time in the ratio of the unpaid principal balance of a mortgage to the value of the property by which such mortgage loan is secured." This is to be determined in accordance

OFHEO's approach has three general characteristics: an explicit link to the stress test economic scenarios, an extensive use of enterprise data, and a specific calibration of their models to the benchmark regime. These characteristics are described below.

Explicit link to stress test scenario: Earlier in our Comment we addressed the specifications in NPR2 for the stress test environment, including proposed specification of the paths of interest rates and house prices over the ten-year stress period. OFHEO proposes to link these stress test scenarios directly to projections of mortgage behavior using detailed statistical models of mortgage performance (default, severity and prepayment).[183] OFHEO uses this detailed modeling approach to relate the ALMO benchmark experience, which was measured only on newly originated loans, to projections of mortgage behavior for seasoned loans and to mortgage products that were missing from the benchmark experience.

Use of Enterprise historical data: OFHEO uses Enterprise data to develop its models of single-family mortgage performance. Enterprise data are used to measure historical relationships among mortgage product attributes, interest rates and house price scenarios, and mortgage behavior. OFHEO estimated its proposed models using performance data on mortgages originated throughout the United States from 1979 to 1993, reflecting exposure years through the end of 1995. The single-family mortgage performance models in NPR2 summarize the relationships between Enterprise default and prepayment rates and the economic scenarios, within the range of actual historical experience. These historical relationships are extrapolated to project mortgage behavior within the extreme economic environments of the stress test.

Calibration to benchmark experience: OFHEO calibrates both the default and loss severity specifications to ALMO. Calibration assures that, given the interest rate and house price experience of ALMO, NPR2 models would reproduce default and loss severity experience of ALMO.

We evaluated OFHEO's proposed models in view of requirements of the Act, our need for any models to be operationally workable and whether the models tie capital to risk. In this regard, we believe the single family mortgage performance models must accomplish the following objectives:

- "Reasonably relate" the rates of default and severity in the benchmark experience to the current portfolio of each Enterprise.
- Respond appropriately to changes in the economic environment that affect credit loss or prepayment.
- Make appropriate distinctions among mortgage products.

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with an index that meets certain statutory requirements including public availability and regular use by the Federal Government. *Id*. at (d)(1).

[183] NPR2 § 3.5.1 and 3.5.2. *See also* NPR2 at 18119-25 (in which OFHEO explains its choice to use statistical models over another approach of applying a table of historical default, prepayment and severity rates).

In describing its statistical modeling approach, OFHEO stated similar objectives.[184] Overall, we believe the general approach taken by OFHEO is reasonable and with certain adjustments could be successfully implemented.

In this section, we separately describe and evaluate each of OFHEO's proposed single-family mortgage performance models. We also recommend adjustments we believe will enable these models to accomplish the objectives set forth above. In so doing, we emphasize the need for the adjustments to the benchmark data that we recommend in *Benchmark Loss Experience* and in our response to OFHEO's initial Notice of Proposed Rulemaking. These benchmark data adjustments are integrally related to our comments below concerning calibration of the proposed single family mortgage performance models.

[184] OFHEO supports its use of statistical models, stating that such models, "can provide valid outcomes when data inputs occur in different combinations from those observed in the available Enterprise historical data." In addition, OFHEO states that statistical models "allow the stress test to make reasonable extrapolations to out-of-sample events, such as the sustained adverse interest rates scenarios of the stress test." Moreover, OFHEO states that the statistical models are "the best approach for addressing the multiple requirements of the Act and the dynamic nature of economic changes in the stress test period." NPR2 at 18119-20 and 18139.

a. Single-Family Default Model

OFHEO proposes to use a default model estimated from historical data to specify mortgage default rates through the stress period. OFHEO specified its model using Enterprise mortgage performance data to measure historical relationships among economic scenarios, mortgage product attributes and mortgage default. These broad historical relationships are calibrated to fit the benchmark experience and are then extrapolated into the severe economic scenarios of the stress test. OFHEO's proposed model and approach are more successful in specifying the down-rate scenario than the up-rate scenario, because there are no good approximations of the up-rate test in historical data. Freddie Mac recommends that OFHEO revise its benchmark calibrations to adjust for inaccurate or missing data in the benchmark region. In addition, we recommend that OFHEO adjust the stress test application of its default model to reduce variation in capital requirements that has no bearing to risk. We also recommend that OFHEO incorporate several refinements into its specification of mortgage product risk to better distinguish risks.

Proposal

OFHEO proposed a joint statistical model for defaults and prepayments as described in *Exhibit 2*.[185] The default model and prepayment model are estimated jointly, and also applied jointly in the stress test. In this section, we focus exclusively on the default specification.[186]

[185] *See also* NPR2 §§ 3.5.1 and 3.5.2.

[186] As noted previously, OFHEO's proposed model is a joint statistical model of default and prepayment in the sense that default model predictions affect prepayment model predictions and vice versa. The parameters that determine prepayment (the coefficients in the γ vector) enter the denominator of the default equation. Similarly, parameters that determine default (the coefficients in the β vector) enter the denominator of the prepayment equation. This joint estimation ensures that the probability that a loan will default, plus the probability that a loan will prepay, plus the probability that it will do neither, is equal to one.

Single-Family Default and Prepayment Models
Functional Form

$Def_q = [\exp\{X_q\beta\}] / [1 + \exp\{X_q\beta\} + \exp\{X_q\gamma\}]$

$Prep_q = [\exp\{X_q\gamma\}] / [1 + \exp\{X_q\beta\} + \exp\{X_q\gamma\}]$

where:

Def_q = quarterly, conditional default rate in stress test period q

$Prep_q$ = quarterly, conditional prepayment rate in stress test period q

X_q = a vector of variables describing a pool of mortgages and features of the economic environment at period q.

β = a vector of parameters specifying how mortgage defaults are affected by the variables included in X_q.

γ = a vector of parameters specifying how mortgage prepayment variables are affected by variables included in X_q.

exp[.] = the exponential function.

Exhibit 2: Single-Family Default and Prepayment Models

Determinants of conditional default rates

A conditional rate of default refers to the portion of the outstanding balance in the loan group that defaults during a given period of time. In the default model equations in *Exhibit 2*, the variables in the "X" vector determine the conditional default rates in each period of the stress test. NPR2 describes a set of characteristics to be included in this vector that affect the level and timing of mortgage default.[187] In a given month, the following factors determine the default rate for single-family loans:

- *Loan-to-value (LTV) ratio* at the time the mortgage was originated. OFHEO groups mortgages into six different categories, based on original LTV ratio.[188]
- *Borrower equity*, which is calculated from the mortgages' original LTV, amortization of the principal balance since origination, and house price changes since origination. Borrower equity is captured through a variable (PNEQ) that measures the probability that a loan from a given product, region, and origination year would have negative equity at any given date in the stress test.[189]

[187] NPR2 at 18174.
[188] *Id*. at 18092, 18133 and 18179.
[189] *Id*. § 3.5.2.3.2.3. As specified by OFHEO, the PNEQ variable requires creating a time series of property values and amortizing loans to create updated LTV ratios throughout the stress period. The updated LTV ratios are used, along with the standard deviations of house price growth paths to compute probabilities of negative equity.

- *Mortgage age,* defined at any point in the mortgage's life by the number of quarters since the mortgage was originated. The variable "Age" is the number of quarters since origination; the square of the Age variable is also included as a separate variable in the "X" vector.[190]
- *Changes in interest rates* are captured through a "burnout" variable. In any given quarter, a mortgage is defined to be "burned out" if interest rates in the recent history have been sufficiently below the mortgage's coupon rate.[191]
- *Occupancy status of the borrower* is a categorical variable that distinguishes investor-owners from occupant-owners.[192]

OFHEO uses a statistical analysis of the relationship between these explanatory variables and historical default rates to estimate the numerical weights (coefficients of the β vector) associated with each variable. Quarterly default rates throughout the stress test period are calculated through this equation. Quarterly default rates are then converted to monthly conditional default rates. These rates are used by the cash flow component of the stress test to calculate monthly principal reductions resulting from defaults and to calculate default losses for each month in the ten-year stress period.[193]

In its model, OFHEO specifies separate default equations for three product categories:[194]

- Fixed-rate 30-year fully amortizing mortgages.
- Adjustable-rate mortgages.
- Other mortgages (including mortgages with 20 or 15-year amortization schedules, and mortgages with a "balloon" repayment prior to the complete amortization).[195]

The conceptual underpinnings and empirical specifications are identical for all three of the above specifications.

Calibration of the default model to the benchmark

After estimating its proposed default model, OFHEO made adjustments to the model to calibrate projected stress test losses to ALMO.[196] Mechanically, the calibration is

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190 NPR2 § 3.5.2.3.2.1. *See also* NPR2 at 18132.

191 *Id*. at. § 3.5.2.3.2.4. *See also* NPR2 at 18134. Burnout is a binary variable. The proposed regulation provides that burnout variable "indicates whether there have been at least two quarters of 'significant refinance opportunities' among the previous 8 quarters of loan life." It further provides that a mortgage undergoes a significant refinance opportunity "when its coupon is at least two percentage points above the then-prevailing rate on 30-year mortgages."

192 *Id*. at. § 3.5.2.3.2.5. OFHEO rejected the use of other variables, such as origination year, unemployment rates, mortgage premium value and credit scores, because it believed these were not required by the Act and would increase the complexity of the model without corresponding benefit. *Id*. at 18135.

193 *Id*. at § 3.5.2.1 at 18241.

194 *Id*. at 18176.

195 *Id*. at § 3.5.2.3.2.8 and Table 3-17.

196 *Id*. at § 3.5.2.3.2.9.

accomplished by adding a new β coefficient to the coefficients in *Exhibit 2.*[197] OFHEO applied this "calibration constant" to increase the conditional default rates to reflect the actual ALMO default experience.[198]

OFHEO estimated the calibration constant in three steps. First, all benchmark loans were assigned the same historical house-price experience, specifically the ten-year sequence of appreciation rates from the OFHEO HPI for the West South Central Census Division beginning in the first quarter of 1984.[199] Second, using the default equations that it estimated on a broader historical data sample, OFHEO projected the ten-year experience of loans comprising the benchmark in order to compute the ten-year cumulative default rate. This cumulative default rate was measured in the same manner for the actual benchmark experience in NPR1.

Finally, OFHEO calibrated the default model to assure that the projected cumulative default rates would match the actual cumulative default rates computed for the ALMO benchmark. The calibration adjustment assures that the default model would reproduce the ALMO default experience.[200] The calibration adjustment is equivalent to an increase in default rates of about 15 percent beyond the projections of OFHEO's default model within the stress test economic scenario.

Discussion and Recommendations

In its comments on the Advanced Notice of Proposed Rulemaking (ANPR),[201] Freddie Mac recommended against the use of statistical models.[202] At that time, Freddie Mac suggested that credit loss projections can be "reasonably related" to the benchmark, achieve appropriate responsiveness to the economic environment, and create appropriate distinctions across mortgage products through simpler specifications.[203]

Based on our subsequent analysis of NPR2, we now conclude that the statistical modeling approach OFHEO has chosen, coupled with calibration of the model to the benchmark experience, could meet the criteria for a successful stress test implementation. However, Freddie Mac has several specific concerns about the proposed default model.

In particular, we are concerned about OFHEO's quantification of the benchmark loss experience because of missing data, incorrect weighting of data and other problems with the benchmark data set.[204] In addition, we believe that the proposed default model is not appropriately responsive to changes in interest rates. Finally, we believe that OFHEO's

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[197] *Id.*
[198] *Id.* and NPR2 at 18143, n.133.
[199] OFHEO acknowledges that the West South Central Census Division does not exactly match the ALMO benchmark; however the actual ten-year house price experience of the West South Central Division and the ALMO benchmark for 1984-1993 are very similar.
[200] *Id.* at § 3.5.2.3.2.9 and at 18143. OFHEO proposes to insert a calibration adjustment of .146 to the exponential function in each default equation.
[201] Fed. Reg. 7468 (Feb. 8, 1995)
[202] *See* Freddie Mac's Response to OFHEO's ANPR (dated May 9, 1995) at 48-58.
[203] *Id.*
[204] *See Benchmark Loss Experience*.

proposed models fail to appropriately distinguish risks among certain mortgage products. We believe these concerns can be addressed by OFHEO without re-estimation of the models.

Models must reasonably relate benchmark losses to current portfolio

Freddie Mac agrees with OFHEO that there are benefits in estimating behavioral models for default on a large amount of historical Enterprise data. Moreover, we concur that OFHEO can reasonably relate the statutory benchmark experience to the starting position portfolios of the Enterprises by calibrating the models. However, as discussed in the *Benchmark Loss Experience* section and in our NPR1 Comment, the ALMO benchmark contains missing and flawed data, as well as incorrect weighting of loans. These data problems, if not properly addressed, result in substantially higher stress-test credit loss projections than warranted for the selected benchmark. We believe that OFHEO does not need to select another benchmark to address these issues.

Our analysis indicates that OFHEO's calibrated default model over-predicts default rates of benchmark loans with high LTV ratios, and under-predicts default rates of lower LTV loans. *Table 5* shows this relationship across LTV categories. The table indicates that the proposed default model creates a distorted view of risk across the range of LTVs.

	Cumulative Default Rates	
Original LTV	**Predicted**[205]	**Actual**
60 and Below	0.34%	2.22%
61 to 70	2.81%	3.54%
71 to 75	7.69%	7.87%
76 to 80	11.82%	9.39%
81 to 85	19.67%	12.02%
86 to 90	24.10%	17.74%
Greater Than 90	31.58%	26.39%

Table 5: Comparison of Model Predicted Default Rates to Benchmark Default Rates by LTV

We recommend two changes in OFHEO's calibration methodology that we believe strengthen the relationship between the default model and the benchmark, and create a stronger relationship between capital and risk. First, OFHEO should calibrate the default model only after correcting benchmark data errors to achieve appropriate measures of the benchmark experience.[206] These adjustments will correct biases from missing Fannie Mae data and eliminate the effects of a peculiar distribution of loans among the four states. Both of these adjustments are documented in a report by the Research Triangle Institute (the RTI report).[207]

[205] The "Predicted" values in this table were generated by simulating the behavior of seven loans with LTV ratios of 60, 70, 75, 80, 85, 90, and 95. The loans were assumed to have a note rate of 13 percent

Second, OFHEO should calibrate default predictions to the corrected benchmark experience within specific LTV categories. Once the benchmark loans are corrected for data biases, OFHEO should calibrate the default model to reproduce default rates of the LTV categories.[208]

Models do not appropriately capture the relationship to interest rates

Freddie Mac believes that OFHEO's proposed default models do not capture the appropriate sensitivity of defaults to the level of interest rates of the stress test. The primary substantive result of this deficiency is an overstatement of credit losses in the up-rate scenario. Within certain ranges of interest rates, NPR2's default specification also has the potential to be extremely sensitive to small movements in interest rates, which will lead to excessive volatility within those ranges.

Historically, interest rates and conditional default rates have exhibited an inverse relationship. Periods of falling interest rates typically lead to high conditional default rates, while periods of rising rates typically lead to low conditional default rates. In published research, OFHEO analysts Yongheng Deng and Charles A. Calhoun[209] found evidence of this relationship using the same Enterprise data that OFHEO used to build their statistical models. This inverse relationship must be captured by the stress test implementation.

Chart 13 shows the relationship between conditional default rates and interest rates in NPR2. OFHEO's specification has a "burnout" variable that creates an abrupt change in conditional default rates when interest rates have fallen by two percent (200 basis points). The bars labeled "Burnout" on this graph show the portion of the conditional default rate related to burnout. When interest rates are above this range, NPR2's conditional default rates are constant — there is no distinction between mortgages that are one percentage point above current rates and those that are five percentage points below current rates.

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and were exposed to the interest rates and West South Central Census division house prices prevailing during the 1984-1993 period. "Actual" values do not reflect our recommended benchmark data correction for bias due to missing values.

[206] Freddie Mac's recommended data adjustments are discussed in detail in *Benchmark Loss Experience* and in Freddie Mac's NPR1 Comment.

[207] Paul P. Biemer, Ph.D., Research Triangle Institute "Comments on the OFHEO NPR Regarding the Estimation of Default, Severity and Loss Rates" (1996) at 4-12 and Table 1 (attached to Freddie Mac's NPR1 Comment as an appendix).

[208] We recommend three LTV categories as a way of avoiding complexity. A greater number of categories would add little refinement to the measurement of risk.

[209] Yongheng Deng and Charles A. Calhoun, "A Dynamic Analysis of Adjustable - and Fixed-Rate Mortgage Termination," December 1996. (Paper presented at the AREUEA Annual Meetings, New Orleans, LA January 3-6, 1997.)

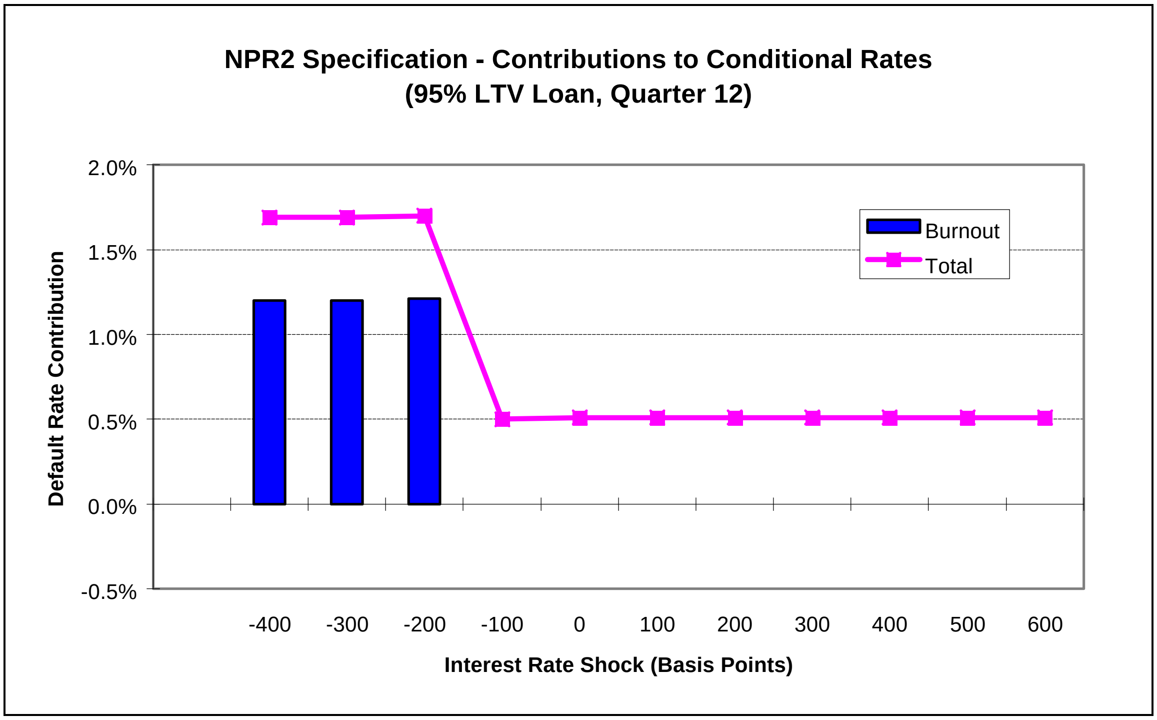

Chart 13: Conditional Default Rates and the Burnout Contribution, NPR2 Specification

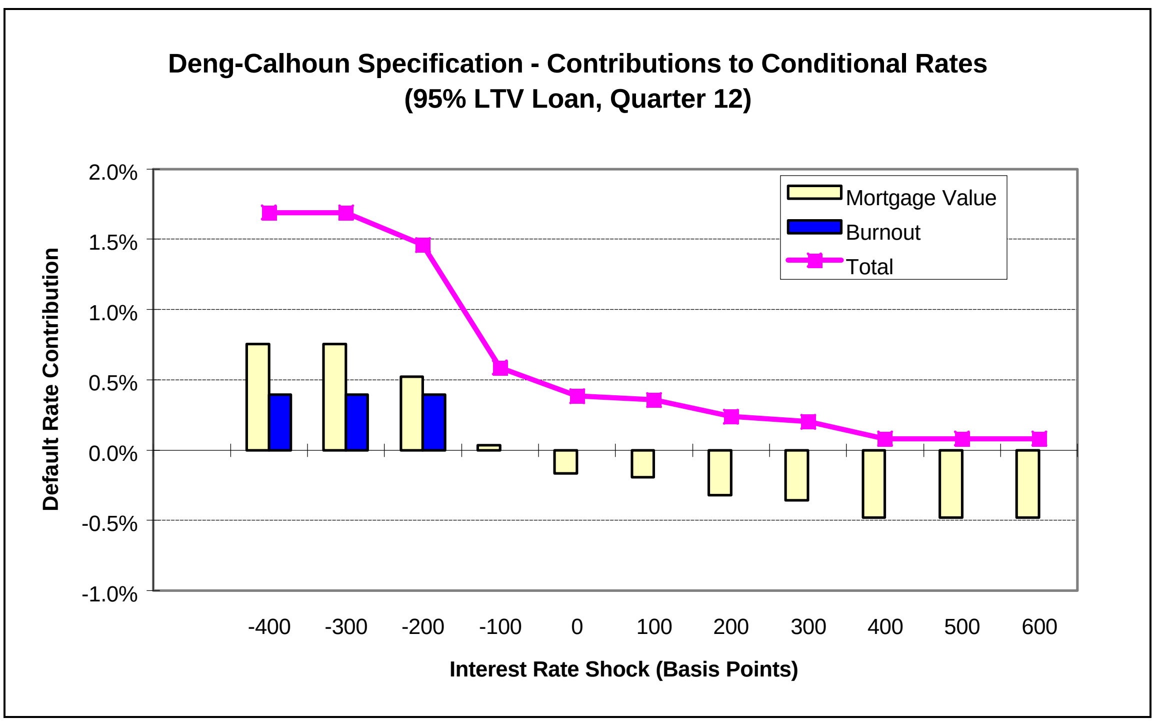

Chart 14: Conditional Default Rates and Burnout and Mortgage Value Contributions, Deng-Calhoun Specification

Chart 14 shows the corresponding relationship in the Deng and Calhoun paper. The graph shows conditional default rates falling continuously as rates rise, resulting in much lower defaults in an up-rate stress test.

There are two reasons for the inverse relationship between interest rates and default. The first can be described as the "burn-out" or "selection" effect. As mortgage rates fall, borrowers have a strong incentive to refinance their mortgages. As these borrowers prepay, a large proportion of remaining borrowers are those who could not qualify for refinancing because of their weak equity position, poor credit record, or due to unemployment. Loans to borrowers who fail to prepay given sufficient refinancing incentive are often described as "burned out;" these borrowers exhibit higher propensity to default and lower propensity to prepay. In NPR2, the conditional default rates of burned-out loans are more than three times greater than other loans.

Second, there is a "mortgage-value" effect. When interest rates rise, borrowers have a greater incentive to keep their existing mortgage, even when faced with events that could normally trigger default, such as declining house prices Conversely, as interest rates fall, borrowers who do not or cannot prepay have an above-market rate. Their weak mortgage financing position gives these borrowers a greater incentive to default.[210]

The Deng and Calhoun model captures both burnout and mortgage value simultaneously. As the chart suggests, combining burnout and mortgage-value effects creates a comparatively smooth relationship across the range of interest rate scenarios. In contrast, NPR2 has only a burnout variable, which means that the effect of interest rates has a very different character from the Deng and Calhoun model. Specifically, the Deng and Calhoun projections for up-rate stress test defaults of 95 percent LTV loans are only about 40 percent of NPR2 projections. Empirical evidence could resolve these model differences, although limitations in available data create significant challenges for the up-rate stress test.

Data limitations

The up-rate scenario projects interest rate increases of unprecedented size and duration. Therefore, up-rate stress test default behavior is necessarily an out-of-sample extrapolation of models that have been estimated on data over a period characterized by declining interest rates.

These data deficiencies are described in *Chart 15*, which approximates the distribution of interest rate changes in OFHEO's estimation sample. In this chart, a ratio greater than one implies rising interest rates; a ratio less than one implies falling interest rates. As the

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[210] Note that in the down-rate scenarios, the remaining borrowers are more likely to be experiencing financial difficulty (due to the burnout/selection process) precisely when they have a great incentive to default (due to the mortgage value effect). Both burnout and mortgage value effects can increase conditional default rates in declining rate scenarios, and it can be difficult to separate or distinguish these effects through empirical research. Default equations in NPR2 capture a burnout effect directly, but the burnout variable also indirectly captures mortgage value effects. The burnout specification in NPR2 should actually capture both burnout and mortgage value effects for borrowers with above-market rates. Therefore, the tripling of default rates for burned-out loans in NPR2 is likely the combined effect of burnout and mortgage value effects.

chart makes clear, most mortgages in OFHEO's estimation sample experienced falling interest rates. In contrast, there are far fewer examples of rising interest rates, and virtually no mortgages experienced shocks approximating the up-rate scenario.[211]

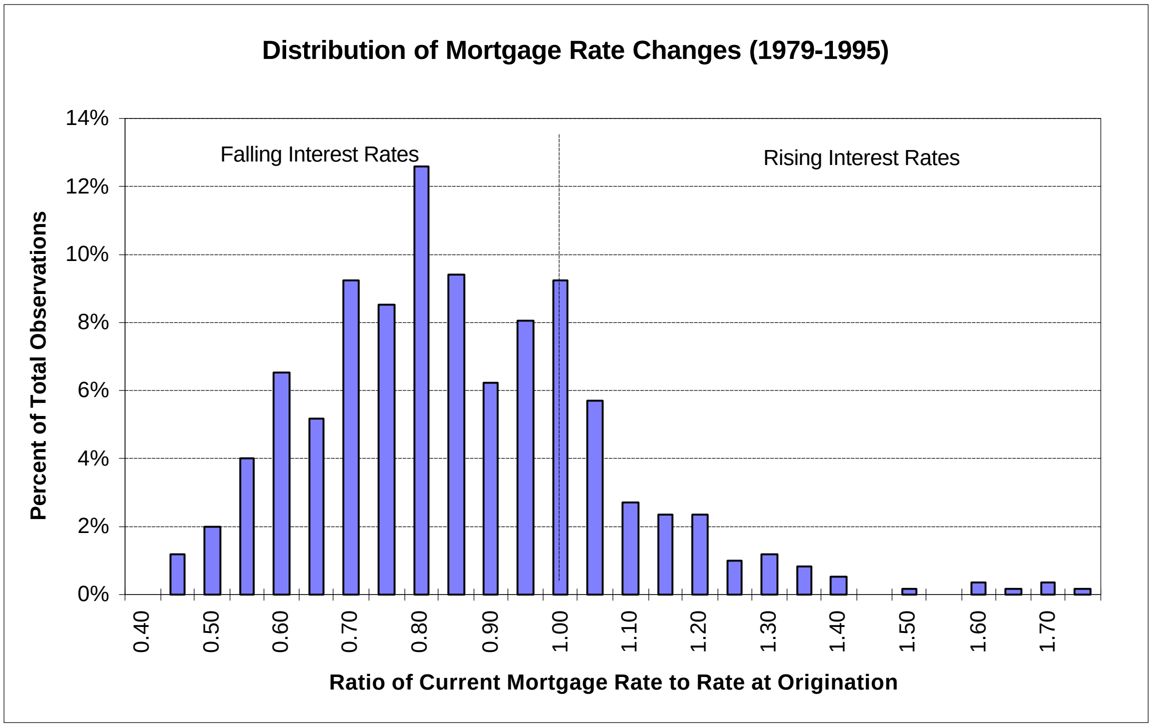

Chart 15: Distribution of Mortgage Rate Changes 1979-1995

The scarcity of rising rate data in OFHEO's estimation sample explains, in part, why up-rate default rates in the Deng and Calhoun specification can diverge so greatly from those of NPR2. When rates have fallen, both burnout and mortgage value effects will work to increase conditional default rates, and it is difficult to disentangle their separate effects.[212] Over the rising-rate range, effects of mortgage value could be separated from burnout, but there are relatively few observations. Therefore, the two specifications both can fit the data relatively well within the sample, while exhibiting strikingly different out-of-sample projections (as in the up-rate scenario).

Two primary conclusions arise from considering the historical behavior of interest rates over the 1979-1995 sample period. First, we believe OFHEO's statistical modeling of

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[211] Source: Quarterly averages of monthly 30-year mortgage rates in the Freddie Mac Primary Mortgage Market Survey. Based on this survey, Freddie Mac estimates that the maximum mortgage rate increase is 70.4 percent experienced by a mortgage originated in the first quarter of 1979 and observed through the fourth quarter of 1981. The data set used by OFHEO to estimate mortgage default and prepayment behavior includes mortgages originated during the years 1979-1993 which are observed through the end of 1995. Interest rates peaked in the fall of 1981,with the result that most of the estimation period constitutes a declining-rate environment.

[212] In the NPR2 specification, the increase in conditional default rates caused by falling rates is attributed exclusively to burnout. In Deng and Calhoun's specification, the burnout coefficient is smaller because some of the increase is attributed to mortgage value effects.

Enterprise data, coupled with a benchmark calibration, can be a successful approach in the down-rate scenario. There are abundant data to describe single-family default behavior in a declining rate scenario like the down-rate stress test — the benchmark experience itself is a reasonable approximation of such a scenario. Both the benchmark experience and the broader set of empirical evidence can be used to support a reasonable down-rate specification.

Second, the data provide far less information to specify the up-rate stress test. Historical evidence does not contain a definitive answer to the question of up-rate stress test defaults. The mortgage market value effects in Deng and Calhoun have a compelling logic, which would have very different implications from NPR2. Still, available data alone are probably not strong enough to distinguish definitively between the markedly different implications of the Deng and Calhoun model and the NPR2 specification in the up-rate stress test.

Freddie Mac believes that there are good arguments for reducing NPR2's projections of credit losses in the up-rate test. Arguments for a mortgage value effect are both compelling and consistent with the empirical analysis of Deng and Calhoun. However, our analysis also indicates that historical mortgage default data cannot resolve this question definitively — precise measurement of the mortgage value effect is very difficult for the extreme scenario of the up-rate test. In ignoring the mortgage value effect, we believe that OFHEO's projections of up-rate defaults are very conservative.

Burnout variable induces significant volatility

As currently specified, the discontinuous nature of the burnout variable in the default model (*i.e.*, it is equal to either zero or one) and the fact that it can be set to one by as few as two quarters of low interest rates[213] induces significant variability in capital requirement. This variability can hinder the operational workability of the stress test.

The burnout variable can cause default rates to triple after the eighth quarter of the down-rate scenario for a new loan. In addition, the capital requirement under the down-rate scenario can triple for a discount loan that becomes less of a discount following an interest rate rally in the market.[214] Moreover, the capital requirement could increase by an excessive amount following even a brief (two-quarter long) period of lower interest rates which would make a high portion of the loans in the portfolio "burned out."[215]

Recommendations on relating defaults and interest rates

Freddie Mac recommends that OFHEO re-specify the stress test implementation of the burnout variable to avoid excessive variability. OFHEO should adjust the application of the burnout variable to assure that the transition to burned-out status is less abrupt. The

[213] NPR2 § 3.5.2.3.2.4.

[214] Given the nature of the down-rate stress test, it is possible for a mortgage with a sufficiently steep discount at the beginning of the stress test to never exhibit burnout. This same mortgage, following a market rally in rates that would lower interest rates during the stress test, can suddenly be subject to burnout for all but the first eight quarters of the scenario resulting in expected credit losses that can be triple what they were before.

[215] The last quarter of 1995 together with the first quarter of 1996 was such a period.

specification can be changed to phase-in the burnout effects over a range of interest rates and over a longer period, thereby eliminating the abrupt transition that creates potential variability in capital standards. These changes will create a credit loss specification that avoids the excessive variability of capital requirements that would arise from NPR2.

Models should make appropriate distinctions among mortgage products

Freddie Mac analysis indicates that a number of mortgage products are sufficiently different from standard products to warrant changes in NPR2. In the sections below, we discuss specific mortgage product characteristics and recommend alternatives to the treatment described for these characteristics in NPR2.

Investor loans

The Act requires OFHEO to take into account differences in mortgage performance by occupancy status[216] and OFHEO has selected occupancy status as a variable in its default equations.[217] OFHEO's model creates a reasonable structure to deal with differences in default behavior of loans on non-owner occupied (investor) property. However, the existing multiplier in the NPR2 model produces defaults that are higher than Freddie Mac's historical experience indicates.

Furthermore, in their application of the default equation, OFHEO specifies that investor properties compose the identical fraction of every mortgage pool. In particular, NPR2 specifies that investor loans have the same loan-to-value distribution as owner-occupied properties; in fact, investor loans have substantially lower loan-to-value ratios.[218]

We recommend that OFHEO assign investor properties a more appropriate multiplier and allocate investor properties to their proper loan-to-value categories.

Other mortgage products

In addition to investor properties, OFHEO should also treat condominium loans and loans on 2-4 unit properties separately. We believe that condominiums and 2-4 unit properties have risks comparable to non-owner occupied (investor) loans. Therefore, we recommend that OFHEO treat these property types as it does investor properties. As the investor loans, we recommend that these loans should also be allocated to their proper loan-to-value categories.

Seasoned purchases

When Freddie Mac evaluates loans for purchase that are over 12 months old, we have information that is not observed on a new-unseasoned-loan. Freddie Mac carefully screens the seasoned loans to exclude those expected to have substandard performance.

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[216] The Act § 1361(d)(2)(E). *See* also NPR2 § 3.5.2.3.2.5.

[217] *Id.* at 18133.

[218] As of the third quarter of 1999, only 0.2 percent of Freddie Mac's investor properties had initial LTV ratios over 90 percent. In contrast, 10.5 percent of the total portfolio had initial LTV ratios in excess of 90 percent. In addition, only 2.9 percent of the investor properties had LTVs greater than 80 and less than or equal to 90 percent, compared to 14.4 percent of the total portfolio having initial LTVs in that range. Thus, OFHEO's assumption that all LTV groups have the same portion of investor properties misrepresents risk.

This reduction in risk is not reflected in OFHEO's approach to seasoned loans. OFHEO's default model does not distinguish seasoned from new loans — it projects the same default behavior for seasoned purchases as it does for new otherwise identical new purchases and, thus, does not tie capital properly to risk.

Our analysis suggests that OFHEO should identify seasoned purchases as a separate category and assign default costs 30 percent lower than a new purchase of the same characteristics.

Balloon mortgages

In NPR2, the monthly payment for balloon mortgages is calculated using the origination term instead of the amortization term.[219] This error leads to incorrect default coefficients.

We recommend that OFHEO use the default projections for fixed-rate 30-year product when projecting default behavior of balloon mortgages. In this way, the error can be corrected without resorting to a complete re-specification or re-estimation of the default equations.

Models overestimate the risk of high LTV loans

The proposed default model projects disproportionately high default rates on high LTV mortgages. One way to see this result is to review the differences between the benchmark default predictions of NPR2 and the corresponding actual defaults (*Table 5*). The NPR2 specification over-predicted default rates for high LTV benchmark mortgages, and under-predicted default rates on low LTV benchmark mortgages.

In the benchmark calibration section, we recommended that OFHEO apply their NPR2 calibration method within LTV groups, rather than across the entire range of LTVs. We believe that this calibration adjustment will more closely tie capital to the benchmark experience, and thus be more consistent with the legislation. We also believe that our recommendation benchmark calibration adjustment will better tie capital to risk by specifying default rates more correctly across the range of LTV ratios.

Exclusion of credit scores is appropriate

NPR2 projects stress test credit losses for mortgages using models based on mortgages purchased by both Enterprises. In recent years, the mortgage industry has improved risk measurement and management by incorporating credit scores in underwriting and risk assessment of mortgage loans. OFHEO chose not to incorporate these scores in their mortgage behavioral models. Freddie Mac believes that OFHEO's choice is appropriate at the current time.

The primary motivation for including credit scores or other measures of mortgage credit risk is to assure that capital is tied to risk. If the composition of borrower credit scores shifts, mortgage default rates could rise or fall with no change in stress test capital standards. Although credit scores were not collected for most of mortgage purchases in the 1980's, our current underwriting standards exceed the standards met by Enterprise loans in OFHEO's estimation sample. For this reason, we believe that using the

[219] NPR2 at 18181.

benchmark experience and 1979-1993 origination data to assess credit loss behavior gives OFHEO a conservative assessment of Enterprise mortgage credit risk.

Purchases of mortgages that fall outside these standards are a small portion of Freddie Mac's total mortgage portfolio. OFHEO should monitor the enterprises' composition of mortgage credit scores to assure that their default projections continue to reflect the credit quality of the enterprise mortgages. At this time, Freddie Mac recommends no change to incorporate credit scores. If OFHEO were to increase the capital required for low credit scores then capital required for higher credit scores should be reduced accordingly to achieve the same average required capital.

Simultaneous origination of first and second lien

Mortgage lenders sometimes originate a first-lien and second-lien mortgage simultaneously. A common example is an "80-10-10" mortgage, in which the first mortgage's principal is 80 percent of the property value and the second mortgage's principal is ten percent of the property value. The 80 LTV, first-lien mortgage has the appearance of a standard 80 LTV mortgage. However, the borrower has a total LTV of 90 percent, so the existence of the second mortgage can increase the default rate on the first-lien beyond that of other 80 LTV mortgages. In that sense, the first lien portion of an 80-10-10 mortgage resembles a first-lien mortgage where the borrower has obtained a second-lien mortgage after origination. In either case, Freddie Mac can take credit risk on the first-lien mortgage without knowledge of the second loan.

OFHEO does not address these mortgage products directly in their proposal. In NPR2, the existence of a second lien has no bearing on the credit risk assessment of the first-lien mortgage. Given current industry data practices, there is no reliable way to distinguish an 80-10-10 mortgage from other 80 LTV mortgages. Therefore, a differential credit loss specification for these mortgages could not be implemented within the stress test.

We also note that second-lien mortgages are not new to the mortgage industry. Variations on the 80-10-10 mortgage were almost certainly present in the benchmark experience, as well as in the broader Enterprise data in the estimation sample. The default behavior of comparable mortgages is therefore already embedded in Enterprise loss data. As with credit scores or other risk attributes not captured explicitly in NPR2, changes in the portfolio representation of 80-10-10 mortgages could increase or decrease risk without a corresponding change in capital. Freddie Mac believes that the overall Enterprises' underwriting standards have improved since the benchmark period so that any increases in credit risk from 80-10-10 mortgages are offset by improvements in credit scores and other risk factors.

b. Single-Family Loss Severity Model

Loss severity is the net cost to an Enterprise of a defaulting loan. OFHEO proposes a multi-faceted specification of loss severity designed to capture several components of loss given mortgage default.[220] A loss-on-principal component is estimated through a statistical model, which is calibrated to the benchmark loss experience through an additive adjustment. OFHEO specifies other components of loss severity through long-run historical averages. All components of loss severity are subjected to present value calculations, based on the time sequence of the cash inflows and outflows in mortgage default. Based on our analysis, Freddie Mac believes the severity model specification is unnecessarily complicated and could produce unpredictable results. Freddie Mac recommends that OFHEO simplify the specification to distinguish a limited number of risk categories and correct the benchmark data deficiencies prior to the calibration of loss severity to ALMO.

Proposal

Description of the loss severity model

When a default occurs, Freddie Mac pays the entire principal of the defaulting mortgage to its security investors. Eventually, this loss is offset partially by proceeds from the sale of the underlying property. OFHEO describes the difference between the principal and the proceeds from the property sale as the "uncovered principal" component of loss severity. Through the process of managing defaulted loans, Freddie Mac incurs other expenses, including transaction costs of foreclosure, costs of property disposition, and asset funding costs throughout the process.[221] OFHEO develops cash-flow discounting rules to translate all of these cost elements to a single point on a time-line that runs from borrower default to ultimate disposition of the property. OFHEO specifies the length of time between various events, either through standard industry practices or based on time-lines measured in the benchmark. In addition to adjusting for the time-value of money, these discounting adjustments capture the funding costs of non-earning assets.[222]

Calculating the uncovered principal in loss severity

A major component of loss severity is the difference between the loss of principal on the mortgage and the dollar amount recovered from the sale of the associated property. OFHEO describes this loss as the "uncovered portion of UPB."[223] This portion of loss severity depends primarily on value received from ultimate sale of the property. In turn, property value depends on house price changes since the mortgage's origination.

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[220] *Id*. at § 3.5.3; *Id.* at 18094; 18139-40.
[221] *Id*. at 18139-41.
[222] *Id*. at 18139-40 and 18188-92. The term "funding costs on non-earning assets" originates from the fact that normally the Enterprise have a non-earning asset called "Real Estate Owned" which captures the REO inventory and needs to be funded. In the OFHEO stress test, OFHEO chose to model these funding costs by discounting the various loss severity elements when calculating loss severity without carrying the REO related asset on the balance sheet.
[223] *Id*. at 18258.

In its model, OFHEO proposes a specification in which the uncovered portion of principal is determined partially by a variable (the "z-score"). The z-score depends on the average house-price appreciation experienced by the property up to the last mortgage payment, as well as the amount of projected amortization for the mortgage and the volatility of house-price appreciation. For any given property, the z-score measures how much that property would have deviated from its regional average path to have no equity at the point that it defaulted. A loan with a high z-score would need to be well below its regional average to have reached negative equity. Loans with higher z-scores have lower original LTVs or favorable house price scenarios, and this specification projects that they will also have lower property value losses than loans with those with low or negative z-scores.

The effect of the z-score on uncovered principal losses is modeled explicitly from historical data through an exponential function.[224] Depending on the z-score, the uncovered principal loss component ranges from a gain of about three percent of principal to a loss of about 36 percent of principal.

Transactions costs component of loss severity

OFHEO proposes that foreclosure-related transaction costs be set to 5.0 percent of the defaulting principal balance. REO holding and disposition expenses are a separate component of loss severity, which include expenses of maintaining and selling foreclosed properties prior to their disposition. OFHEO calculates these components to be 13.7 percent of the principal amount. These estimates are based on OFHEO's analysis of Enterprise historical severity data, reflecting national averages over the history of the Enterprises. OFHEO did not calibrate the transaction cost component of the severity specification to ALMO.

Timing differences and the asset funding cost component of loss severity

To account for timing differences, OFHEO proposes discounting rules to adjust the various components of loss severity. In the stress test, all loss-severity related cash flows are discounted back to the specific quarter of the stress test when default occurred. There are three events on the time-line for the asset funding cost.

The first is when an Enterprise pays off principal to investors. OFHEO proposes to assume that the principal payment loss is recognized on that date, and that cash flow be discounted for a period of four months at the stress-test rate of interest.[225]

The second event is when foreclosure occurs and foreclosure expenses are incurred. OFHEO proposes to treat all transactions costs associated with foreclosure expenses as if they were incurred on the foreclosure date, and to determine the timing of these cash flows by using the average experience of the benchmark region. In the benchmark, OFHEO measured the average time from default to foreclosure as 13 months.

The third event is the disposition of the property – when property sales proceeds are received, and the associated property disposition expenses are assumed to be paid.[226]

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[224] *Id*. at 18257.

[225] For a mortgage included in a Freddie Mac Mortgage Participation Certificate (PC), the Enterprise pays investors their principal balance at the time a mortgage is about four months delinquent.

OFHEO estimated that the average time from foreclosure to property disposition was an additional seven months beyond the 13 months from default to foreclosure.[227] Therefore, property recovery value and property disposition expenses are discounted for a total of 20 months.

Calibration of the loss severity specification to the benchmark

For the loss severity property loss component, OFHEO estimated a calibration constant comparable to the default model calibration. The proposed severity calibration is of an "add-on" to the estimate derived by the severity model. The uncovered principal loss component is calibrated to the benchmark. In this calibration, OFHEO proposes to add 10.34 percent to the principal loss component. After this calibration, the range of uncovered principal is between seven percent and 46 percent across z-scores.

For foreclosure expenses and expenses associated with property disposition, OFHEO chose to use national averages, rather than tying these to ALMO. OFHEO applies the severity specification in conjunction with the projected default rates to the Enterprise mortgage portfolios in the stress test.[228]

Discussion

Freddie Mac believes that the proposed loss severity calculation in NPR2 is unnecessarily complex. The calculation of uncovered principal is a prime example. Historical experience indicates that the rate of loss of principal balance is very dispersed. The econometric specification that OFHEO used to determine variation in loss severity explains only nine percent of the variation in historically experienced rates of loss of principal balance.[229] Given the low explanatory power of the specification, there is relatively little value added from the additional complexity of the exponential fitted values of NPR2.

The "z-score" variable attempts to capture a relatively simple phenomenon. OFHEO states that "the z-score tells how far below the average property value growth in the Census division must the growth of any individual property value be, before all borrower equity is eliminated."[230] As specified, the z-score can give rise to counterintuitive

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[226] OFHEO derives its estimate of the property value from its previous calculation of the uncovered principal amount. In using the z-score specification to estimate the "uncovered portion" of lost principal, the uncovered portion was defined as the difference between the principal balance and the proceeds from sale of the property. In calculating the uncovered portion of principal, property value proceeds were subtracted from the principal amount to calculate the principal balance. While these components were originally combined to develop the z-score specification, OFHEO now separates the two by estimating the property recovery amount as one minus the loss-of-principal.

[227] NPR2 at 18191.

[228] *Id.* at 18118 and 18091-92. As described in NPR1, the Enterprise loan data set used by OFHEO to identify and estimate the benchmark consists of only 30-year, newly originated, owner-occupied, single-family loans.

[229] The R-squared value of the regression is 0.09. *Id.* at 18191.

[230] NPR2 at 18190. The z-score is defined as [ln(HPI) - ln(B)] / sigma, where HPI is the house-price appreciation, B is the ratio of outstanding UPB to original value, and sigma is the standard deviation of house-price growth rates.

results.[231] In addition, through its reliance on volatility equations that are dependent on region, the z-score variable can generate different loss rates by Census division for properties that are otherwise identical.

In contrast to the loss of principal balance that was calibrated to ALMO, the loss severity model takes transaction cost estimates from national averages. Freddie Mac believes that OFHEO should rely on calibration to ALMO for these components of severity. Although OFHEO includes the portion of transaction costs that is used to repair the property in the loss of principal balance,[232] there are other ways in which transaction costs and loss of principal balance are interrelated. For example, longer timelines generally give rise to both high transaction costs and high loss of principal balance, everything else being equal. Freddie Mac, therefore, believes that transaction costs should be calibrated to the experience of the same properties that drive the calculation of the other loss severity components.

Recommendation

Freddie Mac recommends that OFHEO greatly simplify the single-family loss severity calculation. Our recommendation is summarized in Table 6 below. The recommended specification creates total loss severity estimates for a limited number of mortgage groups, depending on original loan to value ratio and age of the mortgage. Freddie Mac also recommends that OFHEO extract estimates for loss of principal balance and transaction costs directly from ALMO, and then use the relevant timelines that are included in the NPR2[233] to calculate the asset funding costs using the six-month agency interest rate.

[231] For example, in the case where expected house value is less than current UPB, higher values of volatility and therefore greater uncertainty about the house value leads to lower loss. (In this case, HPI < B). Then z-score is negative and a higher value of sigma will produce a less negative number and a lower loss. In the case where expected house value is equal to current UPB, the z-score equals 0 regardless of how volatile the house process is. In this case, HPI = B, making the z-score always 0 regardless of the value of sigma. In both of these cases, one normally would expect the loss to increase with higher volatility because a more uncertain house process would make more likely the event that the defaulted property has depreciated substantially. Higher volatility would also increase the likelihood that properties have experienced substantial appreciation but one would not normally expect these properties to default.

[232] NPR2 at 18189, n.235.

[233] 13 months for the time from default to foreclosure and seven months for the time spent in REO status. *Id*. at 18191.

30-Year Mortgages				
	Age <= 2 Years		**Age > 2 Years**	
Original LTV	**Down-Rate**	**Up-Rate**	**Down-Rate**	**Up-Rate**
<= 80%	36%	48%	26%	38%
>80%, <=90%	41%	53%	31%	43%
>90%	50%	63%	40%	53%

15-Year and 20-Year Mortgages (Multiplier = 0.9)				
	Age <= 2 Years		**Age > 2 Years**	
Original LTV	**Down-Rate**	**Up-Rate**	**Down-Rate**	**Up-Rate**
<= 80%	32%	43%	23%	34%
>80%, <=90%	37%	48%	28%	39%
>90%	45%	57%	36%	48%

Notes: Age is as of the beginning of the stress test. Above estimates assume a value for the six-month Agency of 3.00 percent in the down-rate and 10.50 percent in the up-rate.

Table 6: Summarized Severity Rate Information

The recommendation described in *Table 6* is derived from available benchmark data. We believe that our recommendation in this table best meets the objectives of relating credit losses to the benchmark region, responding appropriately to the economic environment and distinguishing risks across product categories. Our recommended severity specification also gives the proper incentive to use mortgage insurance coverage. Finally, our recommendation is simpler to implement than the NPR2 specification.

Our derivation of these loss severity components from the benchmark is described in its entirety below.

Extracting loss of principal balance and transaction costs from the benchmark

Freddie Mac uses benchmark loss severity estimates as published in NPR1[234]. These severity estimates can be grouped within three LTV buckets. Freddie Mac recommends that three LTV categories will be sufficient to capture the relevant dimensions of risk in this exercise.[235] The severity estimates for these buckets are presented in column (1) of *Table 7*.[236]

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234 NPR1 at 29598, Table 4.

235 There are relatively few data points for LTV ratios less than or equal to 70 percent and also for the 81-85 percent LTV range.

236 The weights used are based on Freddie Mac ALMO REO data.

The (<= 80%) estimate is equal to: 0.110*(<=60%estimate) + 0.092*(>60 percent, <=70% estimate) + 0.174*(>70%, <=75% estimate) + 0.624*(>75%, <=80% estimate).

The (>80%, <=90% estimate) is equal to: 0.208*(>80%, <=85% estimate) + 0.792*(>85%, <=90% estimate).

	(1)	(2)	(3)	(4)	(5)
LTV Categories *(30-Year Mortgages)*	**Total ALMO Loss Severity** *(Unadjusted)*	**ALMO Loss-of-Principal plus Transactions Cost Components** *(Unadjusted)*	**Loss-of-Principal Plus Transactions Cost Components** *(Adjusted for Bad Data)*	***Recommended Total Loss Severity*** ***Down-Rate Asset Funding Costs***	***Recommended Total Loss Severity*** ***Up-Rate Asset Funding Costs***
<=80%	54.5%	36.3%	31.0%	36%	48%
80% to 90%	59.1%	40.9%	35.6%	41%	53%
>90%	69.0%	50.8%	45.5%	50%	63%

Table 7: Steps in Progression from ALMO Severity to Loss Severity Recommendation.

Given these specifications of total severity, ALMO asset funding costs are subtracted to obtain estimates for the loss of principal balance and transaction cost portions because these funding costs were specific to ALMO. There are two relevant asset funding costs. The first is the mortgage interest lost and is calculated as the product of the time from the last mortgage payment to REO acquisition times the accounting net yield of the mortgage. The second is the carrying cost of the property and is calculated as the product of the time spent in REO status times the REO financing cost. Assuming a 12.5 percent average accounting net yield for the ALMO mortgages and an eight percent average REO financing cost, and using the 13- and seven-month timeframes from NPR2,[237] yields an estimate of 18.2 percent for the total ALMO asset funding cost.[238]

After subtracting the ALMO funding cost, the resulting estimates for the ALMO loss of principal balance plus transaction costs are given in column (2) of *Table 7***.**

The loss severity estimates should be adjusted for missing data and ALMO state re-weighting. As was the case with the default function, loss severity estimates from ALMO suffer from missing data and from the skewed distribution of loans across ALMO states. Based on the RTI report results, the above severity estimates need to be decreased by 5.3 percentage points.[239] The resulting adjusted estimates are presented in column (3) of *Table 7*.

Calculating asset funding costs

The estimates derived above need to be increased by the appropriate measure of asset funding costs for each stress test. As stated above, the total time period on which we need to calculate funding costs is 20 months: 13 months from default to foreclosure and a further seven months spent in REO status. Asset funding costs vary depending on the

[237] NPR2 at 18191.

[238] Calculated as 0.125*(13/12) + 0.08*(7/12).

[239] The RTI report concludes that ALMO severity should decrease from 62.63 to 57.36 percent, a total of 5.27 percentage points; the decrease from 62.63 to 59.64 percent (2.99 percentage points) is to adjust for missing data and the decrease from 59.64 to 57.36 percent (2.28 percentage points) to compensate for the distribution of ALMO loans by state.

value of the six-month Agency interest rate each time the stress test is run. As an example, if the initial value of the six-month Agency is 6.00 percent and we assume proportional movement during the stress test, the down-rate interest rate would be as low as 3.00 percent and the up-rate as high as 10.50 percent, a 50 percent drop and a 75 percent increase, respectively. Given these interest rates, the resulting severity rates are (rounding to the closest percentage point) given in columns (4) and (5) of *Table 7***.**

Adjust for age

Our recommendation in *Table 6* includes an adjustment for mortgage age. The above methodology works well for mortgages that are new as of the beginning of the stress test. Older mortgages generally have experienced a period of house-price appreciation and, therefore, should experience lower severities. In the interest of simplicity, Freddie Mac recommends two different age buckets: one for loans that are less than or equal to two years of age at the beginning of the stress test, and a second one for loans that are older than two years of age. For the latter group, we recommend that severity rates be reduced by ten percentage points, assuming that this group of loans consists of loans that are four years old on average and have experienced an average 2.5 percent house-price appreciation per year.

Adjust for 15-year and 20-year products and for FHA/VA loans

Both the 15-year and 20-year mortgage products have experienced lower loss severity on average due to faster amortization. Federal Housing Administration (FHA)/Department of Veterans Affairs (VA) loans should have minimal losses and constitute a very small part of the mortgage portfolio. Freddie Mac recommends that OFHEO use a 0.9 multiplier for the 15-year and 20-year mortgage loss severity and assume a zero percent loss severity for FHA and five percent loss severity for VA.

The bottom panel of *Table 6*, presents our severity recommendation for 15-year and 20-year mortgages.

c. Single Family Prepayment Model

As with the default model, OFHEO proposes to use a joint statistical model for stress period prepayment rates. Enterprise mortgage performance data were used to measure historical relationships among economic scenarios, mortgage product types and mortgage prepayment. In contrast to its calibrations of default and loss severity models, OFHEO incorporated these historical relationships with no adjustment for benchmark prepayment experience. As with the default equation, the historical prepayment relationships are extrapolated into the severe economic scenarios of the stress test. This approach results in extremely low prepayments in the up-rate test, largely because there are no close parallels to the up-rate test in historical data. We recommend that OFHEO use borrower mobility data to compensate for inadequate historical experience in specifying prepayments in the up-rate scenario.

Proposal

As discussed previously, OFHEO uses a joint statistical model for single-family defaults and prepayments. OFHEO estimated its proposed single family prepayment models based on historical Enterprise loan level data.[240] OFHEO proposes to calculate single family conditional default and prepayment rates for each month of the stress period. The joint specification for default and prepayment models is described in *Exhibit 3.*

Single-Family Default and Prepayment Models
Functional Form

$Def_q = [\exp\{X_q\beta\}] / [1 + \exp\{X_q\beta\} + \exp\{X_q\gamma\}]$

$Prep_q = [\exp\{X_q\gamma\}] / [1 + \exp\{X_q\beta\} + \exp\{X_q\gamma\}]$

where:

Def_q = quarterly, conditional default rate in stress test period q

$Prep_q$ = quarterly, conditional prepayment rate in stress test period q

X_q = a vector of variables describing a pool of mortgages and features of the economic environment at period q.

β = a vector of parameters specifying how mortgage defaults are affected by the variables included in X_q.

γ = a vector of parameters specifying how mortgage prepayment variables are affected by variables included in X_q.

exp[.] = the exponential function.

Exhibit 3: Single-Family Default and Prepayment Models

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240 *See Benchmark Loss Experience***.**

Determinants of conditional prepayment rates

In the proposal prepayment model, described in *Exhibit 3*, the variables in the "X" vector determine the conditional prepayment rates in each period of the stress test. NPR2 describes a set of characteristics to be included in this vector that affect the level and timing of mortgage prepayment.[241] In a given month, the following factors determine prepayment rates for single-family loans:

- *Loan-to-value (LTV) ratio* at the time the mortgage was originated. OFHEO groups mortgages into six different categories, based on original LTV ratio.
- *Borrower equity*, which is calculated from the mortgages' original LTV, amortization of the principal balance since origination, and house price changes since origination. Borrower equity is captured through a variable (PNEQ) that measures the probability that a loan from a given product, region, and origination year would have negative equity at any given date in the stress test.[242]
- *Mortgage age*, defined at any point in the mortgage's life by the number of quarters since the mortgage was originated. The variable "Age" is the number of quarters since origination; the square of the Age variable is also included as a separate variable in the "X" vector.[243]
- *Occupancy status of the borrower* is a categorical variable that distinguishes investor-owners from occupant-owners.[244]

The interest rate environment is captured by three separate variables:

- *Relative spread* measures the difference between the mortgage coupon and the market interest rate.[245]
- *The slope of the yield curve* measures the ratio of ten-year interest rates to one year interest rates.[246]
- *A "burnout" variable* captures the recent history of interest rates, relative to the coupon rate of the mortgage in question. In any given quarter, a mortgage is defined to be "burned out" if interest rates in the recent history have been sufficiently below the mortgage's coupon rate.[247]

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[241] NPR2 at 18174.

[242] *Id*. at. § 3.5.2.3.2.3. As specified by OFHEO, the PNEQ variable requires creating a time series of property values and amortizing loans to create updated LTV ratios throughout the stress period. The updated LTV ratios are used, along with the standard deviations of house price growth paths to compute probabilities of negative equity.

[243] *Id*. at § 3.5.2.3.2.1.

[244] *Id*. at § 3.5.2.3.2.5. OFHEO rejected the use of other variables, such as origination year, unemployment rates, mortgage premium value and credit scores, because it believed these would increase the complexity of the model without corresponding benefit.

[245] *Id*. at § 3.5.2.3.2.6.

[246] *Id*. at § 3.5.2.3.2.7.

[247] *Id*. at § 3.5.2.3.2.4. Burnout is a binary variable. The proposed regulation provides that burnout variable "indicates whether there have been at least two quarters of 'significant refinance opportunities'

The variables, *LTV, PNEQ, mortgage age, burnout*, and *occupancy status* are identical to those used in OFHEO's default equation. The *relative spread* and *yield curve slope* variables are used only in the prepayment specification.

OFHEO specifies separate prepayment models (sets of equations) for three product categories:

- Fixed-rate 30-year fully amortizing mortgages.
- Adjustable-rate mortgages.
- Other mortgages (including mortgages with twenty or fifteen-year amortization schedules, and mortgages with a "balloon" repayment prior to the complete amortization).[248]

The conceptual underpinnings and empirical specifications are identical for all three.

Calibration of model

Unlike its proposed default and severity models, OFHEO did not calibrate the resulting predictions of the prepayment model to actual prepayment rates experienced in the benchmark region.

Discussion and Recommendations

In its comments on the ANPR, Freddie Mac did not recommend the estimation of a joint default and prepayment model. Despite the concerns we expressed on this general approach, our analysis of NPR2's prepayment specification leads us to conclude that with appropriate adjustments, the approach can meet the appropriate statutory, risk assessment and operational standards that we have described.

We do recommend that OFHEO exploit the benchmark experience in developing their prepayment model. The unique stress test application of this model requires it to work given the extreme movements in interest rates at the very outer limits of historical data. Such extrapolations can be subject to substantial error, and it is useful to consider any available guideposts in the effort to get a sensible result. The benchmark experience is a good approximation of the down-rate test, and we recommend that OFHEO acknowledge the unique requirements of the stress test by calibrating the prepayment specification to assure that it would reproduce cumulative prepayment rates of loans from the benchmark region.[249]

among the previous eight quarters of loan life." It further provides that a mortgage undergoes a significant refinance opportunity "when its coupon is at least two percentage points above the then-prevailing rate on 30-year mortgages."

[248] *Id.* § 3.5.2.3.2.8 and Table 3-17.

[249] As part of this calibration exercise, OFHEO should make adjustments for deficiencies in the historical data of the benchmark region. These adjustments should correct errors in the data and re-weight the data appropriately Our default rate specification describes the calibration exercise on the re-weighted benchmark. Methods to correct the benchmark data deficiencies are described in the *Benchmark Loss Experience* at 14 and in RTI Report at 8-12**.**

Prepayments in the down-rate scenario are reasonable

In NPR2, OFHEO specifies an explicit path for mortgage rates, as well as an explicit path for house prices. The combined elements of house prices and interest rates provide the outline of OFHEO's down-rate specification that captures the essence of the stress test. In translating this economic environment to mortgage prepayment experience, two of the variables in the prepayment specification are very important:

- The rate sensitivity variable, which increases the prepayment rate as current interest rates fall below the mortgage coupon rate.
- The PNEQ variable, which reduces prepayment rates for loans that have a high probability of negative equity.

Down-rate stress test prepayment rates reflect the composite effects of both variables. The rate sensitivity variable measures the borrower's refinancing incentive. In the down-rate stress test, this rate sensitivity variable would push prepayment rates toward very high levels.

OFHEO's PNEQ variable dampens the effect of large refinancing incentives by capturing the effects of the falling house price environment in the down-rate test. In accordance with a great deal of empirical evidence, prepayment rates for loans with high original LTV ratios in falling house price environments will be far lower than those of low LTV loans in good house price environments. Our analysis indicates that the proposed prepayment model produces reasonable answers to the question of prepayments in the environment of the down-rate test.

Table 8 below captures the range of the predictions from the prepayment model under a 50 percent drop in interest rates for extreme values of the probability of negative equity (PNEQ) and original LTV Ratio.[250] An annual prepayment rate of 60 percent as projected by the model is consistent with recent historical experience in healthy housing markets.[251] At the other extreme, the behavior of a 95 percent LTV loan with a PNEQ greater than 0.35 and a 60 percent LTV of similar PNEQ also are consistent with recent experience and ALMO. Loans originated in California during 1990 with LTV of 95 percent prepaid at a rate of only 27 percent during 1993 compared to 49 percent for loans with LTV of 70 percent or below. Prepayment rates for high-LTV loans were even slower for ALMO loans in the 1986 refinancing year. ALMO loans with LTV of 95 percent prepaid at a 19 percent rate during 1986, while ALMO loans with LTV less then 70 percent prepaid at 37 percent.[252]

[250] Predictions are for a 12-quarter old loan, not subject to burnout. The yield-curve slope variable is set to 1.50.

[251] For example, in the Freddie Mac Northcentral region (consisting of Iowa, Illinois, Indiana, Michigan, Minnesota, North Dakota, Ohio, South Dakota, Wisconsin) during 1993, loans of less than 70 percent original LTV originated in 1990 prepaid at a 55 percent annual rate. This region experienced an average house-price appreciation of 13 percent between 1990 and 1993.

[252] This rate is derived as the average of the prepayment rates of ALMO loans with LTV less than or equal to 60 (39 percent) and ALMO loans with LTV greater than 60 and less than or equal to 70 (35 percent).

Original LTV	PNEQ	Prediction (Annualized)
60%	<= 0.05	60%
95%	<= 0.05	50%
60%	> 0.35	41%
95%	> 0.35	33%

Table 8: NPR2 Prepayment Model Predictions for Extreme Values of Equity and Original LTV

Freddie Mac believes that, given our recommended calibration of the prepayment model to the benchmark region, NPR2's proposed prepayment model predictions will be consistent with the character of the down-rate stress test. When this calibration is done, Freddie Mac recommends no further adjustment for the prepayment specification in the down-rate scenario.

Prepayments in the up-rate scenario are too low

Based on our analysis of OFHEO's proposed prepayment model, we have concluded that the model predicts unreasonably low prepayment rates in the up-rate stress test — approximately three percent per year. We believe this is due to limitations of historical data for the purpose of specifying up-rate prepayments. These data limitations suggest that the answer to the up-rate prepayment question does not lie in historical prepayment experience, but can only be found by studying other prepayment factors like borrower mobility.

The first deficiency in historical data is the lack of historical experience comparable to the extreme interest rate movements of the stress test. As noted in our comments on the default model, the up-rate stress test calls for unprecedented increases in interest rates. Therefore, OFHEO's general approach of estimating a prepayment model over the range of Enterprise historical experience is most likely to run aground in projecting mortgage behavior in the up-rate stress test. Prepayment projections for the up-rate scenario derived from the modeling approach of NPR2 are almost pure extrapolations without parallel in actual experience.

The only period with historical increases in interest rates that approximate the stress test occurred between 1979 and 1981. According to PMMS data, rates on 30 year FRM increased from an average of 11.20 percent in 1979 to an average of 16.63 percent in 1981. Hence, 1981 saw something like the up rate stress test, or at least an extremely abbreviated version of such a test.

The second deficiency in historical data arises from structural changes in mortgage markets. At first glance, prepayment rates from 1979-1981 might be thought of as a good guidepost for prepayment behavior in the up-rate stress test. Further analysis of mortgage markets, however, reveals a structural change in the mortgage markets that occurred in the early 1980's which means that prepayment data from this period will tend to understate prepayment rates systematically for mortgages in today's markets.

A problem with using data before 1984 to analyze prepayments on deep-discount mortgages is the result of changes in the assumability features of mortgages. As the result of both state legislative and judicial changes, due-on-sale clauses became unenforceable in many states. Fannie Mae and Freddie Mac generally did not enforce due-on-sale clauses, so a large but unknown share of the loans were assumable.[253] Assumable mortgage are less likely to prepay, because borrowers with assumable mortgages can move without prepaying their mortgage. Virtually no conventional loans today are assumable, and the result is that a much higher fraction of borrowers who change residences today would need to prepay their mortgages.

Because the answer to plausible prepayment rates in the up-rate scenario does not lie in historical prepayment experience, it is most useful to consider other factors affecting prepayment. A 1987 study by John M. Quigley (Chancellor's Professor of Economics and Public Policy at the University of California at Berkeley) analyzed mobility in 1981, the year with the highest mortgage rates that should be most comparable to the experience of the up-rate scenario.[254]

Quigley's paper used samples from the Panel Study of Income Dynamics (PSID) collected by the Survey Research Center of the University of Michigan to model mobility rates with data from 1979, 1980 and 1981. Quigley's analysis acknowledged explicitly that rising interest rates tend to dampen the effects of borrower mobility, so the analysis is well-suited to the question of up-rate prepayments.

The basic results of this analysis can be summarized rather easily. From 1979 to 1981, the period during which mortgage rates increased by over five percent, the overall homeowner mobility rate went from 9.94 percent to 6.95 percent.[255] This predicted mobility rate is a plausible estimate of prepayment rates in the up rate test. Quigley's analysis shows that the interest rate shock decreased mobility rates by about 30 percent, but not to levels close to those implied by the NPR2 specification of prepayment rates in that interest rate environment.

Based on the above analysis, we recommend that OFHEO increase up-rate prepayments by three percent CPR to produce a rate that is more consistent with results from homeowner mobility studies. Freddie Mac believes that annual prepayment rates of six percent per year are appropriate in the up-rate stress test.

[253] *See* Beth Preiss, "The Garn-St Germain Act and Due-on-Sale-Clause Enforcement," *Housing Finance Review* (Oct. 1983).
[254] John M. Quigley "Interest Rate Variations, Mortgage Prepayments and Household Mobility," *Review of Economics and Statistics* (1987) at 636-644.
[255] Data provided to Freddie Mac by John Quigley.

ii. Multifamily Mortgage Performance

Freddie Mac believes that, given the lack of reliable data on multifamily loan performance, a simpler, statistically based approach to assessing multifamily mortgage risk that reflects an underwriting perspective is preferable to OFHEO's proposed econometric approach. The underwriting approach would explain credit losses in terms of simple, observable mortgage risk characteristics, such as debt-coverage ratios (DCRs) and loan-to-value (LTV) ratios, in a way that is consistent with how an underwriter would assess risk. Furthermore, Freddie Mac believes that the limitations in the underlying data compel OFHEO to evaluate the reasonableness of multifamily capital requirements by comparing them with external benchmarks. Freddie Mac recommends adoption of a default model that depends on observable mortgage characteristics, including original LTV, current DCR (from property-level Enterprise inspection data) and balloon payment risk. In addition, Freddie Mac recommends that prepayments and loss severity be based on simple rules.

Background

The credit risk component of the risk-based capital stress test in the Act does not expressly distinguish between single-family and multifamily mortgages.[256] This provision of the Act requires that the stress test's rates of default and severity (credit losses) for "mortgages" owned or guaranteed by the Enterprises be reasonably related to a benchmark loss experience.[257] However, in developing the stress test, the Act also requires OFHEO's Director to "take into account appropriate distinctions among types of mortgage products" as well as "differences in seasoning of mortgages" and "any other factors the Director considers appropriate."[258] As discussed in Freddie Mac's response to OFHEO's earlier rulemakings and noted by OFHEO in NPR2, there are many significant distinctions between single-family and multifamily mortgages.[259]

Multifamily and single-family mortgage marketplaces have relatively little in common. The market participants, mortgage structures, competitive pressures, and data are all very different. Multifamily mortgage loans present unique credit risks to the Enterprises. Consequently, any approach to developing the credit loss component of the risk-based capital stress test should reflect these differences in markets, structure and risk between single-family mortgage loans and multifamily mortgage loans.

Unlike the market for single-family loans, the two Enterprises constitute a relatively small share of the multifamily mortgage market. Through the early 1980s, the multifamily mortgage market was dominated by a few key lenders: life insurance companies, banks and thrifts. During the mid-1980s, both Enterprises became active players in the market; however, traditional sources of debt financing continued to dominate certain segments of the multifamily mortgage market, including the market for very small multifamily mortgages and new construction. Today, the bulk of the credit for "investment grade"

[256] The Act § 1361(a)(1).
[257] *Id*.
[258] *Id*. at § 1361(b)(1).
[259] *See* NPR2 at 18120 and 18125-6.

multifamily loans is supplied by a diverse set of institutions, including the Enterprises, life insurance companies, large commercial banks, and "conduits" (originators of commercial mortgage-backed securities). In recent years the Enterprises have faced significant competitive pressures on both yields and terms from the conduits.

In addition to differences in markets, it is useful to consider the history of Freddie Mac's multifamily program and, in particular, to contrast Freddie Mac's past multifamily program with its current program. At present, all of Freddie Mac's multifamily mortgage products and programs share three key features. First, transactions are underwritten and evaluated using a strict set of Freddie Mac origination standards and procedures designed specifically for multifamily mortgages. Freddie Mac's seller/servicers are active participants in gathering the appropriate information and in quality control functions. Moreover, Freddie Mac typically underwrites each multifamily mortgage loan it obtains. This process includes comprehensive site visits. Each loan is quality rated according to an internal rating system which examines key attributes of the loan, such as the health of the market in which the collateral is located, borrower strength, property quality and financial quality of the loan. In addition, many multifamily loans (including all large loans and ones with particularly unusual features) are reviewed by a credit committee of senior Freddie Mac officers for other factors that might affect risk to Freddie Mac.

Second, only multifamily loans that conform to Freddie Mac's restrictive loan standards are purchased. In general, these standards specify minimum DCRs, LTV ratios, building characteristics, borrower financial strength, and management standards (professional-management is almost always required). In all cases, Freddie Mac has specific, conservative guidelines for use in calculating ratios and assessing project compliance with these standards.

Third, most multifamily loans are subject to a rigorous servicing program that includes periodic collection and verification of operating information. Freddie Mac reviews loans and assesses current loan quality (including current DCRs and estimates of collateral value) based on that information. If problems are detected, remedial action may be instituted, such as placing the loan on a watch list for special attention. Freddie Mac conducts these reviews annually for most multifamily loans.

The operating and underwriting standards described above are a critical part of Freddie Mac's current multifamily mortgage business. However, they have only been in place since 1993. These standards were not in place when Freddie Mac first started buying Multifamily mortgages in the early 1980s. Thus, when evaluating multifamily lending and credit losses at Freddie Mac, it is crucial to distinguish between two regimes: pre-1993 and post-1993. During the pre-1993 regime (also referred to as the "old book") Freddie Mac accumulated a $12 billion portfolio of multifamily mortgages. At this time, Freddie Mac's multifamily program was staffed largely by personnel with single-family mortgage experience. Lending was disproportionately concentrated in high-risk geographic areas. Many multifamily loans purchased by Freddie Mac were of poor quality and not properly underwritten before purchase. The vast majority would not have met Freddie Mac's current underwriting standards.[260] In addition, multifamily servicing was not up to *current* industry standards. As a result, consistent with other well-documented problems in multifamily markets in the late 1980s and early 1990s, Freddie Mac's multifamily portfolio performed quite poorly resulting in significant losses.

For these reasons, Freddie Mac discontinued multifamily lending in the fall of 1990. By the early 1990's, Freddie Mac had assembled a new multifamily team with extensive commercial lending experience. The first task of the new team was to manage the existing portfolio of old book loans and to undertake a focused effort to rid the portfolio of non-performing assets. Freddie Mac did not re-enter the multifamily market to purchase new loans until 1993 and only under the new, strictly-drawn parameters that characterize the current multifamily program. Thus, multifamily loans originated since 1993 (also referred to as "new book" loans) are not comparable to those originated before 1990.

This history of multifamily lending at Freddie Mac, its complete distinction from Freddie Mac's history of single family mortgage lending, and the existence of two clearly documented and different regimes for underwriting standards and operating practices is an important consideration in the development of a risk-based capital stress test. In particular, it highlights several important issues that should be addressed in any risk-based capital proposal for multifamily mortgages. First, what works in the single-family market does not necessarily work in the multifamily market, including highly specified econometric approaches to estimating mortgage default, and prepayment. Second, the existence of the old (pre-1993) and new (post-1993) regimes in Freddie Mac's multifamily programs supports an approach that is focused on *current* underwriting, management and quality control standards, and less on attempts to reconcile the data and performance of old and new book loans. Third, the rapid evolution of multifamily programs and products suggests that inferences from past experience may be limited. In particular, undue reliance on pre-1993 empirical data for multifamily loans should be avoided. Fourth, the wide range of multifamily products and competition in the multifamily market, suggest that a meaningful risk-based capital rule simultaneously must be simple to implement and specific to the risk characteristics of individual loans.

Proposal

In NPR2, OFHEO proposes to establish risk-based capital requirements for multifamily mortgages based on a series of seven econometric mortgage performance models — two for estimating defaults and five for estimating prepayments — and five loss severity rate models.[261] OFHEO estimated all of these multifamily models using Enterprise mortgage data for the period from 1983 to 1995.[262] Using these 12 models and the two economic scenarios (the up-rate scenario and the down-rate scenario) which, in the case of multifamily are defined in terms of vacancy rates, rental growth rates, property value

[260] An internal Freddie Mac study made available to OFHEO showed that the lower standards of underwriting that existed during the old regime inflated reported DCRs and reduced reported LTV ratios in ways that would be unacceptable today. Freddie Mac Internal Memorandum (May 19, 1995).

[261] NPR2 §§ 3.5.4 and 3.5.5. *See also Id*. at Table 3-20 (list of explanatory variables).

[262] *Id*. *See also* NPR2 at 18093.

changes and interest rates, the NPR2 proposes to simulate the performance and cash flows associated with each multifamily mortgage held by the Enterprises.[263]

The proposed default and prepayment models for multifamily are highly specified. The default models, which include a "cash purchases" model and a "negotiated transactions" model primarily rely upon three sets of variables: measures of negative equity and negative cash flow, age variables, and underwriting regime variables. The negative equity and negative cash flow variables, which include the "joint probability" variables JP and BJP, attempt to measure the imputed probability that a mortgage in any given period is simultaneously experiencing both negative equity and negative cash flow, two conditions that OFHEO hypothesizes are necessary for multifamily mortgage default. The age variables consist of the age (AY) and the square of the age of a mortgage (AY^2) which are collectively referred to as a quadratic function of age. OFHEO explains its inclusion of these variables in NPR2 as follows: "Preliminary analysis of the Enterprise data indicated that the peak default period is about four years after loan origination. To capture this underlying trend, a quadratic age function is included in the default equations."

The last set of variables — the underwriting regime variables — include the DW, DD (also referred to as PR), RA, and RF variables. All of these variables, with the exception of the DW variable are "dummy" variables that take on the value of one whenever a loan was originated under a specific program, during a specific time period, or with specific loan terms. In this way, these variables, help to explain differences in the performance of loans in terms of different underwriting regimes, loan terms, or other loan attributes. The DW variable, which is intended to capture the present value of depreciation tax write-offs may also be viewed as an underwriting regime variable since it is largely invariant within a given origination year and thus in part captures performance differences between age cohorts.[264]

The prepayment models proposed in NPR2 are intended "...to best capture the differing prepayment incentives by product and product-life stage."[265] To this end, the proposed approach seeks to capture the differences in performance between fixed- and adjustable-rate loans, and between loans that are inside and outside of yield maintenance or prepayment lockout periods. However, the proposed models do not specifically reference the individual prepayment provisions of each mortgage nor does the cash flow model include the cash inflows that the Enterprises would expect to receive from any prepayments that might occur within yield maintenance periods.

All five of the prepayment models for multifamily rely upon variations of the same three sets of variables: relative spread and interest-rate variables, age variables and qualification variables. The relative spread and interest rate variables, include the current mortgage interest rate, r, and the variables RSD, RSU, RDS1, RDS2, and RS which measure the difference between the value of the current fixed-rate mortgage interest rate and the coupon rate on a given mortgage. The age variables include the same quadratic age function described above, and YTG, the years remaining in a yield maintenance period, where one

[263] *Id. See also id*. at 18094 (Tables 2 and 3).
[264] *Id.* at Table 3-20.
[265] *Id.* at 18204.

exists. The qualification variables include the LTV and PQ variables, which are conceptually similar to the JP and BJP variables in the default equations, and are intended to capture the likelihood that a borrower will have sufficient equity and cash flow to qualify for a new loan, whether it is through a cash-out or regular refinancing.[266]

In order to convert simulated default and prepayment probabilities into losses, OFHEO proposes five loss severity rates.[267] Four of these five are conceptually based on three distinct types of costs — loss of principal (*i.e.*, the unpaid principal balance of the loan less the discounted recovery or "net property sales proceeds"), transactions costs (including foreclosure costs and monthly operating costs) and funding costs — all of which are computed as of the date of default, as a percent of unpaid principal balance at that time. The loss of principal and transactions costs are based on historical averages using Enterprise data (Freddie Mac only). Funding costs are based on the Enterprise discount rates that are applicable for each stress test and the estimated historical average property inventory and disposition times.[268]

The first loss severity rate, which is intended for "retained portfolio: cash loans without recourse" and may be viewed as the primary rate, employs the three types of costs described above. The second loss severity rate, which is intended for "sold portfolio: programs without recourse or repurchase" is the same as the primary rate except that it adds the cost of passing on four months of interest to investors. Loss severity rates three and four, which are intended for "sold portfolio: cash programs with recourse" and "sold portfolio: negotiated programs with repurchase" respectively, are modified versions of rates one and two. The modifications are that they account for recourse agreements by reducing severity in relation to the presumed recourse agreement with seller/servicers. The fifth loss severity rate, which is intended for "FHA-insured programs" is assumed to be a flat three percent under all scenarios. The primary loss severity rate, based on the interest rate path used in the 1997Q2 stress test, ranges from 58 percent to 61 percent in the down-rate scenario and 62 percent to 68 percent in the up-rate scenario.[269]

Discussion

After extensive evaluation, we believe the proposed approach to modeling and establishing risk-based capital levels for multifamily mortgages in NPR2 is ambitious and innovative, but that it has a number of significant shortcomings. All of these shortcomings may be viewed as arising from an attempt to apply single-family approaches to risk management and measurement to multifamily mortgages. The data and tools available to multifamily mortgage analysts are limited and preclude the use of the type of highly structured econometric models that have been successfully deployed in the single-family mortgage arena. The heavy reliance in NPR2 on limited, and possibly flawed historical data, unobserved economic parameters, and new, untested approaches to multifamily mortgage modeling represent undesirable features for a risk-based capital regulation.

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[266] *Id.* at 18205 (Table 35).
[267] *Id.* at § 3.5.5.
[268] *Id*.
[269] *Id.*

Our discussion of OFHEO's proposed approach to setting capital requirements for Multifamily mortgages is divided into four areas: data limitations, conceptual and econometric issues with the proposed behavioral models, analysis of model results and comparison to industry measures of risk.

Data limitations

Data on multifamily mortgage performance are limited in quantity, quality and relevance (given the regime changes in the Enterprises multifamily programs). These limitations are not unique to OFHEO or the Enterprises, but are prevalent throughout the multifamily mortgage industry. This does not imply that no meaningful inferences may be made from the Enterprises experiences in the late-1980s and early-1990s. Rather, it suggests that caution should be exercised in using these data, and that statistical relationships estimated with them should inform, but not dictate the structure or parameters of any proposed capital requirements. It also argues for simple models with relatively few variables.

In NPR2, OFHEO explicitly recognized many of the limitations of the historical multifamily data,[270] yet by proposing seven separate structural econometric models for multifamily mortgage performance, OFHEO has implicitly expressed strong confidence in its interpretation of that data and the underlying mortgage performance. We believe that the current state of multifamily mortgage data and modeling does not support such confidence.

This belief is based on the fact that during the late 1980s, when most of the mortgages observed by OFHEO were underwritten, both Enterprises were plagued by poor underwriting and risk management systems that resulted in significant instances of erroneous, missing or incomplete information regarding loan characteristics or performance. OFHEO attempted to address this problem by making wholesale adjustments to the DCRs and LTVs of loans originated under old multifamily programs. While such adjustments may be warranted on average, it is not the case that every loan originated under the old programs had an overstated DCR and an understated LTV — the data problems were far too complicated and pervasive for a simple fix and, as a result, the adjustments made by OFHEO do little to overcome them.[271]

For example, in many markets during the 1980s, Freddie Mac staff instructed lenders to deliver loans with LTV ratios of 60 percent. Not surprisingly, a large number of loans purchased during this period, particularly in certain regions, have LTV ratios of exactly 60 percent. While in many cases, the "true" LTV ratio may have been 60 percent, we believe that many of these borrowers recast their financial statements in order to generate the desired LTV ratio. This does not imply that all LTV ratios were overstated or that they were all altered in equal proportion. Many loans probably were not altered, while others were probably altered significantly. Unraveling the adjustments and separating the legitimate from the illegitimate LTV ratios would require a case by case analysis of the

[270] *Id.* at 18136.

[271] In fact, since the preponderance of defaults experienced by both Enterprises were loans originated under the old programs, OFHEO's data adjustments do little more than shift the estimated coefficients on the JP variables in proportion to the changes in the data.

loan files, and even then the results of such a review might not illuminate all instances of inaccurate reporting of LTV ratios.

Another example is the difficulty in interpreting the disposition of troubled loans where workouts were pursued. In many cases, such loans may have been recorded as prepayments instead of defaults. Alternatively, some successful loan workouts may be recorded as defaults, when in fact the workout has resulted in little or no loss. As noted above, these types of data and performance idiosyncrasies are common to many multifamily mortgage institutions, and they have been one of the primary impediments to further advances in multifamily modeling.[272]

The reason idiosyncrasies in multifamily data and performance limit the ability of multifamily econometric models to explain multifamily performance is that they prevent such models from adequately relating mortgage performance to economic factors. The disproportionately large number of Freddie Mac mortgages that defaulted in Atlanta and New York illustrates this difficulty. Neither Atlanta, or New York experienced the kind of general market declines in rents or property values that occurred in many other geographic areas, particularly Texas or Florida. Furthermore, significant anecdotal evidence suggests that many of these defaults were the result of fraud or mismanagement. This raises doubts regarding the value of the underlying data as a source of information about the effects of variations in fundamental economic variables on multifamily mortgage performance.

The incomplete and inaccurate state of the Enterprises' historical multifamily data calls into question the highly specified econometric models employed by OFHEO. All econometric models are constrained by the data upon which they are estimated. However, the more complex the model in terms of the numbers of variables, and the transformations employed to create those variables from recorded data, the greater the constraints imposed and the potential errors introduced by the underlying data. These constraints and potential errors do not limit the ability to estimate an individual model, rather they limit the ability to distinguish between reliable estimators and statistical artifacts. We believe that OFHEO's models, which employ numerous variables and complex data transformations, can not be fully supported given the weaknesses in the underlying data and the infancy of the modeling approach.

Conceptual and econometric issues with the proposed behavioral models

OFHEO's proposed models contain a number of weaknesses related to their specifications and estimation. Although a number of our comments relate to all of the models, this discussion will be divided into three separate parts: default models, prepayment models and loss severity rates.

Default models

The primary weaknesses of OFHEO's proposed default model are the construction and interpretation of the JP variables (JP and BJP) and the Age variables (Age and Age^2). The

[272] Follain, James R., Some Possible Directions for Research on Multifamily Housing, *Housing Policy Debate* 5 (4) at 533-68 (1994).

JP variables attempt to measure the dispersion of NOI and property value after mortgage origination. Specifically, the JP variables are based on the likely diffusion of the growth in rents, vacancy rates and property values around an index of average growth rates and represent the estimated probability that, in any given period, a property's DCR will be less than one and its LTV will be greater than one. Thus, the primary reason for the JP variables is that information about contemporaneous DCRs and LTVs is not available to OFHEO.[273] The primary rationale provided for the Age variables is that they provide a good fit with the data.

We have four criticisms of these variables:

- The JP variables are not consistent with economic theory.
- The JP variables are based on questionable indices of rental rates, vacancy rates, and property value.
- The JP variables require untested assumptions regarding the underlying economic processes that govern rent and vacancy rates.
- The age variables are likely capturing omitted variables and measurement problems and are unlikely to be related to the seasoning effects that they are meant to capture.

Each of these will be discussed below.

<u>The JP variables are not consistent with economic theory.</u> While investors in multifamily real estate will consider both current cash flow and property value in making default decisions, there is no reason to believe that the decision rule proposed by OFHEO is the appropriate one to use. This rule, stipulates that investors will consider default when both current LTV is greater than one and current DCR is less than one. This rule is not consistent with either an option-pricing or a liquidity-based theory of mortgage default. In an option pricing paradigm, the mortgagor also would look to the value in the implicit put option embedded in the mortgage when making default decisions, since exercising the option would extinguish all of the remaining value in that option. In other words, because defaulting today would preclude defaulting tomorrow, it might be more profitable to retain the option even when it is in the money and cash flow is negative. This has been demonstrated by Cornell, Longstaff and Schwartz [1996], who show that the magnitude of optimal capital injections may be significant under reasonable parameter values.[274] A similar result is obtained in Kau and Kim [1994].[275] Conversely, if mortgagor default is driven by liquidity constraints, then sufficient conditions for default might be sustained negative cash flows and low, but not necessarily negative equity. However, this result will depend upon the individual borrower's financial condition and the varying liquidity constraints that borrower faces.

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[273] *See* NPR2 § 3.5.4.3.2 for a description of OFHEO's proposed approach to updating NOI, DCR and LTV.

[274] Cornell, B., F.A. Longstaff, and E.S. Schwartz. "Throwing Good Money after Bad? Cash Infusions and Distressed Real Estate," *Real Estate Economics* 24 at 23-41 (1996).

[275] Kau, J.B. and T. Kim. Waiting to Default: The Value of Delay, *Journal of the American Real Estate and Urban Economics Association* 22 at 539-551 (1994).

OFHEO acknowledged the difficulty in establishing a single default rule when it provided a rationale for the Age variables. In NPR2, OFHEO noted:

> Default risk is greatest in the years just after loan origination. Apartment projects are then most vulnerable to economic shocks because DCR may be low, LTV may be high, and it may take several years to create a viable market niche for the property. However, a financially troubled project will not default immediately. First, valuable depreciation write-offs may be available in the early years to counterbalance negative property cash flow. Second, working-capital reserves may forestall default. And third, the owner may "bleed the project" by deferring maintenance and other expenditures prior to delinquency.[276]

This passage clearly supports the argument that negative equity and negative cash flow are not sufficient conditions for mortgage default. While it is difficult to say what the correct decision rule for a multifamily mortgage default model should be, we know that the implicit rule proposed by OFHEO in its JP variables is likely to be too ruthless and that significantly different model parameters will be obtained if that rule is changed. We believe that this sensitivity to unknown parameters is a highly undesirable feature of the proposed model.

<u>The JP variables are based on questionable indices of rental rates, vacancy rates and property value.</u> Since the JP variables are based on estimates of current DCR and LTV (which are, in turn, based on estimates of current NOI and property value, both of which are functions of current rent levels and vacancy rates)[277] OFHEO must identify suitable indices of average rent growth and vacancy rates to use in updating DCR and LTV. OFHEO proposes to use indices of average rents at the MSA level, and state wide vacancy rate estimates to drive movements in NOI. Such aggregate indices fail to capture significant differences in the rent growth and vacancy rates that may be experienced by: different properties types (*e.g.*, big versus small properties, or Class A versus Class B properties), different submarkets within the MSA or state (*e.g.*, Nassau County, NY versus the Bronx, NY or Southern California versus Northern California) or during different time periods (*e.g.*, pre- and post-tax reform). Furthermore, the absence of any independent information regarding expense ratios or expense rate growth eliminates one critical source of variation between projects, and disproportionately increases the importance of the rent and vacancy indices.

A more fundamental problem is associated with the proxy for the index of average property values. High quality indices of multifamily property values are not available for many MSAs or for many years, which leads OFHEO to construct an estimate of the property value index. It does so by constructing its own capitalization rate multiplier and applying it to its constructed MSA indices of NOI. As discussed in the *Multifamily*

[276] NPR2 at 18203.
[277] *Id*. at 18197 for OFHEO's description of the relationship between estimates of current DCR and LTV and rental growth rates, and vacancy rates.

Economic Environment section, this approach generates what we consider to be implausible estimates of property values in the down-rate scenario. In sum, errors of unknown but quite possibly large amounts are introduced by the use of these various proxies for the true variables of interest, current DCR and LTV.

The JP variables require unsubstantiated assumptions regarding the underlying economic processes that govern rent and vacancy rates. The JP variables depend upon strong assumptions regarding the underlying stochastic processes that drive future values of DCR and LTV and the variances and covariances of rental growth, vacancy and price appreciation rates. OFHEO relies heavily on the following assumptions:

- MSA level rental rates follow a log-normal diffusion process with drift equal to the change in the corresponding MSA rental index and constant variance of 7.5 percent across all MSAs and time periods.[278]
- The probability distribution of project level vacancy rates is the same across all projects in the MSA and is equal to the apartment unit vacancy rate distribution.[279]
- The correlation between the change in the natural log of DCR and the natural log of LTV is a constant -0.5975.
- Capitalization rates do not vary by MSA or real estate market conditions and are independent of rent levels or vacancy rates.
- Operating expenses are a constant proportion of rents and consequently grow at the same rate.

Instead of critiquing each of these assumptions in depth, we wish to merely highlight that no significant empirical research is offered by OFHEO to support these assumptions. Nor could there be, since many of the critical questions regarding the behavior of rents, vacancy rates and multifamily prices have yet to be answered. The large body of research on the behavior of single-family house prices has no analog on the multifamily side.

The Age variables are likely capturing omitted variables and measurement problems and are unlikely to be related to seasoning effects. The arguments for including the Age variables are weak and distort the effect of seasoning. There are two possible explanations for the incorporation of the Age variables. First, they are part of the overall approach to capturing the diffusion of property value and DCR around the indices. Age affects the diffusion processes because, all else equal, DCR and LTV are more widely

[278] OFHEO attributes this parameter to unpublished data from the Bureau of Labor Statistics.

[279] OFHEO claims that "...if all apartment units have the same probability of being vacant the distribution of vacancy rates across properties can be assumed to be binomial, with mean and variance parameters $v_{j,t} \sim BN(v_t, v_t\,(1\text{-}v_t))$." NPR2 at 18200. However the distribution for project level vacancy rates is not consistent with this assumption. If a project contains n units, and the vacancy rate of an individual unit is distributed $v_{j,t} \sim BN(v_t, v_t\,(1\text{-}v_t))$ then the variance of the project-level vacancy rate is $v_t(1\text{-}v_t)/n$ which will be lower than the unit-level variance by a factor of n and will converge to zero in large projects. This is a straightforward application of the law of large numbers. Thus, in effect OFHEO's assumption pertains to project-level and not unit-level vacancy rates. OFHEO's stated assumption would actually result in significantly lower vacancy rate variances, particularly for large projects. *See* Johnson *et al*. "Univariate Discrete Distributions," 2nd ed. at 105 (1993).

dispersed the longer the time since origination. However, this is precisely what the JP variable is supposed to be capturing. Furthermore, under this interpretation, it is not the age of the mortgage that is correlated with mortgage performance, but the age of the information about the mortgage. Thus, the age variables under this interpretation are actually measuring the degree of uncertainty that an analyst might have regarding the unobserved financial condition of the underlying property. Thus, if an analyst were able to observe the financial condition of the property, there would be no reason to independently include age variables in the default model.

The second reason for incorporating the Age variables into the default equation is to account for the diffusion process of variables left out of the default equation. The passage from NPR2 cited earlier suggests that this was OFHEO's primary justification for including the Age variables. Since omitted variables are by definition unobserved, we can not analyze them, but presumably they are property, market area or owner-specific. In any event, the age variables capture the influence of these other variables and their variation over time. These could lead to a pattern in which defaults are relatively high in the early years of the mortgage or vice versa.

Unfortunately, available research does not provide definitive opinions about this pattern. Neither is there enough information to separate the two effects we have identified on the age coefficients. As a consequence, the age coefficients are difficult to interpret. As we shall see below, this difficulty may be responsible for what we judge to be an undesirable aspect of the OFHEO model: as a new loans seasons, if its DCR, LTV, and other characteristics all remain the same, the Enterprises would be required to hold more capital each year for that loan until it is approximately five years old. In this way, OFHEO's models implicitly penalize the Enterprises for holding seasoned performing loans.

In sum, the Age and JP variables are poorly constructed, rely upon proxies of uncertain accuracy, are difficult to interpret in terms of the underlying project economics, fail to account for changes in diffusion processes over time and are very difficult to calculate. These are serious concerns because the Age and JP variables play such a prominent role in the calculation of multifamily capital requirements. Virtually all of the variation among multifamily mortgage default rates is due to these two sets of variables.

One final area of concern regarding the conceptual structure of OFHEO's default models is the identification of two types of loans, "cash purchases" and "negotiated transactions." Freddie Mac believes that this distinction is both poorly defined and inappropriate.

In the NPR2, the following description is provided regarding these loan types:

> Separate default equations are used to distinguish between loans acquired through: one, cash purchases and two, negotiated transaction. In a cash purchase, an Enterprise acquires a newly originated loan that meets standard underwriting guidelines; the purchase can include

> recourse to the seller/servicer. In a negotiated transaction, an Enterprise generally acquires a pool of seasoned, nonconforming loans.[280]

It is noteworthy that neither this passage nor any other portion of the NPR2 provides formal guidance to the Enterprises on how to classify loans as either cash purchases or negotiated transactions. Thus, it is not surprising that despite significant effort, Freddie Mac has been unable to replicate OFHEO's starting positions for cash purchases and negotiated transaction loan balances. Freddie Mac believes that this inability to replicate OFHEO's loan classifications is symptomatic of an inappropriate delineation of its multifamily mortgage business into two segments. There are three reasons that this delineation is inappropriate. First, as mentioned in the Background section above, all Freddie Mac multifamily mortgages are underwritten to the same standards, regardless of whether they are held in portfolio or swapped for mortgage-backed securities. Second, not all of Freddie Mac's pool purchases or swaps consist of seasoned mortgages. Third, the assumed link between funding execution and credit risk is simply not representative of how Freddie Mac manages its business. Consequently, we believe that OFHEO should revisit these definitions and consider replacing its two models with a single default model that is applicable to all current multifamily mortgage programs.

Prepayment models

Our primary criticism of the prepayment models is that they fail to recognize the unique features of current multifamily mortgages, including prepayment penalties, prepayment lock-out periods, and other structures that effectively limit prepayments during most of the mortgage term. These features do not simply make it less advantageous for a borrower to prepay, they frequently make it either impossible or highly uneconomic. For most of Freddie Mac's multifamily mortgages, the existing yield maintenance provisions are structured so that Freddie Mac is immunized against loss in the event of a prepayment. These prepayment provisions are a critical component of the Enterprises multifamily interest-rate risk management strategy and to improperly model them distorts the risks inherent in this business.

This is not to say that prepayments inside yield maintenance never occur, but that they are very rare events; and when these loans do prepay Freddie Mac is compensated. In recent Freddie Mac experience, slightly less than four percent of all mortgages originated since 1993 have prepaid inside yield maintenance. Recent research by Fu, LaCour-Little and Vandell supports this finding and demonstrates that prepayments on multifamily mortgages with yield maintenance provisions of the type used by Freddie Mac are extremely low and insensitive to the type of relative spread variable used by OFHEO.[281]

The low level of recent prepayments, combined with the explicit penalty associated with prepayment mean that there is relatively little need to statistically model prepayments within

[280] NPR2 § 3.5.4.3.

[281] Qiang Fu, Michael LaCour-Little, and Kerry D. Vandell, "Multifamily Prepayment Behavior and Prepayment Penalty Structure," Paper presented at the 2000 Meetings of the Allied Social Sciences Association, Boston, MA.

yield maintenance periods. Instead, more accurate, less volatile and vastly simpler prepayment rules should be adopted.

OFHEO's approach to prepayments outside of yield maintenance is also unnecessarily complex. NPR2 specifies three separate prepayment equations for fixed-rate mortgages outside of yield maintenance, with each model explaining performance over a very brief time period. For example, the yield maintenance period is typically 9.5 years for a ten-year balloon mortgage (one of Freddie Mac's most common products), which means that the OFHEO prepayment equation for balloon loans outside of yield maintenance pertains to a very small (three to six month) window in the life of the mortgage. Similarly, modeling the prepayment of a mortgage beyond the balloon period (another OFHEO prepayment equation) is difficult because such prepayments are usually resolved on a case by case basis. Capturing the details of such prepayments in a statistical model is a great challenge.

Loss severity models

In general, the methodology OFHEO uses to construct its loss severity models is appropriate; however, we believe that the underlying data are inappropriate and flawed for many of the reasons discussed above. OFHEO bases all its analysis on the severity experienced by mortgages underwritten under Freddie Mac's old regime which is not representative of current Enterprise business practices. While OFHEO did make adjustments to the default characteristics of the old book of business at both Enterprises, it failed to adjust the historical information on severity. We believe that appropriate adjustments to the old regime data, or analysis of more recent data, would indicate much lower loss severity rates. Such a view is supported by recent research, as described below.

Analysis of model results

A measure of the degree to which the proposed models are flawed is seen in the counter-intuitive results that they produce. For example, OFHEO's NPR2 estimates of the incremental capital required by the Enterprises for different multifamily loans suggests that a 15-year Balloon with an LTV ratio of 70 percent would require incremental capital of -0.10 percent and -1.31 percent, in the up-rate and down-rate scenarios respectively.[282] Both of these numbers are negative, indicating that Freddie Mac would not need to hold any capital for this particular loan type. In fact, if Freddie Mac were to increase its volume of mortgages of this type, it could actually reduce its total capital requirements.

While negative capital requirements are clearly inappropriate, it is not our objective to have OFHEO simply raise capital standards on all products to ensure that they are always positive. Such a response would not ensure that capital was allocated properly among mortgage products and types. Instead, we cite examples such as this to illustrate the flaws in the current proposed rule and to motivate its replacement with a rule that ties capital to risk, and provides more reasonable and stable results.

Another example is provided in the down-rate scenario, where most loans are predicted to prepay within two years and the present value of credit losses on a benchmark ten-year balloon mortgage with a yield maintenance provision, a DCR of 1.5 and an LTV ratio of 70

[282] NPR2 at 18106 (Table 13).

percent is under 10 basis points. Even under non-stressful economic scenarios, we might expect such a loan to have credit losses well in excess of this amount. Similarly, the models predict only modest variation in credit losses between loans with varying DCR and LTV ratios, the key measures of financial risk employed by multifamily lenders and investors. Yet they predict significant variation between loans of different ages. The 15-year balloon mortgage described above that would have an incremental -0.10 percent capital requirement in the up-rate scenario if it were new would have a 3.15 percent incremental capital requirement if it were five years old.[283] Aside from being much too high a level, this suggests a massive increase in the risk exposure associated with a loan that has not experienced any economic stress and which has been performing for five-years. We know of no empirical analysis or economic theory that supports such a steep increase in the risk profile of a performing loan in the absence of information problems and view this as both an unacceptable and counterproductive feature of the proposed model.

Comparison to industry measures of risk

In assessing the ultimate capital requirements implied by OFHEO's multifamily models it is useful to gauge the consistency of OFHEO's results with levels implied by objective third-parties, including rating agencies and industry analysts. It is also instructive to compare the relative stringency of OFHEO's proposed capital requirements for multifamily and single-family mortgages of comparable risk. In general, we find that by most industry benchmarks, OFHEO's proposed capital levels are too low, too insensitive to observable risk characteristics, such as DCR, LTV and balloon risk, and too sensitive to seasoning effects.

For example, we believe that cumulative (nominal) credit losses for one of our typical mortgages — a ten-year balloon with a 1.50 DCR — ought to be in the vicinity of four to six percent of the original amount of the mortgage, depending on the specific loan terms. Indeed, this range is consistent with the subordination levels assigned by rating agencies to the A and AA tranches of commercial mortgage-backed securities (CMBS) after adjustments are made for operations and management risk and the greater geographical diversification of Freddie Mac's portfolio relative to the typical CMBS. As noted earlier, the OFHEO model produces estimates of cumulative credit losses that are much lower than this.

There are several other notable attributes of the rating agencies' approaches to establishing subordination levels for CMBS that can inform a risk-based capital standard for multifamily mortgages. Among these are the following:

- Prepayments are not modeled.
- Subordination levels increase sharply as DCRs decrease below 1.5.
- A significant proportion of total defaults occur in the year in which balloon payments are due.
- Loss severity rates are in the 40 to 50 percent range.

[283] *Id.*

- Significant weight is attached to the quality of underwriting standards, management and the geographic diversification of the portfolio.

While not all of these attributes are equally relevant to the Enterprise's portfolios, we believe that they represent a set of reasonable standards that OFHEO should look to in devising its multifamily capital requirement.

In addition, strong support for a Freddie Mac multifamily capital requirement of one to two percent (and nominal credit losses of between four and six percent) is provided by an independent study by the consulting firm Property and Portfolio Research (PPR). PPR was engaged by Freddie Mac to independently model the credit losses that would be sustained under OFHEO's specified up-rate and down-rate stress scenarios given the parameters of Freddie Mac's existing portfolio. PPR's report states, "It is our opinion that a reasonable capital reserve for the Freddie Mac portfolio based on OFHEO's scenarios should be based upon expected [nominal] credit costs of approximately 600 basis points." See *Appendix 6* for a copy of this report.

One final test of the reasonableness of OFHEO's proposed treatment of multifamily credit risk is a comparison of the credit losses of single-family and multifamily mortgages of comparable risk. Based on Freddie Mac's analysis of OFHEO's single-family proposal, the median single-family product, a new 30-year, fixed-rate, 80 percent LTV mortgage would experience nominal credit losses of approximately 1.4 percent in the down-rate scenario and 2.4 percent in the up-rate. This may be contrasted with a typical multifamily product, a ten-year, fixed-rate balloon, with a 9.5-year yield maintenance period and a DCR of 1.5 and an LTV ratio of 0.65 percent. This product would have nominal credit losses of 0.1 percent in the down rate, and 3.5 percent in the up rate. Aside from the excessive variation between the up-rate and down-rate performance of multifamily, these results suggest that the ratio of single-family to multifamily losses may be too low.

The basis for this contention is both an industry judgment that multifamily credit losses should be approximately three times single-family credit losses, and an empirical observation from thrift performance. According to the OTS, the median quarterly charge-off rate for single-family mortgages from 1990 to the present has been 0.05 percent. The comparable rate for multifamily mortgages has been 0.15 percent, or exactly three times the single-family rate.[284] Based on a ratio of three, the appropriate nominal multifamily credit losses for the median multifamily product, given OFHEO's current single-family proposal, would be 4.2 percent in the down-rate scenario and 6.2 percent in the up rate scenario. This range is entirely consistent with CMBS subordination levels, and the independent PPR analysis.

Although the above benchmarks all include implicit assumptions regarding loss severity rates, we believe that a separate reexamination of the third-party evidence regarding loss severity rates is also necessary to ensure a clear understanding of recent empirical findings. In its analysis of loss severity rates, OFHEO examined and referenced several published studies, both from the academic literature, and from major rating agencies.[285] However, it

[284] Office of Thrift Supervision/1998 Fact Book: A Statistical Profile on the United States Thrift Industry at Table 5.7 (June 1998).
[285] NPR2 at 18212.

appears that OFHEO disregarded the results from those studies and instead choose to base its loss severity rates exclusively on Freddie Mac's limited data on losses from 1990 to 1995. We believe that a closer reexamination of the data and the existing literature would reveal that loss severity rates of 40 to 50 percent are more representative of industry experience and more appropriate for Enterprise business. This is seen in the results of several recent studies that are described below.

First, a recent study by Esaki, L'Heureux and Snyderman found that the average severity of loss on liquidated loans for the entire 1972-1997 period is 37.7 percent, including foregone interest and expenses.[286] This is slightly greater than the 36 percent severity reported in an earlier study by Snyderman.[287] However, it should be noted that the weighted average loss severity for loans that were foreclosed and subsequently sold in the 1992 to 1997 period is slightly higher at 43.8 percent.

Second, research by Ciochetti also supports loss severity rates in the 30 to 40 percent range. In a 1997 study, Ciochetti examines losses associated with foreclosure on 2013 loans and finds recovery rates slightly greater than 69 percent (*i.e.*, 31 percent loss severity) of the outstanding loan balance.[288] In a similar study in 1998 with Riddiough, he analyzes losses on 480 commercial (144 multifamily) mortgages at a large life insurance company that were originated from 1974 to 1990 and foreclosed on between 1985 to 1995. This study finds that net loss recovery through the time that the property title is transferred to the lender is approximately 70 percent (78 percent for multifamily) based on appraised value at the time of foreclosure.[289] Since this estimate does not include carrying or disposition costs incurred after property acquisition, it understates the loss severity rate that is applicable to the Enterprises. The amount of this understatement is likely to be between five and 15 percent based on average property inventory times and carrying and sales costs.

Finally, evidence from Fitch IBCA, a major rating agency for CMBS, suggests significantly lower loss severity rates than those proposed by OFHEO. A 1998 publication from Fitch says "On balance, Fitch IBCA estimates a loss factor of approximately 40-50 percent of the loan amount for defaulted loans for typical pools. This loss level holds for most investment grade categories."[290]

In NPR2, OFHEO cites a 1996 Fitch study as support of its loss severity rates. OFHEO states that "Adding the cost components here [from Freddie Mac data] produces a 54 percent loss severity. This sum is comparable to what is reported by Fitch (1996) in its

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[286] Esaki, Howard, L'Heureux, Steven, and Mark P. Snyderman, "Commercial Mortgage Defaults: An Update," *Real Estate Finance 16* at 83 (1999).
[287] Snyderman, Mark P., "Update on Commercial Mortgage Defaults," *Real Estate Finance 12* at 22-32 (1994).
[288] Ciochetti, Brian A., "Loss Characteristics Associated with Commercial Mortgage Foreclosure," *Real Estate Finance 14* at 53-69 (1997).
[289] Ciochetti, Brian A. and T.J. Riddiough, "Timing, Loss Recover, and Economic Performance of Foreclosed Commercial Mortgages," *working paper, University of North Carolina and MIT*, 1998.
[290] Fitch IBCA, Commercial Mortgage Stress Test Research, *Structured Finance Special Report* at 6 (Oct. 23, 1998).

study of commercial mortgage foreclosures. Fitch reports a 56 percent average loss severity rate on foreclosures."[291] However, our reading of this study does not support this interpretation. Consider the following passage from the Fitch study, "The average loss severity of approximately 37 percent of the original loan balance is surprisingly high considering the mild economic climate during which the loans were resolved. This high loss rate may reflect the property quality and the quality of underwriting that was characteristic of the thrift industry. Indeed 477 of the 547 loss observations are on loans in the RTC transactions."[292] The report continues to provide the loss distribution for its sample. This distribution includes a mean loss rate of 36.9 percent, a median loss rate of 27.0 percent, and first and third quartile loss rates of 1.4 percent and 63.7 percent respectively. Thus, we do not find support for OFHEO's 56 percent loss rate.

Based on the above evidence, Freddie Mac believes that the consensus estimate regarding loss severity rates is within the 40 to 50 percent range, which we believe should be the basis for the loss severity rate employed by OFHEO. The observed rate on Freddie Mac old book loans is not representative of current Enterprise business practices, and thus is an inappropriate basis for a capital requirement.

Recommendations

Freddie Mac understands the inherent difficulties in building structural econometric models of multifamily mortgage default and prepayment. This is why we believe that such models are not a worthwhile pursuit for OFHEO at this time. Instead, we recommend that OFHEO adopt a simplified, yet statistically-based approach to assessing multifamily mortgage risk. Such an approach would seek to explain credit losses in terms of simple, observable mortgage risk characteristics, such as the DCR and LTV ratio, in a way that is consistent with how an underwriter would assess risk *ex ante*.

Furthermore, we believe that the limitations in the underlying data compel OFHEO to consider proposed rules in terms of outcomes (as measured in terms of capital levels, cumulative default rates, or nominal credit losses). Thus, while statistical estimation should inform OFHEO's proposed rule, that rule need not be bound by it, particularly when such estimations produce counter intuitive results. Similarly, OFHEO should allow external benchmarks, such as CMBS subordination levels and the internal business judgment of the Enterprises and other industry participants, to influence its proposals. We believe that such benchmarks and industry perspectives should serve as a litmus test for OFHEO's current and future multifamily capital proposals until the available multifamily mortgage data permit reliable econometric modeling. This is the only way that OFHEO can "reasonably relate" multifamily credit losses to the benchmark loss experience, given the existing data limitations.

Based on these general principles, we believe the following specific objectives represent standards that OFHEO should achieve with a multifamily capital standard:

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[291] NPR2 at 18213.

[292] Fitch Investors Service, *Trends in Commercial Mortgage Default Rates and Loss Severity*. *Structured Finance Special Report* (Nov. 11, 1996).

- OFHEO should evaluate multifamily capital requirements by comparing them with external benchmarks and the business judgment of the Enterprises and other industry participants to ensure that data limitations do not distort the relationship between capital and risk.
- Credit risk should be a function only of observable mortgage characteristics, including original LTV, current DCR and balloon payment risk.
- Risk assessments should be based on the most recent and most reliable information available regarding current or original loan characteristics.
- There should be a single default model for mortgages underwritten to Enterprise quality standards. To capture the risk inherent in alternative mortgage types or underwriting policies, appropriate credit-risk add-ons should be developed and applied.
- Prepayments should not be explicitly modeled, but governed by simple prepayment rules.
- Loss severity rates should be consistent with recent Enterprise and industry experience.

In order to achieve these specific objectives, we propose a model-based approach that is described below. This is only one way that OFHEO could achieve these objectives, there are numerous others. However, whatever approach OFHEO adopts, the ultimate results should be consistent with those generated by our recommended approach, which are provided in *Table 9* through *Table 14* at the end of this section. These tables, which provide recommended cumulative default, nominal credit loss, and discounted credit loss figures for the down-rate and up-rate scenarios, respectively, should not be viewed as model dependent. Rather, one of the evaluation criterion that should be applied to any proposed model or methodology should be: does it generate similar results to those provided below? If not, it does not meet the first objective listed above, that the proposed rule should be consistent with external benchmarks and Enterprise business judgment. This is also why OFHEO's evaluation of the multifamily stress test scenario can not be conducted independently of its development of credit risk models, as was discussed in *Multifamily Economic Environment*.

One final point worth emphasizing is that our proposed cumulative default rates, nominal credit losses, and discounted credit losses are, on average, significantly higher than the levels recommended by OFHEO. Thus, we are not proposing a weaker capital standard — we are arguing for a stricter standard, and one that more closely ties capital to risk.

Our specific proposal is divided into three sections: defaults equations, prepayment rules, and loss severity rate. Each is presented below.

Default equations

Our proposed approach to constructing annual conditional default rates (cdr) is to employ the binomial logistic framework using the following specification:

$$\log\left(\frac{cdr}{1-cdr}\right) = a + b_1 cDCR + b_2 oLTV + b_3 Balloon\_Year * YTB + b_4 LO\_cDCR + b_5 Old\_Book$$

where cDCR is the current DCR as determined by the Enterprise's annual inspection data (adjusted in simulations according to the economic scenario parameters of the stress test);

oLTV is the original LTV ratio; Balloon-Year is a dummy variable that takes the value of one for a balloon mortgage that is within 12 months of the balloon payment date, and 0 otherwise; YTB is the number of years until the balloon payment is due; LO_cDSCR is a dummy variable that takes the value of one if the cDCR is equal to or less than one, and zero otherwise; and Old_Book is a dummy variable that takes on the value of one if a loan was originated under the Enterprises original multifamily programs, and zero otherwise.

Until more reliable data exist and permit accurate statistical estimation, use the following parameters in the above model:

α = -4.3881

β_1 = -1.0283

β_2 = 2.2697

β_3 = 0.1800

β_4= 1.000

β_5= 0.1649

The basic model is captured by the first three variables, which establish both a baseline default rate, and a rate that varies by the current DCR and original LTV, two key drivers of mortgage performance that are observable to an underwriter. While current LTV would in principle be preferable to original LTV, current LTV is difficult to assess in the absence of arm's length transactions.

It is also noteworthy that the proposed parameters for the first three variables represent the actual coefficients that Freddie Mac obtained when it estimated the above model using estimates of cDCR based on MSA vacancy rates and CPI growth.[293] As such, they satisfy OFHEO's desire to employ a statistically-based model of mortgage default; in addition, these particular coefficients generate capital estimates consistent with available external benchmarks.

The last three variables, for which coefficients were not estimated, represent balloon year risk, a low current DCR add-on, and regime shift respectively. The balloon year risk add-on is designed to add approximately 20 percent of the total defaults that would otherwise occur during the OFHEO stress period to the year in which a balloon payment is due. This is consistent with rating agency perceptions of balloon year risk and it represents an unequivocal increase in total credit costs. Similarly, the low DCR ratio add-on, which is applied to loans with DCR ratios equal to or under one, is designed to increase annual default rates for loans that may be viewed as experiencing financial difficulty to ensure such loans are adequately capitalized. The last variable, the Old_Book variable represents the type of regime shift that OFHEO acknowledges and includes in its models.[294] The value of the Old_Book coefficient is less than would be obtained from an analysis of the relative performance of all Old Book and New Book loans. This is appropriate since this

[293] These models were estimated without the adjustments to the data made by OFHEO since such wholesale modifications to the data are likely to bias downward the estimated coefficients.
[294] NPR2 at 18203.

coefficient is not being used to explain historical loan performance, but rather to forecast the future performance of surviving Old Book loans. These loans, by virtue of surviving, are likely to have relatively little Old Book underwriting risk. Thus this coefficient is smaller than it would if it were based strictly on historical performance differences.

In order to update the current DCR during stress test simulations, OFHEO should use its existing method for calculating the contemporaneous DCR using the economic scenario parameters (including the mortgage interest rate in the case of adjustable-rate mortgages). One of the advantages of this approach is that the proposed model makes the difficult task of imputing price changes during the stress period unnecessary. However, as a result, it is critical that OFHEO retain its current rent and vacancy scenarios. This is because the proposed model parameters have been calibrated using that scenario to generate appropriate credit losses in the stress test. Thus, any changes in the definition of the stress test environment would need to be offset by changes in the statistical model parameters. This trade-off between stress test severity and model parameters is discussed in the *Multifamily Economic Environment* section.

In the event that Enterprise loan records do not provide a current DCR, we would propose that OFHEO either use the last recorded DCR or mark-to-market the DCR using the average change in rents in the corresponding MSA, whichever is lower. Thus, the Enterprises would be effectively penalized if they do not keep their operating data current.

It is not yet possible to empirically test the structure of the proposed model, due to data limitations. However, once sufficient, accurate historical data exist regarding Enterprise recorded current debt-service coverage ratios, OFHEO will be able to empirically test this model and if necessary update the parameters. In this way the structure of the model will be stable and predictable, yet the exact risk weightings will evolve as reliable data become available.

While this proposal would be appropriate for loans that are either directly underwritten by the Enterprises or underwritten with strict adherence to Enterprise guidelines, loans that are either not underwritten in this manner or for which critical information is not properly recorded, should receive a credit risk add-on. We propose that OFHEO develop criteria for the application of credit-risk add-ons of up to 30 percent for these loans, with the actual add-ons determined based on program specific analysis. In doing this, we strongly encourage OFHEO to eliminate its confusing, and inaccurate designation of Enterprise multifamily mortgages as either cash purchases or negotiated transactions.

Prepayment rules

As discussed above, most of the Enterprise's multifamily loans are governed by prepayment provisions that severely limit both the incidence of and economic sensitivity to prepayments. Thus, we recommend the following prepayment rules that will minimize the volatility associated with overly complex and potentially misspecified prepayment models.

Fixed-rate mortgages

In the up-rate scenario assume zero prepayments. In the down-rate scenario, assume zero prepayments within yield maintenance periods and an annual equivalent conditional prepayment rate of 25 percent for loans outside of yield maintenance.

Adjustable-rate mortgages

For adjustable-rate mortgages, we propose the same general rules as described above, except that since the contemporaneous DCR will vary with interest rates, we recommend a slight refinement. Specifically, if the loan has a contemporaneous DCR (using the current interest rate) of less than 1.20, the monthly conditional prepayment rate should be zero percent.

In the event that OFHEO chooses to have non-zero prepayment rates for loans within yield maintenance periods, OFHEO must model the cash inflows to the Enterprises resulting from prepayment penalties. These cash inflows should be determined by the exact terms of each loan contract.

Loss severity rate

Our recommendation for loss severity rates is to use a single, invariant loss rate of 45 percent. As noted above, this is consistent with both recent evidence from the Enterprises and a number of published studies and industry practices.

Conclusion

There are numerous advantages of this approach, several of which have already been described. However, it is worth summarizing them again here. Under our proposed approach, capital requirements would be:

- Tied directly to mortgage risk factors — DCR, LTV ratios, and balloon year risk.
- Based on up-to-date and observable mortgage characteristics — minimizing the volatility associated with model and measurement error.
- Consistent with industry benchmarks.
- Simple, transparent and easily implemented by the Enterprises and third parties.
- Easy to update by OFHEO as new and better data become available.
- Able to accommodate new products or modifications to existing products through the application of credit-risk add-ons.

Proposed results

The following tables present the cumulative default rates, nominal credit loss rates, and present value credit loss rates that Freddie Mac generated using our proposed behavioral models and OFHEO's third-quarter 1997 rent, vacancy and interest-rate scenario. These rates all pertain to a fixed-rate mortgage with an eight percent note rate, a ten-year term, a 9.5-year yield maintenance period and a 30-year amortization period.

LTV	Debt Coverage Ratio (DCR)																						
	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
1.10	0.69	0.65	0.59	0.48	0.40	0.38	0.36	0.35	0.33	0.31	0.30	0.29	0.27	0.26	0.25	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16
1.05	0.65	0.61	0.55	0.44	0.36	0.35	0.33	0.32	0.30	0.29	0.27	0.26	0.25	0.24	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15
1.00	0.61	0.57	0.51	0.41	0.33	0.32	0.30	0.29	0.27	0.26	0.25	0.24	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.13
0.95	0.57	0.54	0.47	0.37	0.30	0.29	0.28	0.26	0.25	0.24	0.23	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.13	0.13	0.12
0.90	0.54	0.50	0.44	0.34	0.28	0.26	0.25	0.24	0.23	0.22	0.20	0.19	0.18	0.17	0.17	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11
0.85	0.50	0.46	0.40	0.31	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10
0.80	0.46	0.43	0.37	0.29	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09
0.75	0.43	0.39	0.34	0.26	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.14	0.14	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08
0.70	0.39	0.36	0.31	0.24	0.19	0.18	0.17	0.16	0.15	0.14	0.14	0.13	0.12	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07
0.65	0.36	0.33	0.28	0.21	0.17	0.16	0.15	0.14	0.14	0.13	0.12	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06
0.60	0.33	0.30	0.26	0.19	0.15	0.15	0.14	0.13	0.12	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06
0.55	0.30	0.27	0.23	0.18	0.14	0.13	0.12	0.12	0.11	0.11	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05
0.50	0.27	0.25	0.21	0.16	0.13	0.12	0.11	0.11	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05
0.45	0.25	0.23	0.19	0.14	0.11	0.11	0.10	0.10	0.09	0.08	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04

Table 9: Multifamily: Cumulative Stress Test Default Rate - Up-Rate Scenario

LTV	Debt Coverage Ratio (DCR)																					
	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
1.10	0.31	0.29	0.26	0.21	0.18	0.17	0.16	0.16	0.15	0.14	0.13	0.13	0.12	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07
1.05	0.29	0.28	0.25	0.20	0.16	0.16	0.15	0.14	0.14	0.13	0.12	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07
1.00	0.28	0.26	0.23	0.18	0.15	0.14	0.14	0.13	0.12	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06
0.95	0.26	0.24	0.21	0.17	0.14	0.13	0.12	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05
0.90	0.24	0.22	0.20	0.15	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05
0.85	0.22	0.21	0.18	0.14	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04
0.80	0.21	0.19	0.17	0.13	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04
0.75	0.19	0.18	0.15	0.12	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04
0.70	0.18	0.16	0.14	0.11	0.08	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03
0.65	0.16	0.15	0.13	0.10	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03
0.60	0.15	0.14	0.12	0.09	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
0.55	0.14	0.12	0.11	0.08	0.06	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02
0.50	0.12	0.11	0.10	0.07	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02
0.45	0.11	0.10	0.09	0.06	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02

Table 10: Multifamily: Nominal Cumulative Credit Losses - Up-Rate Scenario

LTV	Debt Coverage Ratio (DCR)																						
	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
1.10	0.22	0.21	0.19	0.15	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05
1.05	0.21	0.20	0.18	0.14	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04
1.00	0.20	0.18	0.16	0.12	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04
0.95	0.18	0.17	0.15	0.11	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03
0.90	0.17	0.16	0.14	0.10	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03
0.85	0.16	0.15	0.13	0.09	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03
0.80	0.14	0.13	0.12	0.09	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02
0.75	0.13	0.12	0.11	0.08	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02
0.70	0.12	0.11	0.10	0.07	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
0.65	0.11	0.10	0.09	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.60	0.10	0.09	0.08	0.06	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.55	0.09	0.08	0.07	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
0.50	0.08	0.08	0.07	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
0.45	0.08	0.07	0.06	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01

Table 11:Multifamily: Present Value of Cumulative Credit Losses - Up-Rate Scenario

LTV	Debt Coverage Ratio (DCR)																						
	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
1.10	0.71	0.67	0.60	0.49	0.42	0.40	0.38	0.37	0.35	0.34	0.32	0.31	0.29	0.28	0.27	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18
1.05	0.68	0.63	0.56	0.46	0.38	0.37	0.35	0.34	0.32	0.31	0.29	0.28	0.27	0.25	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16
1.00	0.64	0.59	0.52	0.42	0.35	0.34	0.32	0.31	0.29	0.28	0.27	0.26	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.15
0.95	0.60	0.55	0.49	0.39	0.32	0.31	0.29	0.28	0.27	0.26	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.13
0.90	0.56	0.52	0.45	0.36	0.29	0.28	0.27	0.26	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.13	0.13	0.12
0.85	0.52	0.48	0.42	0.33	0.27	0.26	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11
0.80	0.49	0.44	0.38	0.30	0.24	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10
0.75	0.45	0.41	0.35	0.27	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09
0.70	0.41	0.38	0.32	0.25	0.20	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08
0.65	0.38	0.34	0.29	0.23	0.18	0.17	0.16	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07
0.60	0.35	0.31	0.27	0.20	0.16	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06
0.55	0.32	0.29	0.24	0.19	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06
0.50	0.29	0.26	0.22	0.17	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05
0.45	0.27	0.24	0.20	0.15	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05

Table 12: Multifamily: Cumulative Stress Test Default Rate - Down-Rate Scenario

LTV	Debt Coverage Ratio (DCR)																					
	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
1.10	0.32	0.30	0.27	0.22	0.19	0.18	0.17	0.17	0.16	0.15	0.14	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.09	0.08
1.05	0.30	0.28	0.25	0.21	0.17	0.17	0.16	0.15	0.14	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.07
1.00	0.29	0.27	0.24	0.19	0.16	0.15	0.14	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.07	0.07
0.95	0.27	0.25	0.22	0.18	0.15	0.14	0.13	0.13	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06
0.90	0.25	0.23	0.20	0.16	0.13	0.13	0.12	0.12	0.11	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05
0.85	0.24	0.22	0.19	0.15	0.12	0.12	0.11	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05
0.80	0.22	0.20	0.17	0.13	0.11	0.10	0.10	0.09	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04
0.75	0.20	0.18	0.16	0.12	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04
0.70	0.19	0.17	0.14	0.11	0.09	0.09	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04
0.65	0.17	0.15	0.13	0.10	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03
0.60	0.16	0.14	0.12	0.09	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03
0.55	0.14	0.13	0.11	0.08	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
0.50	0.13	0.12	0.10	0.08	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02
0.45	0.12	0.11	0.09	0.07	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02

Table 13: Multifamily: Nominal Cumulative Credit Losses - Down-Rate Scenario

LTV	Debt Coverage Ratio (DCR)																						
	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00
1.10	0.29	0.27	0.24	0.19	0.16	0.15	0.15	0.14	0.13	0.13	0.12	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07
1.05	0.27	0.25	0.23	0.18	0.15	0.14	0.13	0.13	0.12	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.06
1.00	0.26	0.24	0.21	0.17	0.13	0.13	0.12	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06
0.95	0.24	0.22	0.19	0.15	0.12	0.12	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05
0.90	0.22	0.21	0.18	0.14	0.11	0.11	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05
0.85	0.21	0.19	0.17	0.13	0.10	0.10	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04
0.80	0.19	0.18	0.15	0.12	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04
0.75	0.18	0.16	0.14	0.11	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.03
0.70	0.16	0.15	0.13	0.10	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03
0.65	0.15	0.14	0.12	0.09	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
0.60	0.14	0.12	0.11	0.08	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
0.55	0.13	0.11	0.10	0.07	0.06	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02
0.50	0.11	0.10	0.09	0.07	0.05	0.05	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
0.45	0.10	0.09	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Table 14: Multifamily: Present Value of Cumulative Credit Losses - Down-Rate Scenario

D. Commitments

The proposed treatment of mortgage purchase commitments results in a risk-based capital requirement that is much greater than the current minimum capital requirement. The high capital requirements for commitments could lead to changes in Enterprise business practices. The proposed approach also does not recognize the effect of credit enhancements on mortgages delivered under commitments. Freddie Mac recommends that the treatment of commitments include credit enhancements based on Enterprise experience in the six months preceding the stress test.

Background

Mortgage originators want certainty about what mortgages the secondary market will purchase, and at what prices, in order to determine what products and rates to offer. The mortgage purchase commitment process provides that certainty. As a regular business practice, each Enterprise makes contractual commitments to its customers to purchase mortgages or issue new securities for periods that may extend from a few weeks up to a year. If an Enterprise intends to securitize the mortgages listed in the commitment, the Enterprise will hedge the commitment at the time it is executed by selling the mortgages forward.

The Act directs that no purchases of mortgages ("new business") shall be assumed by OFHEO except after consideration of additional studies as specified in the Act.[295] The Act also directs that "any contractual commitments of the enterprise to purchase mortgages or issue securities will be fulfilled" during the stress test.[296] In addition, the Act requires that "characteristics of resulting mortgage purchases, securities issued and other financing shall be consistent with the contractual terms of such commitments, recent experience and the economic characteristics of the stress period."[297]

Proposal

In NPR2, OFHEO proposes to define "commitment" as it does in its minimum capital regulation.[298] Specifically, NPR2 defines commitment as "any contractual, legally binding agreement that obligates an Enterprise to purchase or securitize mortgages." This definition covers both "mandatory" and "optional" commitments, including commitments that do not specify fixed prices or volume but otherwise legally bind an Enterprise.[299]

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[295] The Act § 1361(a)(3)(A).
[296] *Id.*
[297] *Id.*
[298] NPR2 § 3.2; Tables 3-7; 3-8 and 3-9. *See also* 12 C.F.R. § 1750.2 (OFHEO's Minimum Capital Regulation).
[299] *See* NPR2 at 18162. As defined by OFHEO, "mandatory" commitments bind the seller to deliver and the Enterprise to accept a certain volume of mortgages. "Optional" commitments are delivery contracts that commit the Enterprises to purchase or swap a specified volume of loans but do not commit the seller to deliver any loans.

In the proposed stress test, OFHEO assumes that all loans delivered under commitments existing at the start of the stress period will be packaged into securities and sold.[300] Therefore, none of the mortgage commitments result in new investments for Freddie Mac that would go on the balance sheet. OFHEO explains that this specification avoids having OFHEO predict business decisions by the Enterprises that are "highly judgmental and impossible to predict accurately."[301]

To determine characteristics of mortgages delivered under commitments, OFHEO uses information obtained from the Enterprises on outstanding commitments at the start of the stress period and deliveries of loans originated in the six months preceding the stress period. In addition, OFHEO uses an interest rate series for the first twelve months of the stress period.[302] Based on this information, OFHEO determines characteristics of mortgages delivered under commitments and creates loan groups with coupon rates that vary based on the interest rate scenario. These loan groups are added to the Enterprise's sold portfolio and the proposed stress test projects their performance during the stress period.

In the down-rate scenario, the proposed stress test provides that 100 percent of the mortgages specified in the commitments are delivered. In the up-rate scenario, 75 percent of the mortgages specified in the commitments are delivered. Despite the terms of Enterprise contracts, the proposed stress test does not credit the Enterprises with income from pair-off fees for the 25 percent commitments that are not delivered in the up-rate. The timing of deliveries is front-loaded: loans are delivered over the first three months of the stress period in the down-rate scenario and the first six months in the up-rate scenario.[303]

Discussion

In the ANPR, OFHEO requested public comment on recommended approaches to commitments in the stress test.[304] Specifically, OFHEO asked for comment on how commitments should be defined; what basis, if any, OFHEO should simulate the fulfillment of outstanding commitments; what mix of products should be assumed; what delivery timing should be assumed and what assumptions OFHEO should make with regard to securitization versus retention in portfolio.[305]

In response to the ANPR, Freddie Mac pointed out that available data are too limited to be able to develop a direct experience based model of the change in delivery rate consistent with the changing economic conditions. Given such data limitations, Freddie Mac suggested a possible alternative approach.[306] Freddie Mac also suggested that OFHEO assume that the mortgages purchased in fulfillment of the outstanding commitments have the same characteristics as the current mortgage portfolio and noted

[300] NPR2 § 3.2. *See* also *id*. at 18163-4.
[301] *Id*. at 18163.
[302] *See; Id*. at § 3.2 *et seq*. (Commitments) and §3.3 (Interest Rates).
[303] *Id*.
[304] OFHEO's Advanced Notice of Proposed Rulemaking, 60 Fed. Reg. 7468 (Feb. 8, 1995) (ANPR)
[305] *Id*. at 7478 (Questions 54-58).
[306] Freddie Mac's Comments to ANPR (filed May 9,1995) at 139-152.

that analyzing recent purchases would be "problematic."[307] Freddie Mac also recommended that OFHEO assume that purchases would occur uniformly over the weighted average maturity of outstanding commitments.[308] In NPR2, OFHEO rejected Freddie Mac's proposed approach in response to the ANPR even though OFHEO agreed with many of Freddie Mac's assumptions, including those concerning data limitations.[309]

The approach to commitments OFHEO proposed in NPR2 is probably more complex than is warranted. Nonetheless, we have concluded that the proposed approach would be operationally workable. Moreover, we fully concur with the general rule stated by OFHEO in this section of the proposed regulation, *i.e.*, that the agency should avoid predictions of Enterprise business decisions (*e.g.*, how an Enterprise would finance and hedge interest rates associated with purchases) and thereby avoid introducing unnecessary assumptions about future Enterprise management which are inappropriate in a 'no new business' stress test.[310]

OFHEO's proposal does not account for the likely credit enhancements, such as primary mortgage insurance, that any mortgages delivered under commitments would have. It is likely that the general level of credit enhancement (of all types) evidenced in the reference data of mortgages origination for the six months preceding the stress period would persist for mortgages delivered under commitments after the start of the stress test. During Freddie Mac's attempts to replicate OFHEO's stress test results, OFHEO provided information indicating that they incorporated credit enhancement coverage in their implementation of the proposal.

The proposal also states, "for each loan group, set remittance cycle to the shortest available options for the Enterprise."[311] Freddie Mac's Adjustable Rate Mortgage (ARM) securities use the 75-day remittance cycle, which is not the shortest available option.

In general, the capital requirements for commitments appear quite high. In the down rate stress test OFHEO reported a requirement on commitments for Freddie Mac of 186 basis points. In the up rate stress test, OFHEO reported a requirement of 65 basis points.[312] These capital requirements are approximately eight and three times, respectively, the 22.5 basis points required by the minimum capital requirement. These high requirements partially arise from the failure to adjust the benchmark as we recommended in NPR1.[313]

If these numbers are not adjusted, the Enterprises will have strong economic incentives to reduce the use of long-dated contractual commitments to purchase mortgages. These capital charges are unlikely to affect the availability or cost of mortgages, but in the current environment, it is doubtful that commitments could support these capital levels.

[307] *Id.* at 149-150.
[308] *Id.* at 151.
[309] NPR2 at 18164.
[310] *Id.* at 18163.
[311] *Id.* at § 3.2.3.6.
[312] NPR2 at 18108.
[313] NPR1 Comment at 18-27.

Recommendation

We recommend that OFHEO explicitly state in the regulation that credit enhancements based on those provided in the preceding six months will be included in the modeling of credit losses and that securities resulting from the commitments will use the remittance cycle consistent with contractual terms of securities issued by the Enterprise.

E. Counterparty Credit Risk

Freddie Mac receives cash flows from a variety of contracts and investments, including mortgage credit enhancements, derivative contracts and investments in non-Freddie Mac securities. OFHEO proposes a "haircut"[314] approach to discount expected counterparty cash flows during the stress test. The proposed haircuts are extremely large and bear little relationship to an Enterprise's risks. The proposed haircuts would encourage the Enterprises to reduce reliance on counterparties for risk management and funding activities, thereby increasing the cost of these activities and, as a consequence, increasing mortgage interest rates to borrowers. Therefore, Freddie Mac recommends that the haircuts be reduced significantly to reflect expected counterparty performance. We also recommend that the capital required for counterparty credit risk be internally consistent with that required for mortgage credit risk.

Background

To varying degrees, non-performance by counterparties during the stress period would drain an Enterprise's capital resources to the extent that the Enterprise does not receive expected payments. The principal counterparty credit risks relevant to the stress period are described below.

Mortgage credit enhancements

Freddie Mac enters into several types of credit enhancement agreements, including primary mortgage insurance, lender recourse (including, but not limited to, lender indemnification and collateral pledge agreements) and pool insurance. Primary mortgage insurance typically applies to mortgages with LTVs above 80 percent. Under lender recourse, the institution selling the mortgage to Freddie Mac agrees to buy back the mortgage or otherwise fully compensate Freddie Mac for all losses Freddie Mac sustains in connection with the mortgage.

Mortgage pool insurance policies, also referred to as pool insurance, provide loss protection for a pool of mortgages, up to policy limits that generally are expressed as a percent of the UPB at the time the policy is issued. In a collateral pledge agreement, the seller/servicer places very high quality collateral, *e.g.*, Treasury securities or Freddie Mac securities, into an account at the time Freddie Mac purchases a pool of mortgages. Any default losses on any mortgage in the pool of mortgages covered by the collateral pledge agreement can be covered by liquidating the collateral that is in the account. Only after the account is depleted does Freddie Mac bear any default losses on the mortgages in the pool. Cash accounts are similar to collateral pledge agreements, with the exception that cash replaces the security pledged to Freddie Mac.

The portion of Freddie Mac's sold portfolio covered by some form of credit enhancement has increased significantly in the past few years. The types of credit enhancement included in NPR2 cover the majority of credit enhancements currently in use; however, several

[314] A haircut is a discount that reduces the expected cash flows due from a counterparty or a security by a specified percentage.

additional types of credit enhancement have been developed. New types of credit enhancements include tiered primary mortgage insurance, 1st loss, and Mortgage Default Recourse Notes (MODERNs). Tiered primary mortgage insurance employs two layers of mortgage insurance. 1st loss is a risk-sharing arrangement where Freddie Mac retains primary default risk up to a pre-determined amount, after which a third party becomes responsible for losses through an indemnification agreement. MODERNs is a re-insurance agreement that provides supplemental coverage through a third-party agreement. The third-party issues a series of bonds that effectively transfers credit risk for the guaranteed mortgages to the capital markets. Freddie Mac also structures credit risk on a deal-by-deal basis where risk is transferred by senior-subordinated transactions.[315]

Mortgage credit enhancements may be categorized into three groups. The first category consists of unsecured promises to pay. The amount of counterparty credit risk depends on the financial strength of the counterparty. Credit enhancements in this category include private mortgage insurance, pool insurance and lender recourse or indemnification. The second category consists of secured or collateralized obligations, which carry almost no counterparty credit risk. Pledged collateral and spread accounts are in this category. The third category is a combination of the first two. It requires a recourse counterparty to post collateral only when its credit rating or capital begins to deteriorate (a “trigger” event). This type of credit enhancement carries little counterparty credit risk so long as the trigger is set well above the institution’s insolvency and the institution is monitored closely and frequently. It does, however, carry operational risk because of the monitoring required.

Investments in non-Freddie Mac securities

Freddie Mac invests in mortgage-related securities other than its own PCs and unsecuritized mortgage loans. These securities consist principally of collateralized mortgage obligations, commercial mortgage-backed securities, mortgage revenue bonds and asset-backed securities. Freddie Mac invests in these securities under a stringent risk management framework. For example, certain mortgages that help fulfill Freddie Mac’s housing goals carry extra risks. In such instances, Freddie Mac may invest in a highly rated tranche of a security backed by these types of mortgages rather than investing in whole mortgages.

In addition, Freddie Mac maintains a liquidity and contingency investment portfolio used to manage recurring cash flows and meet other cash management needs, maintain capital reserves to meet mortgage funding needs, provide diverse sources of liquidity and help manage the interest-rate risk inherent in mortgage-related investments. This liquidity and contingency investment portfolio enables Freddie Mac to fulfill the purpose of providing a stable and reliable supply of mortgage credit nationwide. The liquidity and contingency investment portfolio consists primarily of Federal funds sold, reverse repurchase agreements and highly rated short-term and longer-term investments. Freddie Mac reduces the credit risk associated with investments in non-Freddie Mac securities by implementing numerous internal controls.

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[315] Another type of structured credit enhancement that Freddie Mac uses is a “wrap,” or supplemental insurance, provided by a bond insurer for some investments.

Derivatives contracts

Freddie Mac uses derivatives, both interest rate and foreign exchange contracts, in combination with underlying liabilities or assets to create "synthetic" debt instruments or interest-earning assets that achieve lower effective financing costs or higher effective asset yields than those available on alternative instruments. In addition, derivative financial instruments are used to reduce Freddie Mac's exposure to interest-rate risk.

With respect to the purchase of a derivative contract, counterparty credit risk arises from the possibility that the counterparty will be unable to perform according to the terms of the contract. Exchange-traded contracts, such as futures contracts, do not increase Freddie Mac's exposure to institutional credit risk as changes in the value of open exchange-traded contracts are settled daily. Freddie Mac limits its exposure to institutional credit risk on over-the-counter contracts by using master netting agreements. These agreements provide for the netting of all amounts receivable and payable under all transactions covered by the master agreement between Freddie Mac and a single counterparty in the event that the master agreement is terminated due to non-performance. Freddie Mac also manages the institutional counterparty credit risk associated with derivative financial instruments by dealing only with institutions having credit ratings among the highest available from major rating agencies, by limiting its exposure to any one counterparty, by regularly monitoring financial positions and by requiring collateral in most cases.

The activities described above are undertaken in an effort to manage risk or lower Freddie Mac's funding costs, which ultimately lowers housing costs for America's families.

Proposal

NPR2 proposes counterparty credit risk haircuts for stress test cash flows from mortgage credit enhancements, non-mortgage investments, mortgage-related securities and derivatives.[316] The proposed haircuts are implemented as reductions to contractual cash flows and are applied based on the credit rating of the counterparty for a given transaction. The proposed haircuts increase linearly through the stress test. Counterparty credit risk haircuts are proposed for mortgage credit enhancements, non-mortgage investments, mortgage-related securities and derivatives. An exact list of transactions subject to haircuts is not enumerated, but NPR2 states, "(w)here institutional credit risk is present, the stress test applies a discount factor, or "haircut," based on the credit rating of the counterparty."[317]

[316] NPR2 § 3.6.
[317] *Id.* at 18151.

Rating Category[318]	Cumulative Haircut for Mortgage Credit Enhancement and Securities Counterparties	Cumulative Haircut for Derivative Counterparties
AAA	10%	2%
AA	20%	4%
A	40%	8%
BBB	80%	16%

Table 15: Cumulative Haircut Proposed in NPR2

The proposed haircuts implicitly consist of two components: a default rate and a recovery rate. The default rate represents the percentage of a group of counterparties that default in a given period. Given a default, the recovery rate represents the share of par value that is returned to the Enterprise. The opposite of a recovery rate is a loss severity rate, which is the terminology used for mortgages. Given haircuts on the BBB category approaching 100 percent, Freddie Mac interprets OFHEO's proposed haircuts as very high default rates, with recovery rates of zero.

NPR2 imposes counterparty credit risk haircuts on contracts for private mortgage insurance, indemnification, recourse, spread accounts, collateral accounts, cash accounts and pool insurance. In the event that a mortgage is covered by more than one type of credit enhancement, "only the ratings of the counterparty providing the primary layer of coverage are used."[319] Haircuts for mortgage credit enhancements are applied based on the percentage of unpaid principal balance of the mortgages in each mortgage group for each rating level.

The proposal applies haircuts to cash flows for debt-linked and mortgage-linked derivatives, investments and investment-linked derivatives based on "the public rating of the [investment or derivative] counterparty and the year during the stress period in which the cash flow occurs."[320] The proposed haircuts apply to all investment cash flows at the instrument level. However, to account for netting agreements, the cash flows for debt-linked, mortgage-linked and investment-linked derivative contracts are added together (pay side and receive side) for all contracts with a given counterparty.[321] The haircut is applied to the net cash owed by the counterparty in that month. If the Enterprise owes the counterparty money, then no haircut is applied."

NPR2 proposes to apply haircuts to foreign exchange swaps without netting them against interest rate swaps. Haircuts are applied to the "pay" side of the swap rather than to the "receive" side, with the resulting loss on each swap transaction being equal to the haircut

[318] OFHEO adopts the Standard & Poor's nomenclature for its rating categories. In this Comment, Freddie Mac does the same.
[319] NPR2 § 3.6.3.2.
[320] *Id.* at §§ 3.9.3.3.6(n) and 3.9.4.3(g).
[321] *Id*.

amount.[322] The haircut applied to foreign currency swaps effectively increases the cost of synthetic debt.[323]

NPR2 proposes to allow credit ratings from Standard & Poor's Ratings Services, Moody's Investors Service, Duff & Phelps Credit Rating Company, and Fitch IBCA to assign haircuts for counterparty credit risk.[324] An exception is made for seller/servicers, for whom only ratings from Standard & Poor's and Moody's are used.[325] Credit ratings are required for all counterparties and securities. When no credit rating is available, a rating of BBB is assumed. Counterparties include mortgage insurers, pool insurers, seller/servicers and derivatives counterparties. Securities include mortgage-related securities (*e.g.*, mortgage revenue bonds, collateralized mortgage obligations, REMICs) and non-mortgage securities (*e.g.*, corporate and municipal bonds, asset-backed securities). The proposal appears to use the credit rating of the counterparty to assess the counterparty credit risk of mortgage credit enhancements and derivatives. For mortgage-related and non-mortgage securities the proposal specifies the use of the credit rating of the instrument. If credit ratings for a single counterparty or instrument vary among rating agencies, the lower rating is used.[326]

Discussion

By any measure, the non-mortgage counterparty haircuts proposed in NPR2 are extremely severe. The proposed haircuts represent enormous rates of default and loss for issuers of corporate bonds and other securities, as well as for mortgage credit enhancement providers. Losses of such magnitude place significant additional stress on the Enterprises — well beyond what would be consistent with the interest-rate shocks and mortgage credit losses specified in the Act. OFHEO includes only sparse justification to support its proposed haircuts, in sharp contrast to the sophisticated models that it uses to predict the behavior of mortgages during the stress period.

Methodology for determining haircuts

NPR2 describes the proposed haircuts as being based on rating agency approaches, specifically those of S&P and Duff & Phelps.[327] S&P's approach is described in its criteria for determining loss coverage requirements for mortgage-backed securities.[328] In that context, the rating agency discounts have some limited relevance in assessing the counterparty credit risk on mortgage insurance claims. The discounts have no direct relevance for assessing the counterparty credit risk of investments or derivatives.

The rating agency discounts are used to set support levels for structured finance securities, a task which bears only superficial resemblance to OFHEO's assessment of capital needs for the Enterprises. Structured finance vehicles are essentially rules governing the distribution of mortgage cash flows among subordinated tranches and senior mortgage-

[322] *Id.* at 18160.
[323] *Id.* at § 3.9.3.3.6(o).
[324] *Id.* at § 3.6.2.
[325] *Id.*
[326] *Id.* at § 3.7.2.2.
[327] *Id.* at 18154.
[328] "S&P's Structured Finance Criteria," Standard & Poor's Corporation (1988).

backed securities. The resemblance arises because subordinate tranches are available to assure that promised cash flows are paid to senior mortgage-backed security investors. However, these support levels must cover more risks than capital does, because structured financial vehicles have little ongoing risk management capability, no diversification across pools and no ability to retain earnings. In contrast, the Enterprises have strong risk management systems, diversification across many pools from across the country and many origination years and a strong earnings stream. Structured finance vehicles must support greater levels of risk, and rating agency criteria must be more conservative than capital rules for well-managed financial institutions. Rating agency assessment of mortgage insurer counterparty risks must be interpreted in the limited context of structured finance.

The rating agency approaches described above do not attribute any counterparty credit risk to AAA rated institutions. Explaining its proposed AAA haircut, OFHEO notes, "With respect to the absence of a rating category with zero defaults, Moody's data show that, in a difficult but far from severe environment, 3.2 percent of issuers rated Aaa at the beginning of 1983 defaulted within ten years."[329] OFHEO's justification for including haircuts for top-rated issuers cannot, however, survive close scrutiny. First, there were few AAA companies in 1983. As a result the 3.2 percent default rate has limited statistical significance and represents an extremely small number of defaults. Some of these defaults occurred for reasons other than insolvency.

OFHEO further justifies the relative relationship of its proposed haircuts by rating category on the basis of average ten-year cumulative corporate bond default rates provided in Moody's 1998 corporate bond default study.[330] Referring to this study, NPR2 notes that "(t)hese data suggest that the ten-year cumulative default rate roughly doubles for each one-level drop in rating category."[331]

OFHEO states that its proposed approach "[is] consistent with industry practice" and "draws on the best aspects of S&P's approach to modeling mortgage insurer performance, and Moody's corporate bond study in applying company defaults over time."[332] However, arbitrarily combining these two unrelated measures of default risk results in extremely large haircuts that are not related to risk.

With respect to derivative haircuts, NPR2 states, "OFHEO determined that reducing the haircuts for derivative counterparty risk by 80 percent from haircuts on other types of third party credit risk would provide appropriate recognition for Enterprise collateral agreements."[333] OFHEO provides no further explanation or reasoning for the choice of these haircut levels.

[329] NPR2 at 18155.
[330] Moody's Investors Service, "Historical Default Rates of Corporate Bond Issuers, 1920-1997" (Feb. 1998).
[331] NPR2 at 18154.
[332] *Id.* at 18155.
[333] *Id.* at 18159.

Magnitude of Haircuts

To understand the extent to which the proposed haircuts exceed any reasonable measure of counterparty risk, even in a stressful environment, it is useful to consider the components of the haircuts, the default rate and the recovery rate.

Default rate

OFHEO states that the proposed haircuts, "are far more severe than recent default experience but less severe than Depression-era experience."[334] Freddie Mac agrees that the proposed haircuts are much larger than the average ten-year cumulative corporate bond default rates published by Moody's in its most recent study.[335] However, Freddie Mac strongly disagrees with OFHEO's assertion that the proposed haircuts are less severe than Depression-era experience.

Rating	NPR2 Proposed Cumulative Haircut (Implicit Default Rate)	Moody's Average 10-yr Cumulative Corporate Bond Default Rate (1970-1999)[336]	Moody's Average 10-yr Cumulative Corporate Bond Default Rate (1920-1999)[337]
AAA	10%	0.77%	1.09%
AA	20%	0.98%	3.10%
A	40%	1.55%	3.61%
BBB	80%	4.41%	7.92%

Table 16: Default Rate Implied by Proposed Haircut Compared with Historical Default Rates

The default rates implied by OFHEO's proposed haircuts are 13 to 25 times the average ten-year cumulative corporate bond default rates from 1970 to 1999 published by Moody's and six to ten times the average ten-year cumulative corporate bond default rates from 1920 to 1999, also published by Moody's.

A study of corporate bond performance in the early part of the twentieth century also indicates that corporate bond default rates were well below the haircut levels proposed by OFHEO. The 1958 study by W. Braddock Hickman[338] shows the following lifetime default rates of investment grade bonds issued from 1900 to 1943:

[334] *Id.* at 18155.
[335] Moody's Investors Service, "Historical Default Rates of Corporate Bond Issuers, 1920-1998" (Jan. 2000).
[336] These default rates were not included in the January 2000 update of Moody's report, "Historical Default Rates of Corporate Bond Issuers, 1920-1999," but Moody's provided the updated default rates on Freddie Mac's request.
[337] Moody's Investors Service, "Historical Default Rates of Corporate Bond Issuers, 1920-1999" (Jan. 2000).
[338] W. Braddock Hickman, *Corporate Bond Quality and Investor Experience* (1958).

Rating Equivalent	All Issues	Industrials Only*
I (AAA)	5.9%	0.4%
II (AA)	6.0%	3.2%
III (A)	13.4%	8.8%
IV (BBB)	19.1%	18.5%

*Industrials excludes railroads and public utilities.

Table 17: Lifetime Default Rates for Bonds Classified at Offering 1900-1943[339]

The default rates implied by OFHEO's proposed haircuts range from four to 25 times the default rates experienced by industrial bond issues from 1900 to 1943.

The same study also provides default rates for corporate bonds outstanding at the beginning of a number of time periods. While increasingly sparse as they are further disaggregated, these data indicate that corporate bond default rates during the Depression were considerably lower than those implied by OFHEO's proposed haircuts.

Rating Equivalent	All Issues	Industrials Only*
I (AAA)	6.8%	0.0%
II (AA)	10.3%	0.0%
III (A)	15.3%	11.0%
IV (BBB)	21.5%	17.5%

*Industrials excludes railroads and public utilities.

Table 18: Default Rates from 1928-1939 for Bonds Outstanding in 1928)[340]

Comparing OFHEO's proposed haircuts to the historical default rates included in the tables above, it is clear that the default rates implied by the proposed haircuts are far worse than any experience in the United States. These excessively large default rates are compounded by the fact that the proposed haircuts allow for no recovery in the event of default.

Recovery rate

As discussed earlier, OFHEO effectively assumes no recovery in the event of a counterparty default. For corporate bonds and other securities, there is generally some recovery on obligations following an issuer default. Moody's indicates that recovery rates for all types of debt have averaged 42 percent from 1970 to 1999.[341] Recoveries vary based on debt seniority and security. For senior unsecured debt, the recovery rate has

[339] *Id.* at 190.
[340] *Id*. at 190.
[341] Moody's Investors Service, "Historical Default Rates of Corporate Bond Issuers, 1920-1999" (Jan. 2000).

averaged 49 percent from 1970 to 1999.[342] Moreover, even during the Depression, Hickman's study indicates that recovery rates on bond defaults were at least 50 percent.[343]

Recovery from other sources of income should also be taken into account. With mortgage insurance and recourse, in the event of counterparty default, Freddie Mac has the right to assume monthly borrower payments for mortgage insurance or servicing fees for all loans serviced by the servicer. These cash flows are then available to offset mortgage credit losses in lieu of the credit enhancement. Such measures would substantially mitigate losses, first by providing a strong incentive for the counterparty to perform under the contractual agreement, then by providing valuable assets in the event of non-performance. Freddie Mac has had experience with obtaining recovery from a defaulting mortgage insurer when TICOR/TIMIC became insolvent subsequent to the ALMO experience. Freddie Mac's recovery rate following such default was more than 50 percent.

When recovery rates are included in a comparison of OFHEO's proposed haircuts to historical data, the proposed haircuts appear even more excessive. Assuming a recovery rate of 50 percent, the proposed haircuts range from nine to 50 times the loss rates implied by the historical data discussed above.

Rating	NPR2 Proposed Haircuts	Loss Rate Implied by Moody's Average Default Rates, (1970-1999)[344]	Loss Rate Implied by Moody's Average Default Rates (1920-1999)[345]	Loss Rate Implied by Average DefaultRate for Industrials, (1900-1943)[346]
AAA	10%	0.4%	0.5%	0.2%
AA	20%	0.5%	1.6%	1.6%
A	40%	0.8%	1.8%	4.4%
BBB	80%	2.2%	4.0%	9.3%

Table 19: Loss Rates Based on Historical Data (Assuming 50 Percent Recovery Rate)

Furthermore, with respect to derivatives contracts, Freddie Mac has never experienced a credit loss.

Effects of proposed haircuts

Freddie Mac takes on counterparty risk as part of its risk management. For example, Freddie Mac uses mortgage credit enhancements to reduce mortgage credit losses and derivatives to hedge interest-rate risk and foreign-exchange risk. Freddie Mac also takes on counterparty risk in order to reduce the cost of funding mortgages. For example,

[342] *Id.*
[343] W. Braddock Hickman, *Corporate Bond Quality and Investor Experience* at 192-193 (1958).
[344] These default rates were not included in the January 2000 update of Moody's report, "Historical Default Rates of Corporate Bond Issuers, 1920-1999," but Moody's provided the updated default rates on Freddie Mac's request.
[345] *Id.*
[346] W. Braddock Hickman, *Corporate Bond Quality and Investor Experience* at 190 (1958).

Freddie Mac effectively issues synthetic callable debt, by entering into interest rate contracts or derivatives when the synthetic callable debt has a risk-adjusted cost lower than that of callable debt.

Very large haircuts on cash flows that cause an Enterprise to hold large amounts of capital relative to the risks to which it is exposed would change business decisions around Enterprise risk management and funding strategies. In particular, these haircuts would increase the effective cost of risk management and funding strategies that employ contractual arrangements with counterparties. As the cost increases because of the excessive regulatory capital requirements, Freddie Mac would turn to alternative risk management and funding strategies. For example, the Enterprise might minimize its use of mortgage credit enhancements, exposing it to higher levels of mortgage credit losses. It might limit its use of hedging transactions, exposing itself to more interest-rate risk. In addition, the Enterprise might rely to a greater degree on callable debt rather than synthetic callable debt, raising its funding costs.

These changes in risk management strategies would expose the Enterprises to more risk. Freddie Mac would hold more capital for such risks; however, holding additional capital is less efficient and would increase costs. Similarly, the use of more expensive callable debt over synthetic callable debt increases costs. By creating an incentive for the Enterprises to rely on more expensive risk-management and funding strategies, OFHEO's proposal would increase the costs of funding mortgages, which would lead to higher mortgage rates.

The severe haircuts proposed by OFHEO would disproportionately affect the segments of the mortgage market that rely more on credit enhancements. For example, high LTV mortgages where mortgage insurance is prevalent would be especially hard hit by the proposed haircuts. High LTV, low down payment mortgages, are often used by first-time homebuyers and borrowers targeted by the Enterprises' housing goals. Similarly, mortgage revenue bonds that support affordable lending would be disadvantaged by the proposed haircuts. The underlying mortgages might have had a capital requirement of perhaps four percent. These bonds after credit enhancements are often rated AA, resulting in cumulative haircuts of 20 percent. The capital requirement could increase with the reduction of risk.

Recommendation

The Act instructs the Director to ensure that aspects of the stress test not specifically mentioned should be consistent with the stress period.[347] The primary credit stress specified for the stress test, mortgage credit stress, focuses on the Enterprises' core business and risk exposure. Accordingly, any other aspects of credit stress included in the stress test should be related to the mortgage credit stress that the Enterprises experience in the stress test.

In an effort to relate the behavior of counterparties to the stress period, Freddie Mac recommends a comparison of mortgage default incidence in the benchmark region to average default rates. A good way to estimate a long-term historical average for mortgage

[347] The Act § 1361(b)(2).

defaults is to use a Monte Carlo simulation based on historically estimated default and prepayment functions.[348] Freddie Mac routinely uses this approach in its business. Using Freddie Mac's standard measure of long-term historical averages suggests that ALMO default rates are about three times the long-term average lifetime default rates.[349]

We recommend applying this multiplier of three to the average ten-year cumulative default rates for corporate bonds published by Moody's to derive the default rate portion of Freddie Mac's recommended counterparty credit risk haircuts. For debt instruments, we recommend that OFHEO use the historical average recovery rate of 50 percent.

In order to account for recoveries in the case of mortgage credit enhancements, there are two choices. The first is to use the income resulting Freddie Mac's assumption of borrower mortgage insurance payments and servicing fees. This option would require making assumptions about how administrative expenses would increase when Freddie Mac begins servicing the loan portfolios of defaulting counterparties. Alternatively, one could use the same recovery rate of 50 percent as is used with debt instruments. Based on the TICOR/TIMIC experience, a 50 percent recovery rate represents a conservative estimate of actual recoveries during the stress period. Accordingly, we recommend that OFHEO use a single recovery rate of 50 percent for all counterparty defaults because the additional complexity of establishing different recovery rates for instruments and counterparties is not justified.

Based on the multiplier of three and a 50 percent recovery rate, Freddie Mac recommends that OFHEO use counterparty credit risk haircuts no greater than those included in the table below for assessing the counterparty risk of mortgage credit enhancement providers and non-mortgage and mortgage-related securities.

Rating	Moody's Average 10-Year Cumulative Corporate Bond Default Rate (1970-1999)[350]	Default Rate Component of Recommended Haircut (Moody's Default Rate X 3)	Maximum Recommended 10-Year Cumulative Haircut*
AAA	0.77%	2.3%	1.2%
AA	0.98%	2.9%	1.5%
A	1.55%	4.7%	2.3%
BBB	4.41%	13.2%	6.6%
*Applies a recovery rate of 50 percent.			

Table 20: Recommended Maximum Cumulative Haircut

Haircuts should increase linearly through the stress period until reaching the ten-year cumulative haircut level in month 120 of the stress period.

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[348] Monte Carlo modeling is a standard technique whereby average behavior is projected via simulations of many different future economic environments.

[349] The unbiased estimate of the ALMO default rate using the data of both Enterprises is discussed in Freddie Mac's NPR1 Comment at 18-27.

[350] Provided by Moody's Investors Service.

In general, Freddie Mac's recommended haircuts are consistent with developments in using credit ratings to set capital requirements. Paul Kupiec's analysis published in *Risk* uses current market spreads by credit rating to develop a capital requirement by rating and maturity.[351] Kupiec's analysis suggests that capital requirements should increase approximately linearly as the maturity of an instrument increases.[352] Similarly, the Basle Committee on Banking Supervision is considering an approach of using ratings in setting capital requirements, with the following capital requirements: 1.6 percent for AAA and AA rated counterparties, four percent for A through BBB rated counterparties and eight percent for counterparties rated below BBB.[353] Notably, the capital standards under consideration by the Basle Committee include a broader definition of capital than does OFHEO's proposal.

The haircuts recommended above are derived using a multiplier of three, which is based on mortgage default rates in an environment of declining interest rates. In an environment of increasing interest rates, it is reasonable to expect the presence of general inflation, and as a result, lower mortgage default rates and also lower counterparty credit risk.[354] Thus, counterparty credit risk haircuts, in an up-rate environment, should be lower than haircuts in a down-rate scenario. Accordingly, we recommend that the haircuts be adjusted downward by at least 30 percent in the up-rate scenario. This adjustment is comparable to the reduction in mortgage risk discussed in *Single-Family House Price Scenario*.

Treatment of counterparty credit risk for mortgage credit enhancement providers

Contractual cash flows for credit enhancements having counterparty credit risk (currently private mortgage insurance, pool insurance, tiered primary, recourse and indemnification) expected during the stress test should be discounted using haircuts no greater than the maximum haircuts included in the table above. Haircuts should be applied based on the rating of the credit enhancement provider. The contractual cash flows of collateral-based mortgage credit enhancements (currently cash accounts, collateral pledge agreements and spread accounts) are not exposed to counterparty credit risk and should not be discounted.

Treatment of counterparty credit risk for non-mortgage securities & mortgage-related securities

The contractual cash flows for non-mortgage securities and mortgage-related securities should be discounted using the haircuts recommended in the table above and should be applied based on the credit rating of the security or of the issuer, if a credit rating for the security is not available.

Treatment of counterparty credit risk for derivative contracts

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[351] Paul Kupiec, "An alternative to Basle's reform proposals," *Risk*, March 2000 at 30-33.
[352] *Id*. at 31.
[353] Basle Committee on Banking Supervision, "A New Capital Adequacy Framework," June 1999, The Bank for International Settlements.
[354] *See* Michael R. Darby, "Consistent Macroeconomic Conditions for a Risk-Based Capital Stress Test" (June 1999), attached as *Appendix 4* to this Comment.

The majority of Freddie Mac's derivative positions are subject to collateral pledge agreements. In addition, Freddie Mac has in place management controls to monitor the value of positions and collateral and to monitor the financial strength of derivative counterparties. Any risk exposure to derivatives should be covered by the management and operations risk add-on.

To the extent that OFHEO believes that collateralization and the 30 percent management and operations risk add-on do not provide adequate protection for the counterparty credit risk of derivatives contracts, Freddie Mac recommends using minimum capital treatment to provide an appropriate capital charge.[355] The capital required would then be subject to the 30 percent management and operations risk add-on, meaning that the risk based capital requirement is 30 percent higher than the regulatory minimum. We recommend that OFHEO use the minimum capital requirements rather than reducing the haircuts to account for the continuous posting of collateral. The haircut approach for derivatives greatly increases complexity. For example, the stress test would need to make assumptions about the movement of foreign exchange rates in order to apply a haircut approach. In contrast, the minimum capital approach requires no such assumptions. Freddie Mac monitors current exposures on all derivative positions; therefore, calculating the minimum capital requirement is relatively straightforward.

Assignment of credit ratings

Freddie Mac recommends that OFHEO accept credit ratings provided by nationally recognized rating agencies, currently Standard & Poor's, Moody's Investors Service, Duff & Phelps and Fitch. The types of counterparties and securities covered by the ratings may differ, but the rating agencies are in the best position to summarize the many dimensions of

[355] Applying the minimum capital requirements as a means of approximating the present value of losses, the same methodology applied under NPR2 § 3.1.6, Other Off-Balance Sheet Guarantees, would result in relative capital requirements consistent with OFHEO's previous determinations in the context of the minimum capital regulation.
The Act sets a minimum capital requirement for interest-rate and foreign-exchange rate contracts by providing that "other off-balance sheet obligations" have a minimum capital requirement of 0.45 percent, "except that the Director shall adjust such percentage to reflect differences in the credit risk of such obligations in relation to [mortgage-backed securities]." The Act § 1362(a)(3). To apply that provision to interest-rate and foreign-exchange rate contracts, OFHEO necessarily determined the relative levels of such contracts versus mortgage-backed securities, and the minimum capital regulation reflects the amount by which OFHEO adjusted the 0.45 percent capital requirement. *See* 61 Fed. Reg. 35607, 35612 (July 8, 1996) (final regulation); 60 Fed. Reg. 30201, 30203-04 (June 8, 1995) (proposed regulation).
The proposed risk-based capital regulation requires the same exercise, in that it sets capital requirements for mortgage-backed securities and for interest-rate and foreign-exchange rate contracts, and OFHEO has concluded from its own sensitivity studies that the risk-based capital requirement for sold-portfolio mortgages is, "on average" "similar to the existing minimum capital ratios for sold loans of 0.45 percent. NPR2 at 18099. Accordingly, applying the minimum capital requirements in the context of the risk-based capital regulation would result in consistent OFHEO determinations of relative risk in the minimum capital and risk-based capital regulations.

credit risk. Moreover, rating agencies strive to provide comparability of ratings across markets.[356]

To assess the credit risk of mortgage credit enhancements and derivative contracts, Freddie Mac recommends that OFHEO use the rating of each credit enhancement provider or derivative counterparty. To assess the credit risk of non-mortgage securities or mortgage-related securities, Freddie Mac recommends that OFHEO use the rating of the security, when available. Otherwise the rating of the security issuer can be used.

When a credit rating is available from more than one rating agency, Freddie Mac recommends that OFHEO use the lower of two ratings or the median rating when more than two ratings are available. When no credit rating is available and the counterparty is a federally regulated financial institution, the counterparty credit risk haircuts for the BBB rating category can be applied.

Conclusion

Freddie Mac's recommended approach for assessing counterparty credit risk in the stress tests is consistent with the interest-rate shocks and mortgage credit losses specified in the Act. In contrast, the counterparty credit risk haircuts proposed by OFHEO are inconsistent and could lead to changes in Freddie Mac's risk management and in its choice of funding instruments. Such changes could have negative impact on Freddie Mac's cost of operating, which would lead to higher mortgage rates.

[356] Moody's describes an emphasis on expected loss rate as the primary measure of credit quality to meet investor demand for greater consistency in the meaning of ratings across sectors. Moody's Investors Service, Rating Methodology, "The Evolving Meaning of Moody's Bond Ratings" (Aug. 1999).

F. Enterprise Operations

The Act specifies the credit risk and interest-rate risk components of the stress tests. In order to apply the those components to the Enterprises and generate capital positions through the stress period, OFHEO must make assumptions about how certain Enterprise operations are performed. The Act does not provide specific direction concerning these items. Rather, it indicates that any stress period characteristics not specifically described, "will be those determined by the Director [of OFHEO], on the basis of available information, to be most consistent with the stress period."[357] The Act further requires that the regulation describe treatment of these areas needed to implement the stress test.[358]

The following sections discuss the areas of enterprise operations that must be defined in order to implement the stress test. They include refunding rules, which describe how an Enterprise invests cash and refunds maturing debt during the stress period; treatment of administrative expenses; payment of dividends; and settlement of derivative contracts during the stress period.

[357] The Act § 1361(b)(2).
[358] *Id*. at § 1361(e)(2).

i. Refunding

During the stress test, the Enterprises periodically will have excess cash to invest or will need to refund maturing debt. OFHEO proposes that the Enterprises invest excess cash in short-term instruments and issue short-term debt when a cash shortfall arises during the stress period. This highly simplified approach tends to overstate risks in the up-rate scenario because it does not recognize the different refunding strategies that an Enterprise would use in a rising interest-rate environment. Freddie Mac recommends that a refunding mix of 20 percent short-term and 80 percent non-callable long-term debt be used in the up-rate scenario and 80 percent short-term and 20 percent callable long-term debt be used in the down-rate scenario to better reflect the Enterprises' refunding behavior.

Background

Implementation of the stress test requires the specification of procedures that an Enterprise would follow to refund any debt securities that mature during the stress period or to invest any surplus cash that accumulates. Because the stress test does not envision that the Enterprises will purchase new mortgages or issue new PCs,[359] the overall balance sheet of each Enterprise should shrink over the course of the stress period as existing mortgages "run-off." Even though both assets and liabilities will be shrinking through the course of the test, an Enterprise's assets and liabilities will not mature at identical points during the stress period. Accordingly, there will be some months when an Enterprise will have a cash surplus to invest (*i.e.*, a greater amount of assets relative to liabilities matured in the preceding month) and there will be some months when an Enterprise will have a deficit to finance (*i.e.*, a greater amount of liabilities relative to assets matured in the preceding month).

For example, in the down-rate scenario, we would expect mortgages to prepay relatively quickly, shrinking an Enterprise's asset base. If the Enterprise had funded these mortgages using only long-term debt, it would be left with a surplus of cash resulting from cash inflows from mortgage prepayments. This surplus could be reinvested in new assets. In contrast, if the Enterprise's liabilities were to run-off faster than its assets (*e.g.*, in an up-rate scenario where prepayment rates were relatively low and the Enterprise's short-term debt funding runs off faster than its mortgage portfolio), the Enterprise would have to refund its portfolio with new debt securities.

In practice, an Enterprise will make refunding and reinvestment decisions based on the level and direction of interest rates and the degree to which the duration[360] of its assets varies from the duration of its liabilities. For example, in refunding its maturing debt, an Enterprise could decide — depending on the economic environment and the characteristics of its portfolio — to refund using short-term debt, long-term debt or a mix of debt instruments

[359] The Act prohibits such activities during the stress period. The Act § 1361(a)(3).

[360] Duration represents the sensitivity of the value of a security to a change in its yield. An Enterprise's "duration gap" is the difference in durations between its assets and liabilities, after accounting for leverage.

including callable and non-callable debt.[361] Specifically, in a rising interest-rate environment, an Enterprise will tend to refund its expiring debt with longer-term instruments in order to close any emerging duration gap, while the opposite behavior would likely occur in a down-rate environment.

Proposal

In NPR2, OFHEO proposes a short-term refunding and investment rule. Any Enterprise cash shortfalls during the stress period must be refunded with six-month discount notes at the six-month Federal Agency Cost of Funds Rate, plus a 2.5 basis point issuance cost.[362] In addition, any surplus cash must be invested in one-month maturity assets that yield the six-month Treasury rate.[363]

OFHEO uses the "no new business" rule[364] to justify its short-term instrument refunding and investment approach. NPR2 explains that "[t]he purpose of the 'no new business' stress test is to subject an Enterprise's business at the beginning of the stress period to adverse conditions, without introducing during the stress period any business responses to deteriorating business conditions that would tend to increase or decrease risk."[365] OFHEO states that projecting that an Enterprise would issue or purchase long-term assets during the first year of the stress test would "distort the stress test's evaluation of starting risk positions."[366]

In addition, OFHEO indicates that a fixed refunding assumption is justified because it "intentionally does not propose to predict what asset-liability management decision an Enterprise might make, predictions that would be difficult in any event."[367] In support of this position, OFHEO indicates that the varying responses of the thrifts to financially stressful conditions during the 1980s demonstrates the unpredictable behavior of financial institutions under such circumstances.[368] Because choices made during the early portion of the stress period "could profoundly affect the Enterprises' financial performance in the stress period,"[369] OFHEO apparently chose to eliminate the possibility of choice by setting a fixed rule.

Discussion

OFHEO's proposed approach overstates Enterprise risk exposure

OFHEO's proposed refunding rule is neither most consistent with the specified characteristics of the stress period, nor does it accurately project the likely risks that the Enterprises would experience. In the up-rate scenario in particular, OFHEO's proposed

[361] In practice, the Enterprises also have other tools available to adjust duration mismatches, including taking short or long positions in futures contracts or Eurodollar futures.
[362] NPR2 § 3.10.3.1(c).
[363] *Id.*
[364] The Act § 1361(a)(3).
[365] NPR2 at 18167.
[366] *Id.*
[367] *Id.*
[368] *Id.*
[369] *Id.*

refunding rules do not reflect basic asset/liability management strategies. Accordingly, OFHEO's proposed refunding rules significantly overstate an Enterprise's risk exposure, leading to a capital requirement that is not appropriately tied to risk.[370]

To apply the stress test, OFHEO must make some assumptions about debt refunding decisions that would be necessary for an Enterprise to balance its balance sheet. OFHEO set a standard that the stress test should "subject an Enterprise's business at the beginning of the stress period to adverse conditions, without introducing during the stress period any business responses to deteriorating business conditions that would tend to increase or decrease risk."[371] OFHEO's proposed rules for refunding maturing debt fall short of this standard. Specifically, OFHEO's proposed rules undo risk protection that is already in place and assume that an Enterprise would engage in a refunding strategy that actually would increase risks during the stress period. OFHEO's assumption of exclusive short-term refunding is contrary to well-established Enterprise risk-management practices and would cause significant deviations from target portfolio duration levels in an up-rate environment.

OFHEO's explanation that the "no new business" rule prevents it from predicting any business responses during the stress period[372] misinterprets this statutory requirement. Although the no new business rule expressly assumes that the Enterprises will purchase no new mortgages during the stress period, it does not require an Enterprise to abandon management of its existing business, nor does it prohibit an Enterprise from taking prudent steps consistent with its prior behavior.

OFHEO asserts that it will not "predict what asset-liability management decision an Enterprise might make."[373] However, it is making exactly such a prediction by requiring that the Enterprises refund maturing debt exclusively with short-term instruments. OFHEO's proposed refunding rule establishes a new asset and liability management strategy that is inconsistent with the strategies historically used by the Enterprises and amounts to a prediction that the Enterprises will alter their behavior dramatically during the stress period. As Freddie Mac stated in its ANPR Comments, "[T]he Enterprises' fundamental approach to risk management should not be assumed to change dramatically during the stress period. The Enterprises carefully monitor and manage interest-rate risk under normal economic conditions and would continue to do so during actual stressful conditions."[374]

Furthermore, OFHEO's assertion that it would be difficult to predict the Enterprises' refunding behavior during the stress period is unsupportable because, in this instance,

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[370] Freddie Mac also believes that OFHEO's proposed reinvestment rules are based on inaccurate assumptions concerning an Enterprises' investment of surplus funds during the stress period. However, the risk distortion introduced by the reinvestment rules is considerably less than the distortion that might result from OFHEO's proposed refunding rules. Because the simplicity of implementation of the proposed reinvestment rules may well justify their use in the stress test, Freddie Mac's recommendation concerning OFHEO's proposed refunding and reinvestment rules is limited to a discussion of the refunding rules.

[371] NPR2 at 18167.

[372] *Id.* at 18167.

[373] *Id.*

[374] Freddie Mac's ANPR Comments at 98.

Enterprise behavior is quite predictable. The Enterprises have long based their refunding decisions on the fundamental principle that asset and liability durations should match as closely as possible, and their responses to interest-rate changes in recent years have been consistent with this principle. OFHEO instead makes a highly unrealistic prediction about asset and liability funding decisions.

OFHEO's example of the unpredictable behavior of the thrifts during the financial crisis of the 1980s is not applicable to this situation. The thrift industry in the 1980s consisted of thousands of institutions that varied substantially in terms of size, management ability and existing financial health. In addition, the thrift industry had no track record of sophisticated management of interest-rate risks. Accordingly, that industry represents a very poor proxy for the Enterprises. The responses of the thrifts to financial stress may well have been unpredictable, but that circumstance does little to support an assertion that one cannot predict how Freddie Mac or Fannie Mae would refund maturing debt in rising or falling interest-rate environments.

The following example illustrates how OFHEO's proposed refunding rule would overstate an Enterprise's actual risk exposure to rising interest rates:

> Consider an Enterprise that must refund maturing debt during the third month of the up-rate stress test. Pursuant to OFHEO's proposed rule, the Enterprise would have to refund this debt completely with six-month notes — an action that would be contrary to prudent risk management in a rising interest-rate environment. In the third month, interest rates would have already risen by approximately 100 basis points and any rational manager would issue longer-term debt to reflect the extension of the average life of mortgage assets. However, under OFHEO's proposal, all of this debt (other than that no longer necessary due to mortgage run-off) would have to be refunded again in the ninth month of the stress test, when rates have moved more dramatically from their original position. By following a standard refunding strategy, however, the Enterprise would have "locked-in" a lower rate for a longer period of time by refunding a significant portion of the original debt with longer-term instruments. This simple risk-management technique (*i.e.*, refunding with longer-term instruments in a rising-rate environment) permits the Enterprise to mitigate its risk exposure to rising interest rates. OFHEO's proposed rule, however, assumes that the Enterprise would behave irrationally and creates the perception that the Enterprise has greater risk exposure than it actually does have.

Freddie Mac's recent behavior in response to rising interest rates demonstrates how an Enterprise would actually refund its debt in a rising-rate environment. From the beginning of February 1999 (when the ten-year Treasury yield was about 4.8 percent) to the end of December 1999, the ten-year Treasury yield increased by more than 150 basis points. During this period, Freddie Mac's portfolio duration gap remained in a tight band close to zero and had actually *decreased* by the end of the period. This result occurred because the company acted in a manner consistent with the prudent practice of managing to a target duration range. If Freddie Mac had been unable to rely on longer-term refunding in

1999, its duration gap almost certainly would have increased as interest rates rose, increasing its interest rate risk exposure.

Significantly, this example also illustrates how quickly an Enterprise will respond to changing interest rates — even when the rate change is relatively minor in comparison to the shocks mandated by the Act. Freddie Mac obviously could not be certain whether the modest rate increase during 1999 marked the start of a long-term trend or would be reversed quickly. This lack of prescience, however, did not stop the company from acting quickly to keep its duration gap as close to zero as possible. Accordingly, there should be no doubt that Freddie Mac would take rapid steps to make appropriate portfolio refunding decisions during the stress period.

Notably, adjusting the mix of short-term versus long-term debt is only one of several strategies that an Enterprise could implement in order to narrow a duration gap caused by changing interest rates. Freddie Mac also relies on Treasury futures, among other instruments, as part of its interest-rate hedging tactics.[375] Although many of these additional strategies may be too complex to incorporate into a regulatory risk-based capital rule, it is important to keep in mind the sizable arsenal of financial tools available to the Enterprises to close a duration gap as it emerges. Accordingly, drawing a basic distinction in the stress test between the refunding assumptions for the up-rate and the down-rate scenarios represents a very conservative substitute for the aggressive strategies that the Enterprises could (and do) use to mitigate their exposure to changing interest rates.

OFHEO’s refunding rule creates a perverse incentive to rely on potentially riskier funding strategies

The Enterprises’ existing funding strategies are premised on an assumption that they will be able to make logical and appropriate refunding decisions in response to changing interest rates. An artificial limitation on an Enterprise’s ability to refund during the stress period may create an incentive for the Enterprise to rely to a greater degree on funding its current purchases with longer-term debt instruments. Although such a strategy may “help” an Enterprise in the proposed stress test, it actually may increase the Enterprise’s current exposure to interest rate shifts.

Similarly, OFHEO’s refunding rules can create a perverse incentive for an Enterprise to engage in activities that potentially increase actual risk exposure while decreasing its capital requirement. The following example illustrates this possibility.

> Consider a scenario where, at the start of the stress period, an Enterprise has a long-term callable debt instrument with the first call date in three months. Suppose that current interest rates are 200 basis points below the coupon that the Enterprise is paying on the instrument. Absent stress test considerations, the Enterprise almost certainly would call the debt and refund at a lower rate with a long-term instrument. However, in the up-rate scenario, the stress test requires maturing debt to be replaced with short-term funding at three-month intervals at a

[375] Issues associated with such futures are discussed separately in *Settlement of Derivatives*.

> substantially higher rate. Faced with this dilemma, the Enterprise could significantly decrease its up-rate capital requirement by renegotiating the three-month-ahead call date in exchange for a much longer call date. Such a transaction could decrease the Enterprise's assumed interest costs on the renegotiated debt instrument in the up-rate stress test by at least 300 basis points. However, the incentive is perverse because it restricts the Enterprise's financing flexibility by extending its call option (thereby increasing its actual exposure to interest rate risk) in order to reduce its capital requirement.

Recommendation

Freddie Mac recommends that OFHEO adopt a refunding rule that better reflects the established asset and liability management strategies of the Enterprises. Although Freddie Mac is sensitive to OFHEO's concerns about capturing existing risks and not making predictions about Enterprise behavior during the stress period, it is possible within these parameters to adopt a refunding rule that reflects prudent management of an Enterprise such as might occur with a conservator. Such a rule could identify risk in current assets and liabilities while minimizing the impact of future decisions to the extent that they might materially add or subtract from existing risk.

Freddie Mac's specific proposal is as follows:

- In the up-rate scenario, assume a refunding mix of 20 percent short-term and 80 percent non-callable long-term instruments in each month of the stress test.
- In the down-rate scenario, assume a refunding mix of 80 percent short-term and 20 percent callable long-term instruments. To implement this proposal, we believe OFHEO should avoid elaborate monthly calculations that would mimic the Enterprise's actual refunding rules. Rather, OFHEO should approximate these rules with a single adjustment after the first six months of the stress test. At month six, OFHEO should calculate the total dollar amount of debt that the Enterprise needs to issue at that point. Of the total debt issuance required at month six, 80 percent should be short-term debt and 20 percent should be long-term callable debt. In all other months of the down-rate stress test, the NPR2 refunding approach should be used (*i.e.*, refund with short term debt.)[376]

Because a significant portion of the Enterprises' long-term funding is in the form of synthetic long-term debt,[377] it is critical to exclude from the calculation the discount notes

[376] The recommendation to issue all (callable) long-term debt in the down-rate scenario in month six simplifies implementation with respect to callable debt issuance. In the up-rate scenario, all long-term debt is non-callable and hence there is no corresponding complication. Therefore, the refunding mix of 20 percent short-term and 80 percent long-term debt can easily be applied in each month in the up-rate scenario.

[377] To create synthetic long-term non-callable debt, an Enterprise would issue short-term discount notes and enter into a pay-fixed swap. In such a transaction, the Enterprise pays the market determined coupon on the discount notes it issues. However, on its swap contract, it receives payments determined by the LIBOR rate and pays a fixed rate determined at the time of initiation of the swap contract. The LIBOR-

that are a component of this synthetic position. Failure to exclude such discount notes would understate the risks associated with refunding in the up-rate scenario. At the beginning of the stress test, all callable and non-callable pay-fixed swaps that are linked to an Enterprise's discount notes virtually replicate long-term callable and non-callable debt, respectively. For this reason, application of Freddie Mac's refunding proposal should exclude from maturing short-term debt the dollar face amount of discount notes matched with the dollar face value of swaps.

In comparison to OFHEO's proposed refunding rule, Freddie Mac's recommended approach would tie capital requirements more closely to actual risks. Nevertheless, Freddie Mac's approach is still quite conservative, inasmuch as an Enterprise would normally implement a considerably more aggressive refunding strategy in response to changing interest rates and asset-liability duration mismatches.[378] Freddie Mac's approach provides a more sophisticated prediction of actual risks, yet is nearly as simple to implement as is OFHEO's refunding proposal.

based receipts from the swap contract offset the Enterprise's coupon payments on its discount notes, the net being the fixed-rate payment the Enterprise pays on the swap contract plus the spread between LIBOR and the Enterprise's discount note funding cost.

[378] Confronted with steeply-rising interest rates, Freddie Mac likely would rely exclusively on long-term refunding (rather than an 80 percent long-term/20 percent short-term mix) to close its duration gap. In the down-rate stress test, Freddie Mac's recommended approach actually is more conservative than OFHEO's proposal because Freddie Mac's approach includes the use of some long-term refunding.

ii. Administrative Expenses

Administrative expenses constitute a relatively small portion of Freddie Mac's total expenses, but a disproportionately large component of Freddie Mac's capital requirement. In addition, administrative expenses vary unreasonably between the up-rate and down-rate stress tests. These results stem from OFHEO's overly simplified modeling approach that treats all administrative expenses as variable costs. Therefore, Freddie Mac recommends that administrative expenses be specified in terms of a fixed-cost component and a variable-cost component and that administrative expenses related to new business development be eliminated because the stress test assumes there is no new business.

Background

Freddie Mac's administrative, or operating, expenses include costs such as those related to salaries, benefits and various professional services, as well as property, equipment and office expenditures. As OFHEO has recognized in NPR2, these expenses constitute a relatively small portion of each Enterprise's overall costs.[379] For example, administrative expenses represented approximately 2.9 percent of Freddie Mac's total expenses during the fourth quarter of 1999.

Freddie Mac's administrative expenses can be divided into fixed and variable components. The former, consisting of items such as the costs associated with its buildings, remain substantially the same irrespective of the size of Freddie Mac's portfolio. The latter, including such items as the salaries of individuals directly involved portfolio servicing, will vary to some degree as the size of Freddie Mac's portfolio changes.

Administrative expenses (both fixed and variable) can be further divided to separate costs associated with functions related to new and existing business. This distinction is significant insomuch as approximately half of Freddie Mac's total administrative expenses involve the development of new products and operating techniques, as well as for marketing activities and the creation of modeling approaches that provide improved measures of risks inherent in our business. As discussed below, this division of expenses is highly relevant for purposes of determining an appropriate value for administrative expenses during the stress period.

The Act requires that, "[i]n establishing the risk-based capital test," OFHEO's Director "shall take into account appropriate distinctions . . . and any other factors the Director considers appropriate."[380] While permitting a degree of discretion, implicit in this directive is the requirement that the risk-based capital test account for distinctions that are relevant to determining the actual risks of the Enterprises.

Similarly, the Act also requires that "losses or gains from other activities . . . shall be determined by the Director, on the basis of available information, to be consistent with the stress period."[381]

[379] NPR2 at 18168.
[380] The Act § 1361(b)(1).
[381] *Id.* at § 1361(a)(4).

Finally, the "no new business" requirement of the Act has implications with respect to an Enterprise's operating expenses. The statute specifies that, apart from the fulfillment of existing contractual commitments, the Enterprises will be assumed to purchase no additional mortgages during the stress period.[382]

In addition, OFHEO has set for itself a goal of treating the two Enterprises similarly.[383] With respect to rules relating to the treatment of operating expenses during the stress period, this goal would be met only if the rules do not produce disparate outcomes dependent upon the Enterprises' decisions and policies that are unrelated to risk.

Proposal

In NPR2, OFHEO proposes calculating an average monthly value for operating expenses at the start of the stress period and multiplying that value by the remaining percentage of the Enterprise's mortgage portfolio assets at the end of each month of the stress period.[384] OFHEO explains, "Over the stress period, operating expenses decline in proportion to the decline in the size of an Enterprise's mortgage portfolio (*i.e.*, the sum of outstanding principal balances of its retained and sold mortgage portfolios)."[385]

OFHEO proposes to obtain the required average monthly value by dividing by three the Enterprise's operating expenses for the quarter immediately preceding stress period.[386] As an explanation for this cost-averaging methodology, OFHEO states, "During the stress period, administrative costs depend not only on the volume of loans held or guaranteed, but also on the rate of spending in the quarter immediately preceding the start of the stress period. A higher rate of administrative expense before the stress period increases costs and depletes capital during the stress period."[387]

OFHEO states that it "has determined that disaggregating operating expenses into several categories would add needless complexity without providing any significant corresponding benefit to ensuring an Enterprise's capital adequacy."[388] OFHEO further explains, "While some expense categories might reasonably be assumed to decline faster than the mortgage portfolio, some others might decline more slowly, and some might be expected to increase."[389] OFHEO concludes that operating expenses "should not be subject to complicated modeling [and] proposes to consider operating expenses in a single category rather than desegregating them into distinct categories."[390]

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[382] *Id.* at § 1361(a)(3)(A).
[383] *See*, *e.g.*, NPR2 at 18087 (rejecting an "internal models" approach because it would "result in unequal treatment").
[384] NPR2 § 3.10.3.4.
[385] *Id.*
[386] *Id.*
[387] *Id.* at 18110.
[388] *Id.* at 18169.
[389] *Id.*
[390] *Id.*

Discussion

As OFHEO observes, operating expenses constitute a relatively small portion of Freddie Mac's overall costs. However, these expenses are responsible for a very significant part of Freddie Mac's capital requirement under OFHEO's proposal. In OFHEO's calculation for the second quarter of 1997, operating expenses are responsible for approximately 46 percent of the requirement in the up-rate scenario and approximately 19 percent of the requirement in the down-rate scenario.

Operating expenses — which have little relationship to risk — emerge as one of the most significant components of Freddie Mac's total risk-based capital requirement. Furthermore, the substantial difference between the impact of operating expenses in the up-rate and down-rate scenarios seems highly unlikely to reflect the actual difference in stresses that operating expenses would present under the two interest rate scenarios. While we agree that complex modeling of administrative expenses is not justified, the unexpected impact of administrative expenses on Freddie Mac's capital requirements strongly suggests that OFHEO's proposed approach is flawed. Significant distortions are introduced both because the proposed approach assigns too much significance to average expenses for the quarter preceding the stress test and because the proposed approach assumes that there is a strong positive correlation between operating expenses and the size of an Enterprise's mortgage portfolio. Alternative approaches that also avoid complex modeling would be more consistent with the Act.

Expenses associated with new activities should be excluded

The Act specifies that, apart from the fulfillment of existing contractual commitments, the Enterprises will engage in no new business during the stress period.[391] Consistent with this requirement, an Enterprise would not incur expenses relating to activities that are excluded by statute from the test. In other words, the "no new business" requirement sets an expectation that an Enterprise would not devote any resources to new business development activities during the stress test.

Including expenses associated with new business activities and research and development is not only inconsistent with the "no new business" requirement, it also results in a significant overstatement of stress period expenses. As noted above, expenses related to new business and long-term research and development constitute approximately half of Freddie Mac's total operating expenses, yet these expenses are not an element of existing risk. Consistent with the no new business requirement, this portion of Freddie Mac's operating expenses should drop nearly to zero during the stress period. As a result, including new business and long-term research and development expenses as a component of operating expenses results in significant distortion of the risks predicted by the stress test.

By including expenses associated with new business and research and development as a component of Freddie Mac's administrative costs for purposes of the risk-based capital test, OFHEO creates a significant incentive to reduce the current levels of these activities.

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[391] The Act § 1361(a)(3)(A).

Many of Freddie Mac's research and development activities relate to projects either specifically designed to reduce the Enterprise's exposure to risk, to decrease costs or to expand markets more broadly. An ironic consequence of the failure of OFHEO's proposal to separate new business and research and development activities from other administrative expenses is that the Enterprises may well curtail their development of initiatives that decrease risk, lower mortgage rates, or make mortgages more widely available.

Stress period expenses should not be based on the previous quarter

Tying stress test operating expenses to actual operating expenses in the previous quarter allows accounting decisions — that are unrelated to risk — to affect capital requirements. Because the Enterprises have some discretion over what is classified as an operating expense through their choice of accounting policies, the size of operating expenses in the quarter preceding the stress can vary as a result of these accounting choices.

For example, an Enterprise is permitted under Generally Accepted Accounting Principles (GAAP) to determine whether and how to capitalize or expense certain investments, particularly investments in software and systems.[392] This discretion includes the ability to determine appropriate amortization periods and schedules. Furthermore, an Enterprise could choose to fund its foundation (and other investments, including pensions and employee incentive plans) with either cash or Treasury stock. Using the former will result in higher operating costs while the latter will not — despite the fact that the effective cost to the Enterprise is the same either way.

In addition to distorting risks, calculating stress test operating expenses on the basis of the previous quarter's expenses makes it likely that the two Enterprises will be treated unequally. To the extent that the Enterprises adopt dissimilar accounting policies with respect to administrative expenses, these decisions would produce differences in their capital requirements completely unrelated to actual risks.[393]

Linking operating expenses to portfolio size distorts risk

For simplification purposes, OFHEO's approach assumes that operating costs exhibit similar behavior in up-rate and down-rate scenarios and will decline directly in proportion to the decline in the size of an Enterprise's mortgage portfolio. Because the proposed stress test predicts a substantially faster decline in the size of Freddie Mac's portfolio in a down-rate environment, it sets a significantly lower capital charge for operating expenses in the down-rate environment. In reality, administrative expenses are not that sensitive to interest rates. Notably, Freddie Mac's internal risk management assessment predicts approximately equal administrative expenses in both up-rate and down-rate scenarios.

Certain variable costs are linked to the size of Freddie Mac's mortgage portfolio, and these costs will go down as the portfolio shrinks. Fixed costs, however, will continue to

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[392] American Institute of Certified Public Accountants, Statement of Position 98-1, "Capitalizing Software Costs for Internal Use."

[393] Such likely unequal treatment is inconsistent with OFHEO's own objectives for the design of the stress test.

comprise a sizable portion of Freddie Mac's total administrative costs under both scenarios. The net result is that administrative expenses are likely to be substantially similar in both the up-rate and the down-rate environments. OFHEO's proposed methodology overstates the differences in administrative costs between the two scenarios by a large margin, producing a capital requirement that is not truly tied to risk, and is particularly overstated in the up-rate scenario.

Recommendation

As an alternative approach for the treatment of administrative expenses in the stress test, Freddie Mac recommends that OFHEO divide operating expenses into fixed and variable categories, omitting expenses relating to new business development, product innovation and research. For the fixed-cost component, the test should apply a charge computed as a percentage of the unpaid principal balance of loans in an Enterprise's servicing portfolio at the start of the stress test. For the variable component, the test should apply a charge computed as a percentage of the unpaid principal balance of loans in the Enterprise's servicing portfolio, as such balance decreases throughout the stress test.

Freddie Mac's analysis suggests that the fixed cost component should be set at a dollar amount equal to 1.75 basis points per year of unpaid principal balance at the start of the stress test. The variable cost component should be set at two basis points per year of unpaid principal balance as it declines during the stress test. These percentages should remain fixed throughout the stress period, although the variable cost component would decrease, of course, as the size of the Enterprise's servicing portfolio gets smaller.

There are several advantages of Freddie Mac's approach. In particular, Freddie Mac's approach reduces the interest-rate risk sensitivity implied by OFHEO's treatment of administrative expenses and the resulting distortion of capital requirements between the up-rate and down-rate scenarios. Using Freddie Mac's methodology, administrative expenses will be more closely aligned in the two scenarios — a result that more accurately depicts the likely behavior of such expenses under the two specified stress paths.

Freddie Mac's cost structure has been relatively stable over time, but we would expect OFHEO to monitor periodically baseline administrative expenses and to update the numbers as required.

In addition, Freddie Mac's proposal would be consistent with the requirements of the Act, insomuch as there would be no capital charges associated with activities that would be inconsistent with the "no new business" rule. Because administrative expenses associated with new business development, product innovation and research would be excluded from the calculation, our approach would accommodate innovation and the development of new risk-reduction strategies.

Finally, Freddie Mac's proposed approach would also eliminate fluctuations in required capital arising from one-time charges and variations in administrative expenses resulting from accounting policies and financing policies. Excluding the effects of such fluctuations and variations from the stress test calculation will increase the correlation between an Enterprise's capital requirements and the risks that it actually experiences. In addition, excluding these effects is consistent with OFHEO's objective of treating the Enterprises equally.

While slightly more complicated than OFHEO's proposed treatment of administrative expenses, Freddie Mac's proposal is to implement. Freddie Mac believes that the significant advantages of its proposed approach greatly outweigh the small additional implementation burdens that it imposes.

iii. Dividends

OFHEO proposes that an Enterprise pay dividends on preferred stock at the stated coupon rate so long as the Enterprise meets its minimum capital requirement and pay dividends on common stock for only the first year of the stress period. If earnings are positive and increasing, the common stock dividend rate is the average percent of earnings paid out over the prior four quarters; if earnings are flat or negative, the dividend amount is the dollar amount paid in the prior quarter. Freddie Mac generally agrees with OFHEO's proposal. However, changes in an Enterprise's form of capital distributions could affect its capital requirement disproportionately to actual changes in risk. Therefore, Freddie Mac recommends that the dividend rate on common stock be fixed at the industry average percentage of earnings.

Background

The Enterprises are funded in part by equity capital, in the form of both preferred and common stock. While under no binding legal obligation to do so, the Enterprises could be expected to continue to pay dividends during emerging periods of stress. The Act directs OFHEO to make an assumption as to the Enterprises' dividend policies during the stress period.[394]

Proposal

NPR2 proposes rules for when the Enterprises will be assumed to make capital distributions during the stress period.[395] The Enterprises make dividend payments on preferred stock throughout the stress period, so long as the Enterprise meets the minimum capital requirement both before and after the payment.[396] The dividend rate is based on the coupon rate of the issues outstanding (in the case of variable-rate preferred stock, by reference to the appropriate index). The Enterprises would make dividend payments on common stock during the first four quarters of the stress period unless making a payment would cause the Enterprise's capital to fall below the minimum capital requirement.

The amount of a dividend payment would depend on the earnings of the Enterprise. If earnings are positive and increasing, the dividend rate is the average percent-of-earnings rate paid in the preceding four quarters. If earnings are either flat or decreasing, the dollar amount of the dividend will be the same as for the preceding quarter.

The Enterprises would make no other capital distributions (*e.g.*, stock repurchases) during the stress period.

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[394] "Characteristics of the stress period . . . such as . . . dividend policies, will be those determined by the Director, on the basis of available information, to be most consistent with the stress period." The Act § 1361(b)(2).

[395] NPR2 § 3.10.3.2.

[396] In OFHEO's simulation of second quarter 1997, Freddie Mac was assumed to pay preferred dividends throughout the entire ten-year stress period (*i.e.*, Freddie Mac met the minimum capital requirement for every quarter of the stress period).

Discussion and Recommendation

We agree with OFHEO's proposed treatment of preferred stock dividends. The proposed payment of preferred stock dividends appropriately differentiates between preferred and common stock in the availability of capital to absorb losses in a stressful environment. In addition, this treatment of preferred stock dividends captures distinctions in the effects of different preferred stock structures (*e.g.*, high dividend rates, low dividend rates or adjustable rates) on the extent to which such equity capital is available to absorb losses.

Freddie Mac agrees with the proposed payment of dividends on common stock for up to one year. However, we recommend that the dividend rate for common stock be a long-term industry-average dividend rate set out in the regulation (approximately 25 percent of earnings) rather than a rate based on prior quarter dividend payments.

An Enterprise can follow a strategy of making capital distributions by way of dividends or by repurchasing its own stock. Under the proposal, an Enterprise would have to hold more future capital if it made a capital distribution solely by way of dividend payments than if it made a capital distribution in an identical amount by way of a combination of a dividend payments and stock repurchases. Such capital treatment calls for dollar for dollar capital for annual dividend payments and no capital for share repurchases. This differential treatment is not warranted by the small differences in risk presented by these two forms of capital distributions.[397] Rather than establishing a complicated formula we recommend the payout ratio be set at 25 percent.[398] Applying a percent-of-earnings pay-out ratio for the Enterprises would eliminate the differences in capital treatments between the two forms of capital distributions and so would relate capital to risk more effectively.

This change also would simplify the operation of the regulation by substituting a single, fixed value in place of a process that would require collecting data on four prior quarters of dividend payments and earnings, calculating the pay-out ratio for each quarter and averaging those calculated ratios.

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[397] As reducing dividends is more difficult than ceasing share repurchases, dividends payouts may be viewed as slightly riskier because they create the expectation of future payments. However, OFHEO's proposed differential treatment is too large to be consistent with this subtle distinction.
[398] From time to time, OFHEO would have to review the dividend payout rates to determine whether 25 percent is still appropriate for both Enterprises.

iv. Settlement of Derivatives

During the stress period, the Enterprises periodically will have to make decisions regarding the settlement of certain derivative securities, such as futures contracts. OFHEO's proposal does not address issues associated with such settlements. Freddie Mac recommends a series of simple rules to govern Enterprise behavior with respect to derivative settlements in the up-rate and down-rate scenarios.

Background

The Enterprises' risk management and hedging activities are quite complex and involve many transactions associated with the routine issuance of various types of debt. Derivative contracts are an essential part of an Enterprise's risk management and hedging strategy. For example, the Enterprises take long and short positions in various derivative securities such as Treasury futures, Eurodollar futures and put and call swap options or "swaptions"[399] in order to limit their exposure to changing interest rates. Given the significance of derivatives contracts to the business of the Enterprises, any implementation of the stress test must include rules that address the settlement of these contracts when they mature during the course of the stress test. Absent such rules, the stress test will miss a significant component of the Enterprises' activities.

Proposal

In NPR2, OFHEO sets forth no rules concerning the settlement of derivatives contracts in the up-rate and down-rate scenarios.

Discussion

Any simplified model of Enterprise behavior necessarily is limited in the degree to which it can predict the subtleties of an Enterprise's actual practices. It is important, however, that a model strike an appropriate balance between simplicity and accuracy. In ignoring the settlement of derivative contracts, OFHEO's proposal errs on the side of oversimplification.

To the extent that it does not contemplate the use of Treasury futures and Eurodollar futures for dynamic hedging and does not explicitly recognize Treasury futures contracts as effective substitutes for debt issuance, NPR2 overlooks essential components of an Enterprise's risk management strategy. Furthermore, NPR2 does not consider the settlement of existing swaption contracts, which may mature for settlement during the stress period. These financial instruments are becoming an increasingly important component of the Enterprises' businesses, and settlement rules for derivatives contracts should be specified.

[399] A "swaption" enables (but does not obligate) its holder to enter into a pay-fixed or pay-floating interest-rate swap at some time in the future. The creation of the swap at exercise is called "swap settlement" of the swaption. Often, in lieu of swap settlement, a swaption contract allows "cash settlement," in which the holder of the swaption receives the market value of the swap at the time of exercise.

To facilitate this discussion, Freddie Mac would like to set forth some guidelines that should govern any settlement rules established in the stress test. In addition, Freddie Mac believes that it would be useful to define clearly certain terms used to describe the settlement of derivative contracts.

Guidelines for rules governing the settlement of derivatives contracts during the stress period

1. The choice of whether to take delivery on a futures contract or to have a cash settlement should reflect normal prudent behavior of an Enterprise given the stress test scenario and should not distort risks. For example, a rule should not favor the up-rate versus the down-rate scenario but should be appropriate for each. This guideline is consistent with Freddie Mac's general principle that capital should be tied to risk.
2. Rules for accepting delivery versus cash settlement should be as simple as possible, to the extent that such rules can be consistent with the principle that capital requirements be tied to risk.
3. Rules for accepting delivery versus cash settlement should not assume perfect foresight on the part of the Enterprise. That is, decisions at any point in the stress test should not assume that the future path of interest rates will evolve exactly as specified in the Act.

Terms of Settlement

Two general methods of derivative contract settlement would be relevant for settlements occurring during the stress period: cash settlement and delivery into the position. *Table 21* defines various derivative positions and describes how the two settlement options would operate in each case.

Position	Definition of Transaction	Cash Settlement	Delivery
Short Position Treasury Futures	External counterparty has obligation to buy Treasury securities at a fixed price upon expiration of the contract.	The difference between the price fixed in the contract and the actual value of the asset (within the stress test) is a cash inflow or outflow to the Enterprise at expiration.	The Enterprise issues debt, buys the asset at the market price upon expiration and delivers the asset to the counterparty.
Long Position Treasury Futures	Enterprise has the obligation to buy Treasury securities at a fixed price upon expiration of the contract.	The difference between the price fixed in the contract and the actual value of the asset (within the stress test) is a cash inflow or outflow to the Enterprise at expiration.	The Enterprise issues debt and buys the asset at the fixed price upon expiration.
Short Position Eurodollar Futures	External counterparty has obligation to buy the contract at a fixed price upon expiration.	Cash[400]	NA
Long Position Eurodollar Futures	Enterprise has obligation to buy the contract at a fixed price upon expiration.	Cash	NA
Call Swaption	Enterprise has an option to enter a swap where the Enterprise pays a floating rate and receives a fixed rate for a fixed period of time starting on the expiration date of the option.[401]	Cash settlement results in a cash inflow - the amount depends on the value of the swap at expiration during the stress test.	The Enterprise exercises the option to enter into the swap upon expiration if the underlying interest rate has fallen.
Put Swaption	Enterprise has an option to enter a swap where the Enterprise pays the fixed rate and receives a floating rate for a fixed period of time starting on the expiration date of the option.[402]	Cash settlement results in a cash inflow - the amount depends on the value of the swap at expiration during the stress test.	The Enterprise exercises the option to enter into the swap upon expiration if the underlying interest rate has risen.

Table 21: Cash vs. Delivery Settlement

Rational Derivatives Contract Settlement

In designing derivatives contracts rules for the stress test, OFHEO should consider the normal and predictable behavior of the Enterprises, which typically is guided by the direction of interest rates. Similar to an Enterprise's predictable behavior when it must refund

[400] A Eurodollar futures contract is a contract on the LIBOR rate. A rise in the LIBOR rate at expiration reduces the value of the contract while a fall in the LIBOR rate increases the value of the contract. A Eurodollar futures contract always settles in cash since an interest rate cannot be "delivered."

[401] A call swaption benefits the holder if the underlying interest rate has *fallen* (*i.e.*, it benefits the holder to exercise its right to enter into the swap and pay a floating rate in exchange for receiving a higher fixed rate).

[402] A put swaption benefits the holder if the underlying interest rate has *risen* (*i.e.*, it benefits the holder to exercise its right to enter into the swap and pay a fixed rate in exchange for receiving a higher floating rate).

maturing debt,[403] a principal issue with derivatives contracts concerns the manner in which settlement is funded. For example, with respect to a short-position in Treasury bond futures contracts, delivery upon settlement requires the Enterprise to determine whether it will rely primarily on short- or long-term debt to fund the purchase of Treasury bonds that it is obligated to deliver upon expiration. Cash settlement, of course, requires no such funding. *(See Table 21.)* The Enterprise's decisions about how to fund the purchase of asset for delivery should be based on the interest rate scenario. Some rational Enterprise decisions with respect to the settlement of derivatives contracts (and how these decisions might be incorporated into a stress test) are described in the following paragraphs.

Treasury bond futures short position

If an Enterprise has a short position in a Treasury bond futures contract that matures six months into an up-rate environment, normal prudent behavior would be to issue long term debt to purchase the Treasury bonds at the market price and deliver the bonds to the counterparty. In a rising rate environment, the duration[404] of the Enterprise's assets will be increasing and issuing longer term debt to match this increase would enable the Enterprise to close its duration gap.

Conversely, in a down-rate environment, normal prudent behavior would be to issue short-term debt at the six-month point and purchase the Treasury bonds at the market price to deliver to the counterparty. In a falling rate environment, the duration of the Enterprise's assets will be decreasing and issuing short-term debt to match this decrease enables the Enterprise to close its duration gap.

Treasury bond futures long position

Now suppose that an Enterprise has a long position in a Treasury bond futures contract that matures in six months in an up-rate environment. At the six-month point, normal prudent behavior would be to take delivery and fund it with long-term debt. When interest rates rise, the duration of the Enterprise's assets increases. In a rising rate environment, the duration of the Enterprise's assets will be increasing and issuing long-term debt to match this increase enables the Enterprise to close its duration gap.

Conversely, in a down-rate environment, normal prudent behavior would be to issue short-term debt at the six-month point to purchase the Treasury bonds from the counterparty at the fixed price. Again, when interest rates fall, the duration of the Enterprise's assets decreases and issuing short-term enables the Enterprise to close any duration gap.

Incorporating these Enterprise behaviors into the stress test would sometimes require that the market price of Treasury bonds be calculated for a point six months into the test in both scenarios. In practice, this calculation should be quite simple using standard and well documented methods,[405] given that the Treasury yield curve is completely specified at all points in the stress test. Moreover, these methods require no further auxiliary assumptions

[403] *See Refunding* for a discussion of typical Enterprise refunding decisions in different interest rate environments.
[404] *See Refunding* for a discussion of duration and duration gaps.
[405] *See, e.g.,* Robert Jarrow, *Modeling Fixed Income Securities and Interest Rate Options* (1996).

other than the Treasury yield curve. However, the approximation using the duration and convexity of a par Treasury security presented below will simplify implementation:

$$Change\ in\ value\ of\ Treasury\ bond = -duration \times \Delta r + \frac{1}{2} convexity \times (\Delta r)^2$$

where Δr represents the magnitude of the change in the yield of the security.

Eurodollar futures

Eurodollar futures contracts are contracts based on the LIBOR rate. They always settle in cash because the LIBOR rate cannot be "delivered" and there is no delivery option.[406] Accordingly, a stress test modeling of these contracts should always assume cash settlement.

Swaptions contracts

Cash settlement of swaptions cannot be reliably or objectively modeled in the stress test, because the future market value of a swap cannot be forecast. In contrast, swap settlement[407] could be modeled readily using the stress test assumptions for projecting interest rates. Notwithstanding these differences, the question of whether a swaption will be swap- or cash-settled should have little or no significance to the determination of an Enterprise's financial risk in the stress test. Therefore, we suggest that swaptions be modeled in the stress test under an assumption of that the Enterprise will enter into the swap.

Recommendation

In consideration of the guidelines and the examples of rational Enterprise behavior set forth above, Freddie Mac recommends that OFHEO adopt the following derivatives contract settlement rules:[408]

	Up-Rate Scenario	**Down-Rate Scenario**
For Short Sales of Treasury Futures	Make delivery of the underlying security by issuing debt of long term fund purchase (and delivery) of the security to the counterparty.	Make delivery of the underlying security by issuing short term debt to fund purchase of the security.
For Long Positions in Treasury Futures	Take delivery of underlying securities and fund with long term debt.	Take delivery of the underlying securities and fund with short term debt.
Eurodollar Futures (Short and Long) [409]	Cash	Cash
Swaptions	Swap settlement	Swap settlement

Table 22: Treasury Futures Summary

[406] *See, e.g.*, John C. Hull, *Options, Futures and Other Derivative Securities* (1999).

[407] A swap settlement means that the holder of the swaption exercises the option to enter into a swap upon expiration of the contract. As such, a swap settlement for a swaption contract is the equivalent of delivery in a futures position.

[408] This is not an exhaustive list of all possible derivatives but is intended to be indicative. Other transactions such as repurchase (repo) transactions should be treated analogously in keeping with the guidelines set forth here.

For simplicity, we propose that the gains or losses on futures positions be calculated using the average duration and convexity of a par Treasury security as follows:[410]

Underlying Treasury Security in Futures Contract	Duration	Convexity
5-Year Note	4.2	0.2
10-Year Note	7.3	0.7
30-Year Bond	13.0	2.8

Table 23: Average Durations and Convexities of Par Treasury Securities

All of these recommendations are consistent with the guidelines set forth by Freddie Mac earlier in this section. Our recommendations consider normal prudent behavior on the part of the Enterprises. In addition, they should be simple to implement and do not assume perfect foresight by the Enterprises during the stress test.

[409] The Eurodollar futures contract only allows cash settlement. The contract is on a $1,000,000 three-month Eurodollar time deposit.

[410] For a ten-year Treasury note futures contract, Freddie Mac proposes using the duration and convexity of a par ten-year Treasury note (about 7.3 units and 0.7 units, respectively) to calculate position gains and losses. The formula to estimate the value change in the price of a note for a given change in the level of interest rates is given by: $ValueChange = -\Delta r \times Duration + \frac{1}{2}\Delta r^2 \times Convexity$

For example, suppose an Enterprise has a $1 million long position in a 3-month 10-year Treasury note futures. If interests rates increase by 150 basis points in three-months the Enterprise will lose ten percent (or $100 thousand) at maturity. $ValueChange = -1.50 \times 7.3 + \frac{1}{2} \times (1.50)^2 \times 0.7 = 10.2\%$

G. Calculation of the Risk-Based Capital Requirement

In calculating the amount of capital the Enterprises have during the stress period, OFHEO distorts the assessment of capital and risk by using a discounting procedure that implicitly assumes that losses from management and operations risk occur at the start of the stress period. Freddie Mac recommends that the discounting procedure be eliminated from the calculation of required capital.

Background

The Act provides that the risk-based capital stress test "shall determine the amount of capital that is sufficient for the enterprise to maintain positive capital during the 'stress period."[411] The required risk-based capital level is that amount determined by applying the stress test, plus an additional 30 percent for management and operations risk. To calculate the 30 percent add-on, one must first calculate exactly the amount of total capital required to maintain positive capital throughout the stress period.

Proposal

OFHEO proposes to calculate the capital needed to maintain positive capital throughout the stress period by subtracting from starting position total capital the lowest discounted capital amount from the 240 *pro forma* monthly stress period balance sheets.[412] The discount factor used in this calculation is constructed from Enterprise after-tax borrowing rates (for months in which the Enterprise is modeled as a borrower) and after-tax six-month Treasury rates (for months in which the Enterprise is not a borrower).[413]

Discussion

Capital to support interest-rate risk and credit risk depends on the amount and timing of stress test losses. Since management and operations risk is assumed to be proportional to interest-rate risk and credit risk, the amount of capital to support management and operations risk should also depend on the amount and timing of stress test losses. However, OFHEO calculates the amount of capital to support management and operations risk as 30 percent of the difference between initial capital and the discounted value of stress period capital at its lowest point.

OFHEO's discounting method is equivalent to assuming that losses associated with management and operations risk occur at the very beginning of the stress test. This assumption is not consistent with the timing of losses due to credit risk and interest-rate risk. An alternative would be to not discount, thereby assuming that losses from management and operations risk occur toward the end of the stress period. A more complicated alternative would be to model the timing of losses arising from management and operations risk explicitly. In that case, the amount of capital required to support management and operations risk would be between that amount obtained using the

[411] The Act § 1361(a)

[412] *See* NPR2 § 3.12.1[b]. In NPR2, balance sheets are constructed for each month of the ten-year stress period, for both the up-rate and down-rate scenarios.

[413] *Id. at* § 3.12.3.

discounting methodology in NPR2, and that using the approach with no discounting. However, explicit modeling of the timing of management and operation losses would complicate the stress test with no additional value in tying capital to risk.

Recommendation

We recommend that the final regulation provide for calculation of the amount of total capital necessary to maintain positive capital by subtracting the lowest stress-period capital level (*i.e.*, without discounting) from the starting position total capital rather than subtracting the lowest discounted stress-period capital level from the starting position total capital.

III. Infrastructure

The Act requires OFHEO to classify the Enterprises on a quarterly basis through the application of the risk-based capital regulation. Additionally, for the Enterprises to conduct their capital planning and comply with the regulation, they must be able to anticipate the amount of capital required by the stress test and incorporate it into their business processes. Therefore, the infrastructure systems (database, cash flow and accounting systems) used to apply the risk-based capital stress test must meet a level of accuracy, predictability and timeliness that corresponds to production standards.

Standards for production systems are very high. They require extensive testing, user manuals, and fully documented computer code and controls. If the infrastructure system used to apply the stress test meets these high standards, OFHEO would have the ability to classify the Enterprises in a timely fashion and to take prompt corrective action if an Enterprise fails to meet its risk-based capital requirement. In addition, the Enterprises could have the ability to anticipate their capital requirements and incorporate the risk-based capital stress test into their business operations and processes. In contrast, if production standards are not met, classifications may be late, erroneous and invalid, and the Enterprises would be unable to anticipate their capital requirements. In short, the regulation would be operationally unworkable.

One option for ensuring that the infrastructure systems used to apply the stress test meet production-quality standards would be for OFHEO to upgrade, test and fully document its current infrastructure systems. Based on our experience attempting to replicate OFHEO's published stress test results for the second quarter of 1997 and our experience in developing similar systems, we believe this process would take several years to accomplish.

Another option would be to adapt existing, production-quality Enterprise systems that perform comparable functions (*e.g.*, forecasting earnings). The Enterprises would use these systems to apply OFHEO's risk-based capital stress test, subject to OFHEO's strict, verifiable performance standards and any other necessary specifications. We expect that this process could be accomplished within a year. OFHEO could specify key requirements of the infrastructure now. As its systems develop, OFHEO could consider whether its regulatory needs would be better met by specifying more of the infrastructure. We believe this approach would enable the Director to implement an operationally workable final regulation in a reasonably short time frame.

Background

The risk-based capital test must be operationally workable. OFHEO must be able to apply the risk-based capital standard to classify the Enterprises on a quarterly basis in a way that is accurate, predictable and timely. Accordingly, the infrastructure of systems and procedures used to apply the stress test must be fully operational and of the highest quality. In addition, the application of the stress test must be flexible due to the dynamic nature of the two business organizations and their systems and technology. Moreover, for the Enterprises to conduct their capital planning and comply with the regulation, they must be able to anticipate the amount of capital required by the stress test and incorporate it into their business processes. Enterprise business decisions must reflect appropriate capital requirements at the time those decisions are made. This, too, requires application of a capital test that is accurate, predictable and timely.

OFHEO published its proposal on April 13, 1999, and OFHEO and Freddie Mac immediately began to work to replicate the second quarter 1997 stress test results included in NPR2.[414] That effort involved programming computer code; comparing OFHEO's behavioral model results with ours for various test cases; incorporating corrections and supplemental information posted on OFHEO's website into our analysis; and analyzing results.

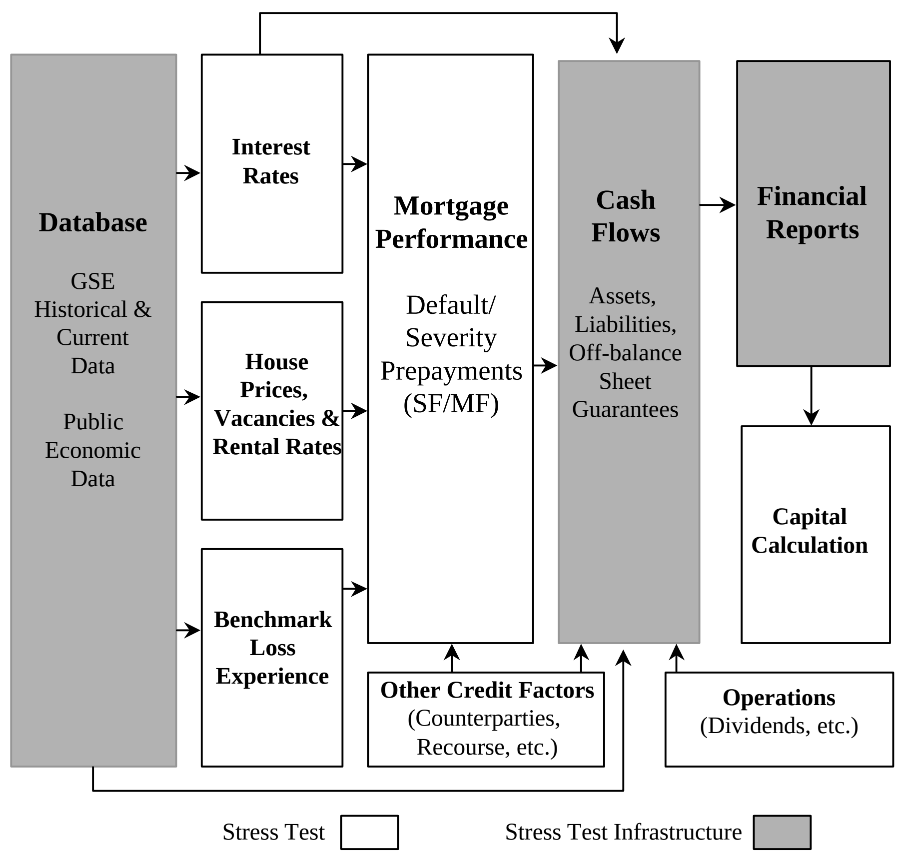
As a result of that substantial effort, Freddie Mac has essentially replicated the proposed behavioral models for default, prepayment and severity. We believe we understand stress test specifications, such as the stress test economic environment, counterparty "haircuts" and Enterprise decision rules (*e.g.*, dividends and operating expenses). As a result of this process, OFHEO's and Freddie Mac's second quarter 1997 stress test results have come closer together. However, to date we still have been unable to replicate or reconcile with OFHEO's second quarter 1997 stress test results. That is, our application of the stress test has resulted in the calculation of a different risk-based capital requirement (replication), and we have been unable to identify the reasons for the differences (reconciliation).

Because we have been able to understand the stress test components, we believe our inability to replicate OFHEO's stress test results has arisen principally as a consequence of OFHEO's database, cash flow and accounting "infrastructure," referred to by OFHEO as the Research Systems Environment.[415] The Research Systems Environment infrastructure is not fully described in the proposal or in additional information OFHEO has made available.[416] Some problems are to be expected when using such a system for the first time. Others arise from difficulties of developing and maintaining a complex system that is not integrated with a business. In addition, in several instances the Research Systems Environment did not accurately use our data and did not produce accurate financial reports.

What is infrastructure?

OFHEO distinguishes between the risk-based capital stress test and the infrastructure necessary to make the stress test operational. OFHEO illustrated and described that distinction in the figure and language below.

[414] NPR2 at 18113-14.
[415] OFHEO Press Release, *OFHEO Submits Budget Request* (Feb. 7, 2000).
[416] www.ofheo.gov/docs/regs/supps/12_flowcharts.pdf *Proposed Risk-Based Capital Stress Test Implementing Computer Programs: Flow Charts (Aug. 9, 1999).*



"OFHEO's stress test is comprised of a number of components, some that correspond to subjects specifically cited in the Act and others that represent the infrastructure that makes the stress test operational. Figure 1 illustrates these components and their interrelationships. The infrastructure components – database, cash flows, and financial reports are shaded gray. The unshaded components implement the specific requirements of the Act, as well as many other aspects of the stress test that the Act either requires or permits OFHEO to determine."[417]

Exhibit 4: OFHEO's Illustration of the Risk-Based Capital Stress Test

The stress test specifications create the hypothetical stressful environment to which an institution will be exposed. The infrastructure does the arithmetic to simulate what would happen with respect to contractual obligations and balances under the stress period conditions, and it simulates *pro forma* financial statements to calculate capital. OFHEO characterizes this as "a straightforward but simplified representation of the actual cashflow and accounting operations of the Enterprises."[418]

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[417] NPR2 at 18089; *see also* 1998 OFHEO Annual Report to Congress at. 6-7 (Box1).
[418] *See* 1995 OFHEO Annual Report to Congress at 36.

If an institution were fairly simple, the necessary infrastructure might be the relevant contractual terms, characteristics and balances in electronic form (data) and a computer spreadsheet program. When an institution is as complex as the Enterprises are, the infrastructure necessary to apply the stress test will be relevant contractual terms, characteristics and balances in electronic form (data) and a highly sophisticated customized program that accesses multiple databases and accurately projects complicated financial reports.

An ultimate goal of the infrastructure is accuracy. A completely accurate stress test infrastructure would create *pro forma* financial statements for every period within the stress period that are entirely consistent with the contractual terms of every instrument.

In practice, however, infrastructure systems necessarily incorporate some simplifications, balancing a desire for perfect accuracy with the need to avoid unwarranted complexity. For example, it could be necessary for modeling efficiency to treat a group of similar instruments as a single instrument, or to treat a group of instruments with similar contractual terms or characteristics as if they all had the same contractual terms or characteristics.

The aim of the simplification is to approximate the effect of using actual contractual terms or characteristics, in a way that will not distort the stress test results.

Requirements for production-quality infrastructure systems

To make the stress test operational, the infrastructure must be of production quality. For example, the following documentation is generally required for financial models, operating environments and operational controls:

- A complete description of models including purpose, functional capabilities, current design, theoretical constructs that shaped design, correspondence between theoretical and empirical constructs and computer code used to implement them, assumptions required to run the model, inputs required to run the model and model outputs;
- A user manual, which will allow a knowledgeable professional to use the model successfully, including required assumptions and inputs to the model (including their sources), flowcharts of the system structure and sequential activities involving the system and any manual operations, description of system output and control procedures; and
- Application controls that define requirements for completeness and accuracy of input, and completeness and accuracy of processing and data integrity, to ensure that a model completely and accurately processes intended data (*e.g.*, automated procedures, manual user controls, or a combination of both).

Because systems must evolve continuously to reflect the business, it is standard to have both a production version, which meets the requirements described above, and a development version, where improvements and maintenance are tested before being fully implemented in the production version. It is important to maintain "versions," which are updated and made available for use (released) periodically. Production and development versions of code must be maintained in physically separate environments. Documentation of changes must be maintained and changes thoroughly tested to ensure that errors are not introduced to results. Prior versions of programs and data must be retained to support recovery.

Freddie Mac's infrastructure

Freddie Mac has created a customized infrastructure that effectively includes components that correspond to all three of the shaded boxes in OFHEO's figure. Freddie Mac has used this system and its predecessor systems at least quarterly for years to forecast net interest margin, forecast earnings and apply Freddie Mac's internal ten-year stress tests. These forecasts are of critical importance. As a consequence, the system is tested monthly by comparing forecast earnings with actual earnings.

OFHEO's infrastructure

OFHEO has created its own customized infrastructure, which it calls the Research Systems Environment. The Research Systems Environment includes the components that correspond to the three shaded boxes in *Exhibit 4*. The database component is called the Data Warehouse. The cash flow and financial report components are encompassed within OFHEO's Financial Simulation Model.[419] The documentation available to us on the Research Systems Environment is limited to NPR2 and the flow charts posted on OFHEO's website.[420]

To date, we are aware of OFHEO using the Research Systems Environment to apply the stress test to an Enterprise only four times, applying it both to Freddie Mac and to Fannie Mae for the third quarter 1996 and second quarter 1997. OFHEO published the results in NPR2 in April 1999. In the case of Freddie Mac's second quarter 1997 stress test results, OFHEO has had to correct inaccuracies in how the stress test was applied. We did not subject the other stress test results to comprehensive testing.

Proposal

The distinction between the stress test and the infrastructure is not made as clearly throughout the proposed regulation as it is made in OFHEO's illustration. NPR2 did not propose the entire infrastructure (the Research Systems Environment) along with sufficient documentation to apply the stress test. OFHEO also did not release any computer code.

The database component

The proposal describes generally the concept of starting positions, and describes some of the aggregations necessary to create starting positions compatible with OFHEO's cash flow and financial report infrastructure.[421] The proposal does not describe the

[419] *See* OFHEO Press Release, *OFHEO Submits Budget Request* (Feb. 7, 2000); 1996 Annual Report to Congress at 60; HUD FY 2000 Budget Summary, OFHEO, at 2-3, 5, 6, 10.
[420] www.ofheo.gov/docs/regs/supps/12_flowcharts.pdf *Proposed Risk-Based Capital Stress Test Implementing Computer Programs: Flow Charts (Aug. 9, 1999).*
[421] *See* NPR2 § 3.1 (Enterprise Data).

specifications for translating Freddie Mac data files or Fannie Mae data files into starting position data.

The cash flow component

The proposal describes inputs, procedures and outputs related to generating cash flows for most instruments.[422] Those specifications, supplemented by additional information from OFHEO, do not completely describe the cash flow portions of OFHEO's Research Systems Environment.

The financial reports component

The proposal describes what is included in total capital and describes generally the approach of generating 120 monthly *pro forma* balance sheets and income statements.[423] It also describes certain accounting treatments and starting position balance adjustments.[424] However, the proposal, supplemented with additional information from OFHEO, does not completely describe the financial reporting component of OFHEO's Research Systems Environment.

Our discussion and recommendations below address both the elements of the infrastructure that are in NPR2 and some elements that are not.

Discussion

For the final risk-based capital regulation to be operationally workable, the infrastructure for applying the stress test must be able to reliably produce timely and accurate results and capital classifications for every quarter and must enable Freddie Mac to anticipate our risk-based capital requirements. We discuss each of the three infrastructure components in turn.

[422] *See* NPR2 §§ 3.9 (Cash Flows) and 3.7 (Mortgage Credit Enhancements). The application of the counterparty credit risk haircuts is addressed in *Counterparty Credit Risk* at 138.

[423] *See id*. at § 3.10.3.6 (Accounting).

[424] Proposed Section 3.10.3.1.1, Accounting for Positions and Cash Flows from Cash Flow Components, describes for various instruments how "[b]alances at the beginning of the stress test and subsequent changes to related *pro forma* balance sheet and income statement accounts are obtained from data generated by cash flow components of the stress test." Proposed Section 3.10.3.6.2, Accounting for Other Changes in Starting Position Balances, describes how various balance sheet balances are recorded during the stress period. Under proposed Section 3.10.3.6.3, Other Accounting Principles, several "[a]dditional accounting principles that affect *pro forma* balance sheets over the stress period are applied." Finally, proposed section 3.10.4, Output, provides that "[f]or each month of the stress test, the stress test produces a *pro forma* balance sheet and income statement. These *pro forma* financial statements are the inputs for calculating capital."

The database component

Data are an important aspect of every modern financial institution. Financial institutions use multiple data systems to collect, maintain and apply data, applying business rules. Those systems are constantly evolving to keep up with changes in business and to take advantage of advances in technology. Every institution is unique.

In this context, the process that OFHEO has followed has been to request that Freddie Mac provide data files from various of our data systems monthly, quarterly and annually, with most data files requested quarterly.

To use those data files, the Data Warehouse component of OFHEO's Research Systems Environment "translates" the Enterprises' actual data files into consistent OFHEO data sets.[425] This was a difficult task for OFHEO to accomplish, as OFHEO observed:

> The size and complexity of the Enterprises' data files make this a substantial undertaking. The task is further complicated by the differences in the way that the Enterprises record and report their information;[426]

and –

> A significant obstacle in this task [of building OFHEO's Data Warehouse] is the fact that Fannie Mae and Freddie Mac maintain their data in different formats and database structures.[427]

We agree that this is a substantial undertaking. For example, in our second quarter 1997 data submission to OFHEO we provided more than 600 million data elements to OFHEO, included in 34 different data extracts, accompanied by a four-inch binder of supporting documentation. The Summary of Report shown below illustrates the magnitude of the data-translation challenge.

[425] 1996 OFHEO Annual Report to Congress at 60.
[426] *Id.*
[427] Kinsey Remarks (May 7, 1997), *supra*, at 5.

OFHEO Request	*Enclosure*
Mortgage Data	Two 4 mm cartridges
Mortgage Information	Two 4 mm cartridges
Detailed Loan Product Summary	1 diskette
Detailed Loan Product Codes	1 diskette
Outstanding Commitments	1 tape
SF Adjustable Rate Mortgages	1 tape
Contracts (MIS)	3 tape
SF Adjustable Rate Mortgages (MIS)	1 tape
Financial Product Codes	1 diskette
Multifamily: • **MF Database** • **Yield Maintenance Period** • **MF Credit Enhancements** • **MF Bond Reinsurance Contracts** • **MF Off-Line REO Data**	1 diskette
Liabilities, Debt and Investment: • **Guaranteed Mortgage Securities** • **Investments** • **Derivatives** • **Liabilities** • **Derivative Data for Liabilities** • **Liability and Derivative Unamortized Balances**	8 diskettes
Inventory of Mortgage-Backed Investments / REMICs	See Liabilities
MRBs	Included in Inventory of Mortgage-Backed Investments/REMICs
GNMA Off-Line Product	Included in Inventory of Mortgage-Backed Investments/REMICs
SF Credit Enhancements	1 tape
Mortgage Insurance Coverage	1 tape
Summary Trial Balances	4 diskettes; 6 hard copy reports
Consolidated Financial Statements	1 diskette, 1 hard copy reports
Alternative Collateral Off-Line Product	1 diskette, 1 hard copy report, 1 agreement
Prospectuses -- REMICs	44 Offering Circulars (hard copies) and 5 diskettes
Prospectuses – GMS Purchases	47 Offering Circulars (hard copies)
MF Secured Transactions	Collateral imbedded in Mortgage Data
Amortization of Sold Portfolio and Retained Mortgages	2 diskettes
Preferred Stock – Minority Interest	1 hard copy report
Reconciliation Items	Included where applicable
HPI Data	7 tapes

Table 24: Summary of Report: Freddie Mac Second Quarter 1997 Data Submission

Not surprisingly, OFHEO's first application of the Data Warehouse to a huge volume of data files resulted in a substantial number of translation errors. Those errors arose principally from OFHEO's unfamiliarity with Freddie Mac data file structures and business rules, as illustrated by the following examples:

- OFHEO applied an incorrect business rule and therefore looked to the wrong field to identify the margin on an instrument. Such a data error has the potential to change stress test results by more than a billion dollars.
- OFHEO picked up the wrong amortization term, again by looking to the wrong data field.
- While Freddie Mac provided OFHEO with business rules to determine the correct mortgage insurance coverage amounts, OFHEO included its own business rules, which misrepresented the actual amount of coverage.
- OFHEO relied on the wrong field to identify the underwriting type for multifamily mortgages and, as a result, applied the wrong multifamily default model to many multifamily mortgages.
- To our knowledge, OFHEO relied on certain data files to create starting positions, despite our cautioning OFHEO that the requested files were not suitable for OFHEO's modeling purposes and our providing alternative data files that were suitable for OFHEO's purposes.

Errors such as these seriously impair the accuracy and reliability of the application of the stress test and could result in substantial errors in the calculation of the risk-based capital requirement. These errors could be prevented by changing the format in which OFHEO requires the Enterprises to submit data, whether or not OFHEO uses its own infrastructure to apply the stress test.

The cash flow component

NPR2 does not fully specify the cash flow component of the Research Systems Environment. However, we do agree with the principle that seems to underlie it: modeling the contractual terms or actual characteristics, or making reasonable simplifications. We discuss below issues that arise both from what is proposed and from what we understand about some aspects of OFHEO's cash flow components that are not included in the proposed regulation.

Freddie Mac, like other large financial institutions, has undertaken extensive efforts to build cash flow and accounting systems. We have relied on those systems to forecast earnings, to analyze the risk and rewards of possible transactions and to conduct internal stress tests. We enhance those systems continually to incorporate changes in the business, markets and technology. Accuracy in cash flows is critical to Freddie Mac in each of these applications.

However, any cash flow system for a complex business necessarily makes trade-offs between literal application of contractual terms and practical simplifications.

We describe below some of the simplifications incorporated into OFHEO's cash flow component of the Research System Environment that Freddie Mac believes inappropriately reduce the accuracy of the application of the stress test, where Freddie

Mac would have to adjust our systems to less accurately capture the contractual terms to replicate OFHEO's infrastructure.[428]

Remittance cycles

Section 3.9.1.3.1 describes OFHEO's cash flow system as modeling only two of Freddie Mac's three principal remittance cycles.

ARM cash flows

Section 3.9.1.3.3.1 describes OFHEO's cash flow systems as modeling ARM cash flows as if they all adjust annually and as if they all had the same margins and caps. This approach fails to capture the impact of a substantial volume of ARM products that adjust monthly or every six months and that have different margins and caps, resulting in extra income to the Enterprises.

Use of end of month balances

OFHEO's cash flow system uses end-of-month figures as the basis for issuing new debt or purchasing new investment, and ignores the timing of payments within the month.[429] This simplification misses substantial income and expenses over the ten-year period and significantly understates debt expense.

Mortgage credit enhancements

Perhaps the most significant mismeasurement of risk could occur as a result of how OFHEO's system models cash flows on mortgage credit enhancements. There is no inherent reason to treat credit enhancements in a manner different from that of any other contractual cash flow.

OFHEO described its decision to simplify as follows:

> A threshold issue for OFHEO was whether to track and model each credit enhancement with the loan or pool to which it relates or to use some level of aggregation for credit enhancements to increase modeling efficiency. Tracking and modeling each individual credit enhancement agreement with the particular loan or pool to which it is related would yield the most precise estimate of the value and behavior for credit enhancements, but would make the model very complex. Aggregating credit enhancements for efficiency in modeling, on the other hand, gives rise to "cross support," which overestimates the amount of credit enhancements that would actually be used to offset losses… The approach adopted by OFHEO strikes a balance between the benefits of simplicity and efficiency and the benefits of precision while imposing minimal regulatory burden. By estimating the coverage provided by each type of credit enhancement on the basis of loan groups, tracking

[428] We also note a contrary example: the treatment of bi-weekly mortgages, which OFHEO's infrastructure models explicitly, despite the small volume of such mortgages. *See* NPR2 § 3.9.1.3.2. Simplification is appropriate because of the minimal impact on overall accuracy.
[429] NPR2 §§ 3.10.3.1(b), (c).

> credit enhancements for each loan group can be accomplished efficiently. The large number of loan groups used by the stress test minimizes cross support between different types of credit enhancements, loans, and time periods.[430]

Shortcomings of OFHEO's simplification of credit enhancement cash flows include the following:

- OFHEO's approach provides an Enterprise with the benefit of some cross support to which it is not entitled under the contractual terms of the credit enhancements. This overly favorable treatment misrepresents the Enterprises' risks. Similarly, OFHEO's approach fails to provide the benefit of some cross support or overlapping coverage to which the Enterprise is entitled. These effects are substantial, and one could not reasonably rely on those effects somehow to balance out.
- NPR2 states that credit enhancement expiration dates are a required piece of data for modeling,[431] but OFHEO's cash flow systems apparently ignore the effect of such dates. This omission could overstate the benefits the Enterprises are entitled to receive from credit enhancement contracts having expiration dates.
- OFHEO's level of aggregation prevents its infrastructure from having the capability to track relevant mortgage balances, creating an impediment to modeling the cash flows necessary to project balances consistent with the contractual terms of credit enhancements that have caps that may increase over time (*e.g.,* spread accounts).[432]
- OFHEO's infrastructure is unable to apply the stress test specifications accurately in cases where there is more than one layer of credit enhancement. In such cases, all credit enhancements receive the credit rating of the primary credit enhancement provider.[433] In the example of a loan covered by primary mortgage insurance and recourse, the counterparty credit risk for both credit enhancements is assessed at the rating of the primary mortgage insurer. The recourse provider is likely to have a different credit rating than that of the mortgage insurer since many seller/servicers are not rated by nationally recognized rating agencies and would receive BBB counterparty credit risk treatment.
- OFHEO's simplification accommodates only those credit enhancements where a third party assumes credit losses up to some pre-set point and Freddie Mac assumes the balance of losses. Freddie Mac has recently entered into credit enhancement contracts that have different structures and cannot be accommodated within that simplification.

In contrast, Freddie Mac has concluded that the complexity necessary to explicitly model the contractual terms of credit enhancements is fully justified by the need to assess accurately the value of mortgage credit enhancements. More than 30 percent of our portfolio is credit-enhanced beyond primary mortgage insurance. Accordingly, Freddie

[430] *Id*. at 18152.
[431] *Id*. at § 3.7.2.
[432] *Id*. at § 3.7.3.2.3.
[433] *Id*. at § 3.7.2.2.

Mac has made the investment necessary to build the capability to model mortgage credit enhancements at the loan level and employs that methodology in its internal assessment of capital adequacy.

In sum, NPR2 does not fully describe the cash flow infrastructure component of OFHEO's Research Systems Environment, but many of the specifications of which we are aware simplify cash flows in ways that we believe provide an insufficient level of accuracy to the application of the stress test. This is not an unexpected result for the first external test of the cash flow component of OFHEO's Research Systems Environment. The level of accuracy we have been able to maintain in our systems owes much to the years of quarterly testing of forecasts against actual results.

The financial reports component

NPR2 does not fully describe OFHEO's financial reports infrastructure. However, we are in agreement with the basic structure of generating 120 monthly *pro forma* financial statements for each scenario.[434] We also are in agreement with the basic principle of making use of GAAP to the extent applicable, reasonably adapted to apply in a stress test.[435] We have some comments, however, on several aspects of OFHEO's financial statement infrastructure, as it is described in the proposal.

Mark-to-market accounting effects

Under GAAP, the Enterprises are required to value available-for-sale (AFS) investments on the balance sheet at market value.[436] The excess (or shortfall) of the market value relative to historical cost is an unrealized gain (loss) that is recorded in other comprehensive income (OCI), a component of stockholder's equity that is not included in core or total capital. Under GAAP, debt used to purchase the AFS investments is not valued at market value on the balance-sheet the asset and associated debt are not treated symmetrically.

This is an instance in which GAAP cannot directly be applied, because it is not possible to forecast mark-to-market adjustments over the stress period. Any attempt to model market values of financial instruments (and the associated effects on retained earnings, OCI and capital) over the stress period would be arbitrary and unreliable.

Accordingly, we agree generally with OFHEO's proposed approach of backing out the effects of the mark-to-market accounting; unrealized gains or losses do not accurately reflect changes in the economic risks borne by the Enterprises. The value of such gains and losses measured under GAAP excludes the offsetting change in value of debt used to fund the purchase of the AFS asset, and thereby misstates the effect on the Enterprise's risk. Further, changes in market value of the asset are irrelevant in terms of cash flows if the Enterprise holds the asset to maturity.

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[434] *See* i*d*. at § 3.10.3.6(d).

[435] "To the extent applicable, the stress test makes use of Generally Accepted Accounting Principles (GAAP)." *Id*. at 18097.

[436] Statement of Financial Accounting Standard 115 ("FAS 115") of the Financial Accounting Standards Board.

However, Section 3.10.3.6.2(1) proposes that these unrealized gains (losses) be charged to *pro forma* income in the first month of the stress period. That treatment would increase (decrease) retained earnings and total capital in all monthly *pro forma* balance sheets over the stress period. This treatment is inconsistent with NPR2's proposed assumption that all investments are treated as held to maturity because, as stated above, market gains or losses do not affect cash flows when an asset is held to maturity.

The proposed treatment also distorts the assessment of an Enterprise's starting position and required capital. The proposed treatment, which excludes the gain (loss) from the starting position but includes it in the stress period capital balances, incorrectly assumes that the gain (loss) occurred during the stress period as opposed to *before* the stress period. This false assumption leads to incorrect assessment of the amount of capital lost by the Enterprise during the stress period, and hence to incorrect assessment of the Enterprise's required capital.

We believe that a better way to back out the mark-to-market accounting effects would be by treating AFS assets in the stress test as held to maturity. The starting position balance sheet should be adjusted at the start of the stress test to include AFS assets at (amortized) historical cost. Any unamortized premiums or discounts associated with these assets should be amortized over the stress period just as if the assets were held to maturity.

NPR2 is silent on issues related to Financial Accounting Standard (FAS) 133, which will significantly change GAAP when it becomes effective (for calendar year companies) on January 1, 2001.[437] However, we believe that same type of treatment ought to apply. That is, because one cannot project mark-to-market values throughout the stress period, the mark-to-market effects of FAS 133 should be backed out as an adjustment to the starting balance sheet.

Such treatment would be fully consistent with relating capital to risk. Market gains and losses on derivatives reflect changes in the cash flows that the market expects to be generated by the derivatives. However, the market's expectations for these cash flows (and for interest rates and other economic variables) generally will be vastly different from the cash flows and economic assumptions generated in the stress test. Therefore, market valuations give a distorted picture of the risk and value of derivatives in the stress test economy.

In contrast to market values, amortization and cash flows from financial instruments generally can be forecasted readily, given the assumptions for interest rates already made in the stress test. The use of (amortized) historical cost and *pro forma* cash flows provides a basis for allocating the risks and benefits of derivatives and other financial instruments in a manner that is objective, verifiable and consistent with the economic scenarios posed in the stress test.

[437] Under FAS 133, all derivative securities (*e.g.*, swaps, swaptions, options, short sales, *etc*.) held by an Enterprise will be marked-to-market on the balance sheet. The offset to these mark-to-market adjustments will be recorded either in (1) another asset or liability, (2) other comprehensive income (similar to the treatment of unrealized gains and losses on available for sale assets, described above) or (3) net income (and hence retained earnings and total capital). Which of these three possibilities applies to any given derivative is determined by strict rules defined in FAS 133.

Because of these facts, mark-to-market adjustments under FAS 133 should be treated in the stress test in a manner that focuses the assessment of capital adequacy on the *cash flow* effects of financial instruments rather than their market value fluctuations. The stress test should retain the treatment of derivatives and other financial instruments required under GAAP as it existed before FAS 133. Mark-to-market gains and losses recorded in the starting position balance sheet (*i.e*., in amounts shown for assets, liabilities, other comprehensive income, and retained earnings) should be eliminated when calculating the starting position for the stress test.[438] Similarly, no forecasts of mark-to-market fluctuations should be included in *pro forma* income over the stress period.

Low-income housing tax credits

Low-income housing tax credit investments provide a substantial vehicle for facilitating affordable housing. However, section 3.10.3.6.2(3) assumes that Enterprises would maintain constant levels of investments in low-income housing tax credits, and so would continue to fund the investment with debt for the entire ten-year stress period. This is inconsistent with reasonable business judgment and could create a strong disincentive for the Enterprises to make such investments. A better approach would be to convert low-income tax credit investments to cash when Enterprises begin to show net losses, to reflect the fact that the tax benefits associated with such investments are eliminated.

End of month balances.

The proposal would base the issuance of new debt or new investments on the balances at the end of a month, and "[t]iming or sources and uses of cash within each month are ignored.[439] A better approach would be to use average balances.

Allowances for loan losses during stress period.

While allowance for loan losses count as part of total capital and so are important to determining an Enterprise's total capital level, allowances for loan losses have no impact within the stress period, other than to play a part in determining the amount of stress period income taxes. We note also that OFHEO's financial statement infrastructure allocates the allowances between single-family and multifamily, in a manner not described in section 3.10.3.3, and that treatment creates a large effect on the determination of stress period income taxes. This is a needless complication that creates some distortion of the relationship between capital and risk.

[438] Alternatively, the same effect can be obtained without adjusting the starting position total capital if the calculation of "adjusted capital" is changed appropriately.
[439] NPR2 § 3.10.3.1(b)(c).

Options

Based on both the description of OFHEO's Research Systems Environment included in NPR2 and on OFHEO's application of the proposed stress test to Freddie Mac for the second quarter of 1997, Freddie Mac believes that OFHEO's Research Systems Environment would not be sufficiently accurate, predictable and timely to make a final regulation operationally workable in the near term.

One option would be for OFHEO to upgrade, test and fully document its current infrastructure systems to meet production-quality standards. Based on our experience attempting to replicate OFHEO's published stress test results for the second quarter of 1997 and our experience in developing similar systems, we believe this process would take several years to accomplish. Moreover, we believe this approach would necessitate full specification of the infrastructure in the regulation, subject to notice and comment rulemaking.

A second option would be to adapt existing, production-quality Enterprise systems that perform comparable functions (*e.g.*, forecasting earnings). The Enterprises would use these systems to apply the risk-based capital stress test, subject to strict, verifiable performance standards and any other necessary specifications.[440] We would expect that process could be accomplished within a year. OFHEO could specify key requirements of the infrastructure now. As its systems develop, OFHEO could consider whether its regulatory needs would be better met by specifying more of the infrastructure. We believe this option would enable the Director to implement an operationally workable final regulation in a reasonably short time frame.

Under either option, we would recommend that OFHEO eliminate the need to perform data file translations by requiring the Enterprises to report their data files in a standardized format that OFHEO specifies, a call-report-like approach modeled after the approach federal banking regulatory agencies use.[441] The Enterprises should then respond by providing the Enterprise's best representation of the data, subject to an officer's declaration.[442] The integrity of the data can be verified by examination.

We discuss below some aspects of how the second option might be applied.

Cash flow component standards

OFHEO could establish accuracy standards for Enterprise cash flow systems used to apply the test. For example:

[440] This alternative solution would place the burden and responsibility for producing quarterly stress test results on the Enterprises, subject to OFHEO's standards for accuracy, further subject to OFHEO's examination, verification and oversight. We note that the Farm Credit Administration has proposed this approach in its implementation of a similar risk-based capital test. Farm Credit Administration, Proposed Risk-Based Capital Requirements, 64 Fed. Reg. 61740-64 (Nov. 12, 1999).

[441] *See* FFIEC Call Report Instructions (*www.ffiec.gov*).

[442] To the extent that OFHEO needed additional data for research purposes, we would recommend that OFHEO request it outside of the quarterly risk-based capital process.

- An Enterprise cash flow system must generate cash flows consistent with contractual terms and actual characteristics, or use reasonable simplifications.
- Any such simplification must be well-documented and consistent with those used within the Enterprise for comparable purposes to support the Enterprise's management decisions or other internal processes (*e.g.*, forecasting earnings).

In the event OFHEO determines to include any additional, specific instructions for projecting cash flows, those instructions should be cast as setting a minimum level of disaggregation (*i.e.*, they should allow the Enterprises to apply the stress test at a more detailed, accurate level.)

Financial reports component standards

OFHEO could establish standards for Enterprise financial report systems used to apply the risk-based capital stress test. For example:

- An Enterprise financial report system must be consistent with GAAP to the extent applicable, reasonably adapted to apply to produce *pro forma* financial statements.
- Such adaptations must be consistent with those used for comparable Enterprise purposes.

We also recommend that, whichever approach OFHEO elects to take, OFHEO include specific provisions consistent with the discussion above providing that:

- Mark-to-market accounting treatment should be backed out.
- Low-income housing tax credits should be converted to cash as soon as earnings go negative.
- New debt or investments are to be based on average monthly balances.

If OFHEO determines that differences in stress period accounting could result in marked differences in the impact of the stress test on the two Enterprises, OFHEO should incorporate specific instructions into the regulation.

Procedures

Under this second option, OFHEO could require that an Enterprise's infrastructure be well-documented, subject to internal controls and easily auditable. Even before OFHEO issues a final regulation, OFHEO can assess whether the Enterprises' infrastructure systems meet appropriate standards by, for example, comparing forecasts against actual outcomes. Also, the Enterprises should be required to report quarterly documentation of changes in their infrastructure systems used to apply the stress test to ensure that OFHEO is able to examine any changes in order to determine possible impact on its accuracy and appropriateness for applying the risk-based capital stress test.

OFHEO also can compare stress test results generated using OFHEO's Research Systems Environment against results generated using an Enterprise's infrastructure and determine the sources of differences.[443] If OFHEO determined that an Enterprise had incorrectly applied a stress test specification, it could make an adjustment based on OFHEO's stress test results. Even if OFHEO's Research Systems Environment were not yet up to production standards, it would still be a valuable and significant means of examining Enterprise results.

OFHEO also might look to the one-year transition period as an opportunity to further examine and verify the adequacy of both Enterprises' application of the stress test using their own infrastructures. If that examination suggests that additional specifications are required to ensure that the Enterprises' infrastructures were suitable for applying the stress test, the one-year transition period would provide an opportunity to address those additional specifications.

Finally, all reports to OFHEO are accompanied by an officer declaration declaring that the report is true and correct to the best of the officer's knowledge and belief, a declaration that is not taken lightly.

Internal models

We are aware that OFHEO has rejected an "internal models" approach.[444] The fundamental difference between the alternative approach above and the "internal models" approach is the difference in who controls the stress test — the unshaded boxes in OFHEO's illustration.[445] Under the internal models approach, each Enterprise develops its own stress test. Under the alternative approach, OFHEO develops a single stress test which is applied to both Enterprises.

As OFHEO observes, if an Enterprise controls the specifications of the stress test the Enterprise would have broad discretion to determine the level of capital it was required to maintain in relation to its risk. The two Enterprises, therefore, could be subject to significantly different stress tests and capital standards. Moreover, the stress tests would be non-public and would not be subject to a notice and comment rulemaking.[446]

In contrast, under either of the infrastructure options described above, OFHEO would specify a single stress test in the regulation, subject to public notice and comment rulemaking. The capital standard for the two Enterprises would apply an identical relationship between capital and risk. Neither Enterprise would have discretion to change the stress test specifications, thereby changing its capital requirement.

The use of the Enterprises' infrastructures does not present the same problems as the Enterprises using their own stress tests. The infrastructure — the shaded boxes in

[443] For example, if OFHEO's cash flows for monthly adjusting ARMs differed from those of the Enterprise, the difference would be a compliance problem if it arose from the Enterprise applying the wrong default coefficient, but would indicate the Enterprise was reaching a higher degree of accuracy if the difference resulted from the Enterprise adjusting the interest rate monthly and OFHEO adjusting the rate annually. We would expect that, over time, such differences in levels of accuracy would diminish.
[444] NPR2 at 18087.
[445] *Exhibit 4.*
[446] NPR2 at 18087.

OFHEO's illustration[447] — principally involve calculations and can be evaluated by examination as to accuracy. The stress test will be properly applied as long as OFHEO sets high standards for accuracy and ensures that the Enterprises meet them. Accurate infrastructure will apply the stress test according to its specifications, and will not change the stress test's correlation of capital to risk. To the extent that OFHEO identifies any infrastructure choice or convention that could have an impact on the relation of capital to risk, OFHEO should incorporate specific instructions into the regulation.

Exhibit 5 compares the three approaches.

	OFHEO Builds Infrastructure	*OFHEO Verifies Enterprise Infrastructure*	*Internal Models Approach OFHEO Rejected*
Does OFHEO Develop Stress Test Models?	Yes	Yes	No
Is Stress Test Publicly Available?	Yes	Yes	No
Is Stress Test Specified in a Regulation and Subject to Notice and Comment?	Yes	Yes	No
Does OFHEO Control Changes to Stress Test Models?	Yes	Yes	No
Are Both Enterprises Subject to the Same Stress Test?	Yes	Yes	No

Exhibit 5: Comparison of Risk-Based Capital Approaches

Conclusion

Infrastructure obstacles to operational workability could delay substantially a final risk-based capital regulation. A final regulation would be operationally unworkable if the infrastructure for applying it were not accurate, predictable and timely. As an alternative to waiting to bring the development infrastructure embodied in the Research Systems Environment up to production standards, OFHEO could place the burden of maintaining infrastructure systems and applying them quarterly on the Enterprises, subject to OFHEO examination and accuracy standards. Freddie Mac has developed and refined our infrastructure of highly sophisticated, fully operational accounting and cash flow systems by using them in a production capacity to generate information upon which Freddie Mac's management relies in making decisions about business operations. The performance of comparable applications of those systems have been tested against actual outcomes for years. An approach that makes use of Enterprise infrastructure systems would benefit from the high standards of accuracy and reliability already in place.

[447] *Exhibit 4.*

By contrast, OFHEO's Research Systems Environment has been used to apply the stress test to the Enterprises on only two occasions. As one might expect, it had very limited success. To achieve production-quality accuracy, substantial testing, retesting and documentation is necessary.

Adopting this alternative would not preclude OFHEO's continuing development of its infrastructure. OFHEO could specify key requirements of the infrastructure now. As OFHEO's systems develop, OFHEO could reconsider whether its regulatory needs would be better served by specifying more of the infrastructure.

We recognize that this alternative would place substantial requirements on the Enterprises to ensure that their systems accurately apply OFHEO's stress test. We believe that the accuracy of that application can be readily verified through OFHEO's examinations. We are committed to the implementation of a risk-based captial standard, and we believe this approach would enable the Director to implement an operationally workable final regulation in a reasonably short time frame.

IV. Procedures

Freddie Mac has commented to this point on the stress test components and infrastructure set forth in NPR2. In the following sections, we focus on the procedures that OFHEO will use to classify the Enterprises under the stress test. We present our comments in six sections, which address, respectively, the following topics: the reporting and classification process, treatment of new activities, anomalies in stress test results, amendments to the regulation, reporting procedures and transition-period issues.

A. Reporting and Classification

The proposal does not fully specify the process to be used by OFHEO in making a quarterly capital classification for the Enterprises. Given Freddie Mac's experience to date, however, it appears that OFHEO contemplates a process in which: (1) the Enterprises report data to OFHEO; (2) OFHEO applies the stress test and reports the result to the Enterprises; (3) OFHEO and the Enterprises then seek to reconcile results. The stress test applied by OFHEO to the Enterprises' second quarter 1997 book of business demonstrated that this process is not operationally workable. The reconciliation process proved to be time-consuming, inefficient and unnecessarily focused on issues that bear little or no relationship to the Enterprises' safety and soundness. Freddie Mac recommends that OFHEO adopt the approach used under the minimum capital rule. Under that process, the Enterprises would be required to report stress test results and risk-based capital calculations in their quarterly reports to OFHEO, and OFHEO would classify the Enterprises based on those reports, unless OFHEO determines that the Enterprise has made an error, or otherwise failed to apply the regulation correctly. Furthermore, Freddie Mac recommends that the final regulation provide OFHEO with discretion to classify an Enterprise as adequately capitalized if the Enterprise meets its minimum capital requirement and quickly remedies a failure to meet risk-based capital requirement.

Background

The central aim of the risk-based capital regulation is to ensure the safety and soundness of the Enterprises by assuring that the Enterprises hold sufficient capital to withstand ten years of severely adverse economic conditions. Although described only in general terms in the Act and the proposed regulation, the process that OFHEO employs in applying the stress test will determine in large part whether the regulation is a workable and effective regulatory tool. This process lies at the heart of the effectiveness of the regulation.

For the risk-based capital regulation to be effective, the reporting and classification procedures must produce accurate and timely results in which both the Enterprises and OFHEO can have confidence. A process that is accurate, predictable and timely — in short, a process that is operationally workable — is essential to ensuring that the Enterprises and OFHEO can take prompt corrective action should the need ever arise. By contrast, a process that is time-consuming and inefficient, and that compels the Enterprises and OFHEO to spend inordinate time reconciling and adjusting items that have no real regulatory significance, is bound to frustrate the goal of prompt classification and prompt corrective action.

Despite the importance of reporting and classification issues to the workability of the regulation, the Act merely suggests the procedure by which OFHEO will make a quarterly capital classification for the Enterprises. It provides, of course, that the Director shall classify the Enterprises on a quarterly basis,[448] that OFHEO must afford the Enterprises

[448] The Act § 1364(c).

notice and an opportunity to respond to OFHEO's proposed classification,[449] that the Enterprises can submit "any relevant information" to OFHEO for consideration prior to a final classification,[450] and that a classification other than "adequately capitalized" triggers mandatory and discretionary prompt corrective measures.[451] It also authorizes the Enterprises to seek judicial review of OFHEO's quarterly determinations.[452]

The Act does not specify, however, either the content, form, or timing of reports that the Enterprises must submit in order to enable OFHEO to make its quarterly classification. Nor does it specify how the quarterly classification is initiated.

Proposal

The proposal contains only two provisions[453] that address the reporting and classification process. Neither significantly clarifies or supplements the framework set forth in the Act. NPR1, as amended by NPR2,[454] requires the Enterprises to submit quarterly risk-based capital reports that contain "information identified by OFHEO in written instructions to each enterprise."[455] Following receipt of the Enterprise's risk-based capital reports, OFHEO has 60 days to notify the Enterprise of its proposed capital classification.[456] Following receipt of OFHEO's proposed classification, an Enterprise has 30 days in which to respond by submitting information to OFHEO.[457] At the conclusion of the response period, OFHEO has 30 days in which to issue its final classification decision.[458]

NPR2 leaves several important elements of the reporting and classification process unspecified, including the content, form and timing of reports that the Enterprises must submit in order to enable OFHEO to make its quarterly classification, and how the reporting process is initiated. The proposed regulation appears to contemplate a process in which Freddie Mac submits data to OFHEO, which would then apply the test, provide notice to the Enterprise of the outcome, and then reconcile differences with each Enterprise during the response period. This process is not set forth in NPR2 in explicit terms. However, in the second quarter 1997 test run OFHEO required the Enterprises to report data files to it; OFHEO used those data files to apply the stress test to the Enterprises; OFHEO provided the Enterprises with its stress test results; and the

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[449] *Id.* at § 1368(a)-(c).
[450] *Id*. at § 1368(d).
[451] *Id*. at §§ 1365, 1366.
[452] *Id*. at §1369(b).
[453] NPR2 §§ 1750.12 and 1750.21.
[454] NPR2 modifies the Procedure and Timing provision proposed in NPR1. *Id.* at 29620. NPR1 states: (a) Each Enterprise shall file with the Director a risk-based capital report each quarter, or at such other times as the Director requires. The report shall contain information identified by OFHEO in written instructions to each Enterprise, including, but not limited to: (1) all data required to implement the risk-based capital test, and (2) such other information as may be required by the Director. NPR2 amends subsection (a) by omitting subsection (a)(1)'s requirement that Freddie Mac submit the underlying data. *Id.* at 18218.
[455] *Id.*
[456] *Id*. at § 1750(b)(1).
[457] *Id.* at § 1750(b)(2).
[458] *Id.* at § 1750.21.

Enterprises and OFHEO worked together to reconcile the outcome. Notably, the goal of reconciliation has not been accomplished.[459]

That process is in contrast to the process currently used by OFHEO to determine the Enterprises' minimum capital requirement. The minimum capital reporting process calls for the Enterprises to provide OFHEO not just with aggregated data, but with a proposed minimum capital requirement and a recommendation as to any overage or shortfall. OFHEO then scrutinizes the report and issues its final classification.[460]

Although the specifics of the reporting and classification process are not specified in either the Act or NPR2, Freddie Mac has now participated in one complete dry run of the proposal (including both the proposed stress test and the apparently contemplated process) and will comment not only on the elements of the process explicitly specified in the proposal but also on what is implied and what Freddie Mac understands to be the process contemplated by OFHEO.

Discussion

Freddie Mac's experience suggests that the process employed to date, and apparently contemplated by the proposed regulation, is not practicable. Replication of OFHEO stress test results has been elusive and the reconciliation process has been slow. OFHEO and the Enterprises have become mired in tedious and painstaking micro-reconciliation procedures that focus on how various instrument-level data were aggregated or sorted for modeling purposes. The process has absorbed significant capacity and drained substantial resources at both Enterprises and at OFHEO. The delay and difficulty involved in replicating OFHEO's results have cast substantial doubt on the viability of the proposed test as an effective regulatory tool, and Freddie Mac believes that continuing the present course under the final rule would be unwise and that several negative consequences would result.

Timing

First, under the current process, OFHEO almost certainly will not be able to discharge its statutory duty to classify the Enterprises within any timeframe consistent with the goal of supervision and prompt corrective action. To the contrary, OFHEO will be required to reduce significantly the time required to apply the stress test to the Enterprises and to reconcile results with them even if it adopts the more modest goal of classifying the Enterprises twice a year. As it is, the process specified in NPR2 contemplates that a final classification may not be rendered until 150 days after the close of the quarter: 30 days from the end of the quarter for Freddie Mac to submit its reports,[461] 60 days for OFHEO to notice its proposed classification,[462] 30 days for the Enterprises to respond,[463] and 30

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[459] Although OFHEO has published results for both third quarter 1996 and second quarter 1997, OFHEO and the Enterprises have not attempted to reconcile the third quarter 1996 results.
[460] *See* 12 C.F.R. § 1750.3.
[461] NPR1 at 29620.
[462] *Id.*
[463] *Id.*

days for OFHEO to make its final classification determination.[464] These requirements are graphically represented in *Exhibit 6.*

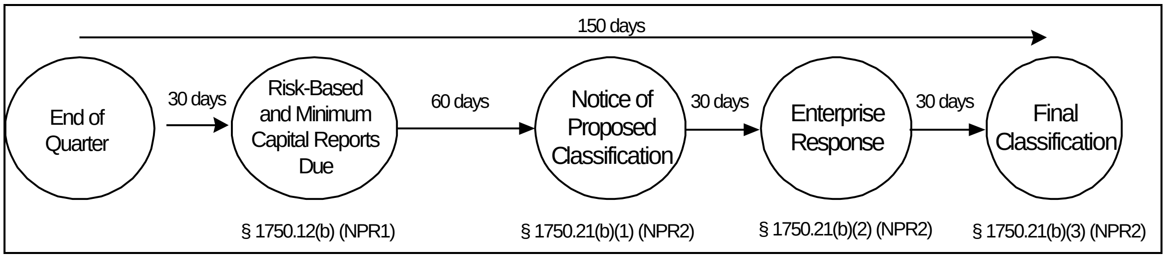

Exhibit 6: The Capital Classification Process

If experience is any guide, the reconciliation process will place even more drag on this timeline, rendering it very likely that OFHEO will not be able to produce a final classification of the Enterprises until at least six months after the quarter ends and perhaps significantly longer.

Moreover, after a final classification, an undercapitalized institution has 45 days to submit a capital plan to OFHEO,[465] which then has 30 days to approve or disapprove the plan.[466] If the plan is disapproved, an Enterprise is required to resubmit a proposal within 30 days.[467] Thus, the corrective action process may not be complete until 75 or 105 days after a final classification. In theory, then, corrective action might not be implemented until 265 days after the close of the quarter or longer.

This result is wholly inconsistent with the goal of prompt corrective action that underlies the Act. The very goal of this regulatory process is to assure early warning and foster prompt and voluntary remediation. A process that requires 150 days (or more) to produce an accurate final classification undermines that goal. Indeed, few, if any, regulatory benefits flow from taking “prompt” corrective action six to nine months after the close of a quarter. Moreover, it is far from clear what regulatory significance OFHEO’s capital classifications would have if they were generated on this schedule. Both Enterprises will be able to state credibly that OFHEO’s capital classifications are based on obsolete and stale financial data. And OFHEO would not have before it an agency record that sufficiently reflects the Enterprises’ current book of business as to enable it to make prudent judgments about what prompt corrective action mechanisms might be necessary. Thus, the timing contemplated by the proposal, and OFHEO’s implementation record to date, strongly suggest that the interests of prompt corrective action will not be served under the current system.

[464] NPR2 § 1750.21(b)(3).
[465] The Act § 1362(b).
[466] *Id.* at § 1362(c).
[467] *Id.* at § 1362(d).

Accuracy

Second, as discussed in greater detail above, Freddie Mac's experience to date has shown that OFHEO's stress test results have not been accurate. In reconciling the results for the second quarter 1997 run, Freddie Mac and OFHEO have identified a multitude of significant errors in OFHEO's application of the test. This is not surprising, given that the systems necessary to model the Enterprises accurately take years to develop and perfect. OFHEO's effort — although commendable — still exhibits research-grade qualities. Based on the record over the last two years, it is a fair conclusion that OFHEO is years away from developing the sophisticated infrastructure necessary to produce accurate test results on a timely, predictable basis.

Credibility and enforceability

Third, the proposed process raises serious credibility and enforceability concerns. When classifications that go final six months to a year after the close of a quarter, are revealed to contain a substantial number of errors, neither the Enterprises nor the public can have confidence in the results. If the reconciliation problems experienced to date continue, the validity of OFHEO's test results could well be susceptible to legal challenge on any number of grounds, including that the results are inaccurate, obsolete, and inconsistent with the Act or represent arbitrary agency action. Moreover, as detailed above in the discussion on infrastructure, the proposed process is fraught with the potential for conflict that is the antithesis of effective safety and soundness supervision. The process requires OFHEO and the Enterprises to engage in difficult, time-consuming data aggregation and data assembly reconciliation — issues that have no real regulatory significance and that are largely unrelated to OFHEO's safety and soundness mandate.

Recommendation

The problems associated with the reporting and classification process contemplated by NPR2 can be remedied easily. OFHEO should modify the reporting and classification requirements to parallel the minimum capital requirement processes. It is central to this recommendation that OFHEO in administering the test would require the Enterprises to report quarterly based on OFHEO-developed models and OFHEO-specified infrastructure. The Enterprise reports would contain appropriate supporting and documentary material as with the minimum capital report. All of that documentation, as well as the Enterprise analysis, would be subject to review and approval by OFHEO.

The Report

Under such an approach, an Enterprise would be required to submit a report to OFHEO that contains:

- Enterprise initial calculation of risk-based capital requirement, including intermediate outputs specified by OFHEO (*e.g.*, detailed monthly *pro forma* income statements and balance sheets).
- Initial calculation of total capital surplus or shortfall relative to the risk-based capital requirement.

- Starting position data, in the format necessary for OFHEO to apply it to the stress test using OFHEO's infrastructure.[468]
- Documentation of any changes to the infrastructure used to apply the risk-based capital stress test.
- A full description of any new activities and their proposed treatment.[469]
- Any other information specified by the Director.
- An officer declaration that the report is true and correct to the best of the officer's knowledge and belief.[470]

Review and classification

Freddie Mac further recommends that each Enterprise's proposed result be critiqued and accepted by OFHEO so long as the Enterprise applied the test reasonably — *i.e.*, applied the test consistent with the Act and the regulation. In its notice of proposed classification, OFHEO would adopt an Enterprise's proposed result unless the Enterprise misapplied the test or made a computational or ministerial error. In that event, OFHEO should require the Enterprise to re-report after applying the test correctly or correcting the arithmetic error. If the Enterprise fails to do so in a timely and appropriate manner, then OFHEO should itself make an appropriate correction or adjustment. Finally, the regulation should be modified to provide that OFHEO has the discretion to classify an Enterprise as adequately capitalized where it meets the minimum capital requirement and reports a risk-based capital deficit but where it self-corrects to the Director's satisfaction within a short period of time (*e.g.*, 60 days) after the quarter.

Start now

Freddie Mac recommends that OFHEO not wait until it issues a final regulation before it develops and begins to implement this procedure. Experience with the procedure, or phases of it, would improve OFHEO's ability to administer the test efficiently once the regulation becomes final.

Benefits of this approach

This proposal has numerous virtues. First, requiring the Enterprises to report initial calculation results will help to expedite the classification process and will further the prompt corrective action process. Under the process recommended by Freddie Mac,

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[468] As set forth above, Freddie Mac recommends that when the Director specifies OFHEO's data request, the Director build on the results of OFHEO's development of a standardized data format. That is, OFHEO should replace the existing data requests with a request for the Enterprise data described in proposed section 3.1, in whatever format (*e.g.,* file positions, numbers of characters, *etc*.) fully translates the data into the starting positions OFHEO needs to feed into its Research Systems Environment — changing the data request into something more like call report instructions (although Freddie Mac expects that these instructions will not be made public in the interests of protecting proprietary and confidential Enterprise data).

[469] See discussion in *New Activities* at 196.

[470] OFHEO also could require the Enterprises to submit with their quarterly report an independent auditor's attestation as to the accuracy and validity of the reported material.

OFHEO will have a detailed and documented initial risk-based capital calculation from each Enterprise early in the reporting period. If a problem appears, both OFHEO and the Enterprise will be well situated to focus on the problem and to act quickly and responsively. In serious cases, the Enterprise immediately could proceed to the prompt corrective action process. Under the regulation as proposed, however, the likelihood of an early proposed classification, much less prompt corrective action, is greatly reduced. In short, the central regulatory purpose of the Act would be well served by the approach recommended by Freddie Mac.

Second, the proposed approach would solve the problem presented by the difficult reconciliation process. As OFHEO has stated, the final regulation "has to be something that the Enterprises can use to anticipate what their capital requirements will be."[471] If an Enterprise's proposed risk-based capital level is deemed by OFHEO to be the starting point for classification and OFHEO's review, the Enterprise will be able to anticipate better its risk-based capital requirements and conduct its business to maintain the requisite level of capital.

Third, Freddie Mac's proposal would preserve OFHEO's authority and control over the classification process. OFHEO would judge the adequacy, accuracy and reasonableness of the Enterprises' quarterly reports, and the Enterprises would report the data OFHEO needs, in the format designated by OFHEO. At the same time, OFHEO's limited regulatory resources would not be dissipated in a search for micro-level differences in calculations or data assembly.

Fourth, Freddie Mac's recommendation minimizes unnecessary and costly regulatory expenses that the Enterprises would otherwise bear. Freddie Mac's data systems are developed over time and they are routinely updated. The current reporting scheme requires Freddie Mac to bear the unnecessary cost of maintaining OFHEO's databases in the course of its own business, even where those data systems are obsolete and more precise measures become available.

Fifth, the proposed system would eliminate the possibility for quarterly disputes over data-level issues by requiring each Enterprise to report information in a format designated by OFHEO. OFHEO thus would have greater resources to devote to serving its mission — monitoring the Enterprises for capital adequacy and safety and soundness.

Sixth and finally, under this approach the Enterprises will provide accurate information on a timely basis which will assure that the test results have credibility. The Enterprises would be required to submit a declaration by an officer of the Enterprise that the report is true and correct,[472] and OFHEO in any event would retain plenary authority, including sanctions power, to inspect and review Enterprise reports and to certify their accuracy. Certainly, any attempt to manipulate the results of the test would subject the Enterprises to sanctions. Moreover, the marketplace would surely penalize an Enterprise that had

[471] Mark Kinsey, Acting Director, OFHEO, Testimony Before the Subcommittee on Capital Markets, Securities, and Government Sponsored Enterprises (May 12, 1999) at 3.
[472] See NPR1 at 29620.

supplied to OFHEO inaccurate or unreliable reports or had sought to manipulate a filing to achieve a favorable result.

B. New Activities

OFHEO recognizes that the risk-based capital regulation must accommodate innovation and change. Nonetheless, the proposed regulation does not specify fully how new activities will be treated in practice. The regulation appears to suggest that new activities will be given "an appropriately conservative treatment"[473] pending a final determination by OFHEO. This standard provides little guidance to the Enterprises as to how new activities will be treated for risk-based capital purposes and could be interpreted in a manner that will stifle innovation. Accordingly, Freddie Mac recommends that, in their quarterly reports, the Enterprises document any new activities or instruments and a proposed capital treatment. OFHEO would review and assess the proposed treatment for reasonableness and consistency with the Act and accord the new activity the proposed treatment unless and until OFHEO amends of the regulation to incorporate a different treatment.

Background

The risk-based capital regulation must be able to accommodate innovation.[474] The regulation must serve as a complete, fixed set of stress test specifications and, at the same time, it must be able to accommodate products and instruments that are not contemplated at the time the regulation is issued in final form.[475] The secondary mortgage market is a fast-changing environment in which products and instruments to promote housing finance and manage risk are constantly evolving. The pace of change is measured in hours and days rather than weeks or months. Freddie Mac's active participation in these evolving products and instruments can reduce risk and increase the availability of mortgage finance, which is the purpose for which the Enterprises were chartered. Accordingly, the regulation must be crafted in such a way that it can be applied immediately to new products and instruments.

The risk-based capital treatment of new activities should be relatively straightforward. It will involve projecting contractual cash flows on a new instrument over a ten-year period, adjusted by applicable stress-test specifications (*e.g.,* default, prepayment or severity equations, counterparty haircuts and/or applicable interest rates), and projecting the

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[473] NPR2 § 3.11(b).

[474] OFHEO has recognized that "[g]iven rapid innovation in the financial services industry ... the Enterprises will become involved with new mortgage products, investments, debt and derivative instruments, and business activities that the stress test will have to accommodate." NPR2 § 3.11.

[475] Director Falcon has stated, "I must make an important distinction here between a final risk-based capital regulation and a final stress test, which determines the risk-based capital standard. We will have a final regulation, but the stress test will, of necessity, be dynamic…. By its nature, the stress test will need to evolve and change over time to reflect new products, innovations in risk management, and new techniques for measuring risk." Remarks Before America's Community Bankers, Scottsdale, Arizona, January 26, 2000. *See also* Remarks of Acting Director Kinsey, May 1999 ("The stress test . . needs to be flexible enough to address innovation. The proposal must be able to capture the risk of new products when they are introduced, and just as importantly, capture the reduction in risk from the effective use of new financial investments. This type of flexibility keeps the stress test from becoming obsolete over time.").

impact of those cash flows on monthly financial statements. If it would take an inordinate amount of effort to model the contractual terms exactly, a reasonable approach might be to simplify the treatment of the instrument, consistent with its impact on risk. The vast majority of "new" activities are small variations on existing activities and involve no novel risk or other issues.

Proposal

NPR2 provides that OFHEO will "monitor the Enterprises' activities and, when appropriate, propose amendments" to deal with new activities.[476] The proposal also emphasizes, however, that "the regulation is sufficiently flexible and complete to address new Enterprise activities as they emerge."[477]

NPR2 further explains that the final regulation will be applied to new products in one of three ways. First, OFHEO will generate a risk-based capital treatment for some products "using approaches described throughout [the] Appendix." Second, for products for which the regulation's "approaches" are not "directly applicable," OFHEO will generate a risk-based capital treatment by "combining and adapting" established approaches in an "appropriate manner." Third, for products for which "there is no reasonable approach using existing combinations or adaptations within the timeframe for computing a quarterly capital determination," OFHEO will employ "an appropriately conservative treatment until such time as sufficient information is made available to justify an alternative treatment."[478]

Finally, NPR2 suggests but does not specify in detail the procedure by which OFHEO will regulate new products and new activities. It encourages the Enterprises to notify OFHEO of proposals related to new products before they are purchased or sold, or as soon as possible thereafter, but in no case later than in connection with submission of the quarterly risk-based capital report. It also states that OFHEO will furnish an estimate of the capital treatment as soon thereafter as possible but no later than in connection with a notice of proposed classification.[479]

Discussion

Freddie Mac concurs in large part with NPR2's substantive treatment of evolving products and the process that is to be followed in generating a capital treatment for them. In particular, Freddie Mac agrees that each Enterprise should inform OFHEO of innovative products and activities as soon as practicable and in any event no later than submission of the quarterly risk-based capital report. It is significant that OFHEO has determined the Act does not require any form of pre-clearance before innovative products could be brought to market. Such a pre-clearance requirement would curtail innovation; moreover, pre-clearance is unnecessary in light of OFHEO's ample safety and soundness powers. Freddie Mac agrees with OFHEO's observation that the existing regulation can accommodate and address new activities and programs.

[476] NPR2 § 3.11(a).
[477] *Id.*
[478] *Id.* § 3.11(b).
[479] *Id.* § 3.11(c).

Freddie Mac is concerned, however, that OFHEO's proposal fails to provide an adequate means of addressing new activities in practice. The proposed regulation does not contain a definition of "new activities" and does not provide sufficient guidance as to how particular new products will be treated for capital purposes. The Enterprises will be the most familiar with the terms of an instrument and with the databases where the information relevant to the risk created by that instrument resides. Nonetheless, the proposed regulation requires OFHEO to render a capital treatment of the new activity in the first instance and contemplates that the Enterprises will bear the burden of transferring sufficient information about the transaction such that OFHEO can project accurately its cash flows and accounting treatment under stress test conditions and assumptions. The delay inherent in such a process could be substantial.[480]

Moreover, while OFHEO labors to assess an appropriate capital treatment for a new product, under the proposed regulation OFHEO will accord it an "appropriately conservative" treatment. The delay described above combined with interim conservative treatment will have several significantly adverse consequences. First, establishing a presumption of "conservative" treatment creates a strong incentive for the Enterprises to forego participation in new products and activities. If a "conservative" treatment imposes a risk-based capital level unwarranted by the product's actual risk-profile, the interim (and unpredictable) conservative treatment may well deter Freddie Mac from bringing the benefits of that product to the public.

Second, under the process contemplated by NPR2, OFHEO holds *de facto* prior-approval authority for new products. Because OFHEO always can rely on that section to impose a conservative treatment for new activities, Freddie Mac effectively could be required to vet new products and their capital treatment with OFHEO or risk imposition of an unjustifiably "conservative" interim risk-based capital treatment after the fact. As noted, that process could take many months. In the meantime, Freddie Mac effectively could be denied the opportunity to participate in new instruments that might reduce risk. Pushed to extremes, the rules proposed in NPR2 could lead to *de facto* OFHEO veto power over new products and activities. A purportedly "interim" excessively conservative capital treatment could become permanent if a more realistic capital analysis were not promulgated.

[480] Recent experience demonstrates the magnitude of this problem. More than a year ago, Freddie Mac entered into a credit derivative transaction referred to as "MODERNs" in which Freddie Mac was able to lay off substantial mortgage credit risk. OFHEO has publicly lauded the transaction as a beneficial innovation that should be incorporated into the stress test. *See,* e.*g.,* Remarks of Mark Kinsey, Acting Director, Before the Federal Agency Committee of the Bond Market Association at 3 (May 6, 1998) ("MODERNs *can be an effective way for Freddie Mac to adjust its credit risk exposure*. The stress test will appropriately reduce Freddie Mac's credit risk exposure by modeling, under stressful conditions, *the cash flows associated with the contract terms of the agreement*. Assuming a good quality counterparty, this in turn will lower their capital requirement.") (emphases added). To Freddie Mac's knowledge, however, OFHEO has yet to determine how to treat that instrument for capital purposes — even though Freddie Mac has provided OFHEO with substantial information about the instrument. In the interim, Freddie Mac has incorporated the risk impact of the MODERNs transaction in its own stress tests for every quarter since entering the transaction. Freddie Mac's experience with several other types of transactions identified to OFHEO has been comparable.

Third, application of a conservative interim capital treatment "consistent with OFHEO's role as a safety and soundness regulator" strays from the Act's directive to treat gains or losses on other activities in a manner "consistent with the stress period."[481] It also is inconsistent with the purpose of the risk-based capital test. The risk-based capital test is designed to determine a risk-based capital level that generates a capital requirement that is tied accurately to risk.

Recommendation

Freddie Mac recommends that OFHEO modify its proposed procedures so that, instead of having OFHEO determine the capital treatment of new activities in the first instance, the regulation shift that burden to the Enterprises. Specifically, Freddie Mac recommends that OFHEO require each Enterprise to notify OFHEO in its quarterly reports of new activities — which should be defined in the regulation as "any products, investments or instruments to which the stress test has not previously been applied" — by reporting the following information:

- A description of the new product, investment or instrument, including contractual terms.
- A proposed capital treatment, including a method of projecting cash flows and an appropriate accounting treatment.
- Documentary support for the proposed treatment.
- Separate monthly and annual breakouts of the cash flows and balance sheet impact of the new product, investment or instrument, incorporated into the Enterprise's reported risk-based capital stress test results.

If OFHEO determines that the proposed treatment of the new activity is reasonable, the Enterprise would continue to apply the proposed treatment unless and until OFHEO amends the regulation to incorporate a different treatment. Any amendment should be applied prospectively only.

The recommended procedure possesses several benefits. First, it places the burden to determine the capital treatment for a new product, investment or instrument on the entity that as a matter of ordinary business prudence and precaution has already conducted financial analysis of that instrument. OFHEO can perform the regulator's traditional role of review, assessing the proposed treatment for reasonableness, safety and soundness, and consistency with the regulation and the Act.[482]

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[481] *See, e.g.,* the Act §§1361(a)(4). ("Losses or gains on other activities, including interest rate and foreign exchange rate hedging activities, shall be determined by the Director, on the basis of available information, to be consistent with the stress period"); (b)(2) (characteristics of the stress period other than those specifically set forth in the statute "will be those determined by the Director, on the basis of available information, to be most consistent with the stress period").

[482] *See, e.g.,* Remarks of Mark Kinsey, Acting Director, Before the Federal Agency Committee of the Bond Market Association at 3 (May 6, 1998) ("The stress test should measure the relative risk associated with the Enterprises' activities consistent with the way they do themselves.").

Second, the recommended procedure creates an incentive for the Enterprises to propose a capital treatment early and to provide detailed documentation and analyses to OFHEO, in order to reduce any doubt as to how that activity will be treated. No other approach affords the Enterprises the flexibility to participate in evolving instruments while ensuring that when they do so they act consistently with safety and soundness.[483]

[483] *See, e.g.,* Written Statement of Mark Kinsey, Acting Director, OFHEO, Before the Subcommittee on Capital Markets, Securities, and Government Sponsored Enterprises at 3-4 (May 12, 1999) ("The stress test allows the Enterprises to manage their own businesses according to their individual strategies. It does not dictate the kinds of activities they should be involved in or how they should manage their risks…. The proposal must be able to capture the risk of new products when they are introduced, and just as importantly, capture the reduction in risk from the effective use of new financial instruments. This type of flexibility keeps the stress test from becoming obsolete over time.").

C. Anomalies

Because the proposed risk-based capital stress test is a relatively untested regulatory tool, Freddie Mac is concerned that under unforeseen circumstances it may produce aberrant or anomalous results. Freddie Mac believes that OFHEO should prepare for such a possibility by providing a mechanism in the regulation to override the stress test in the face of irrational or absurd outcomes. Freddie Mac recommends that in the event an anomaly produces a facially absurd result, the Enterprises be afforded an opportunity to document the proposed anomaly and propose an appropriate response to it, subject to review and approval by OFHEO. Freddie Mac further recommends that OFHEO make clear its authority to suspend the risk-based capital regulation pending adoption by OFHEO of a suitable and appropriate response to the anomaly.

Background

In adopting the Act, Congress recognized the “novelty” and “uncertainties” associated with basing a regulatory capital standard on stress test results.[484] Indeed, the legislative history reflects that Congress “supplemented” the risk-based capital stress test with “the more traditional minimum capital standard” to hedge against unexpected risk-based regulatory results.[485] The track record of the risk-based capital stress test remains unclear today: the test has been applied to only two prior periods and OFHEO and the Enterprises have not been able to reconcile their results for either period.

In the future the capital test may produce an aberrant or bizarre result — creating incentives to which OFHEO might not want the Enterprise to respond, or even requiring the Enterprises to engage in irrational conduct to maintain compliance. The complexity of the stress test increases the likelihood that one aberration may have cumulative or cascading effects that distort the test.[486]

Proposal

Nothing in the proposed regulation addresses how OFHEO or the Enterprises should address anomalous results should the circumstance arise.[487]

Recommendation

Freddie Mac recommends that the regulation be modified to reflect that OFHEO and Enterprises are not tied irrationally to the outcome of the risk-based capital test in the face of arbitrary and facially absurd results. In such circumstances, OFHEO should classify the

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[484] *See* Sen. Rep. at 2733 (May 5, 1992).

[485] *Id.*

[486] *See, e.g., Single-Family Default Model* at 82 (describing potential for “burnout” variable to change single-family default rates dramatically in response to small changes in interest rates); *Single-Family Loss Severity Model* at 88 (describing potential for “z-score” variable in single-family loss severity model to cause large changes in credit losses in response to small changes in house price volatility).

[487] OFHEO has recognized that anomalies are possible. *See, e.g.,* Written Statement of Mark Kinsey, Acting Director, OFHEO, Before the Subcommittee on Capital Markets, Securities, and Government Sponsored Enterprises of the House Banking and Financial Services Committee at 12 (Oct. 30, 1997) (referencing “possible model anomalies or program bugs that we need to address”).

Enterprises according to the true measure of risk facing their business operations. To achieve that goal, OFHEO should equip itself in the regulation with two specific regulatory mechanisms.

First, in the event of an anomaly, each Enterprise should be afforded an opportunity to present in its quarterly capital report an alternative capital calculation to that generated by the stress test, with all necessary supporting documentation — that identifies the source of the anomaly and proposes a method for addressing it. If OFHEO determines that the risk-based capital calculation was not distorted by an anomaly, OFHEO would classify the Enterprise based on the unadjusted stress test results. If the Enterprise were able to justify to the Director's satisfaction that the anomaly distorted the stress test calculation, and that the proposed treatment was reasonable, the Enterprise would be able to apply that modification until OFHEO amended the regulation to address the anomaly.

Second, OFHEO also should modify the regulation to provide explicitly that in cases of unforeseeable anomalies — whether they increase or decrease the risk-based capital level — OFHEO retains the right to suspend the risk-based capital test and to employ the minimum capital test to one or both of the Enterprises until such time as the anomaly is corrected. Although Freddie Mac expects such a situation will never arise, OFHEO should provide itself with this explicit override in the regulation.

Each of these regulatory mechanisms is consistent with the Act, and in practice each should be consistent with the protections and requirements of the Administrative Procedure Act (APA). Nothing in the text of the Act precludes OFHEO from administering the risk-based capital test in a prudent and practical manner when unexpected anomalies in the models produce extreme stress test results. Moreover, such a modification would further the purpose of the Act to maintain safety and soundness. In a circumstance to which the stress test has never been applied, it is possible that one variable could yield stress test results that show the Enterprises to be tremendously over- or undercapitalized or that create incentives for the Enterprises to take actions that OFHEO does not consider prudent as a matter of financial safety and soundness. Regulatory inflexibility in the face of such novel circumstances is inconsistent with OFHEO's safety and soundness goal.

D. Amendments

OFHEO has authority to initiate additional rulemakings to amend the final risk-based capital regulation. Changes to the specifications of the stress test diminish its value as a means of monitoring changes in risk over time and make it difficult for the Enterprises to engage in capital planning. Moreover, amendments are likely to have cascading effects on many other parts of the regulation. Freddie Mac recommends that OFHEO refrain from amending the regulation to incorporate *de minimis* improvements and that it amend the regulation only when consistent with OFHEO's safety and soundness mandate.

The final regulation inevitably will require amendment and refinement as circumstances change and as OFHEO and the Enterprises obtain greater experience with the regulation in practice. Such amendment and refinement will entail a delicate balance because, while change will be necessary, it can also be quite disruptive.

Freddie Mac is especially concerned with future amendments to the final regulation that change behavioral coefficients. From OFHEO's perspective, one of the costs of admendment is that any changes to the coefficients diminish the value of the test in measuring changes in risk over time. A reasonable question following an amendment is whether changes in capital requirements are the result of changes in risk or changes in coefficients. Moreover, the various components of the stress test are sufficiently inter-related that a change to one component can lead to significant changes to the effects of other components. Of course, changes also impair the ability of the Enterprises to develop means of ensuring continual compliance with the standard and to conduct long-term capital planning.

On the other hand, we hope that OFHEO will amend the regulation to correct errors or anomalies. Also, we expect that OFHEO will explore incorporating credit scoring into the regulation and look forward to working with OFHEO in that regard.

E. Reporting Procedures

To improve the operational workability of the reporting and classification process, the proposed regulation should omit the requirement that the quarterly risk-based capital reports be submitted 30 days after the end of the quarter and provide instead that the Director retains discretion to specify due dates for quarterly capital reports; that an Enterprise must re-file a risk-based capital report for a prior period only when an adjustment in data might cause a change in the Enterprises' capital classification; and that the contents of the quarterly reports shall be specified only by the Director of OFHEO.

Due dates for quarterly risk-based capital reports

NPR2 provides that risk-based capital reports be submitted within 30 days of the end of the quarter.[488] Freddie Mac recommends that the final regulation authorize the Director to specify the time required for submission of the risk-based capital reports. At least initially, Freddie Mac believes that it may be more consistent with the goal of operational workability for OFHEO to retain discretion to specify due dates than it will be to adhere rigidly to the 30-day due date requirement contained in NPR2.

Threshold for re-submitting quarterly risk-based capital reports

OFHEO proposes that "[i]f an Enterprise makes an adjustment to the data contained in the risk-based capital report for a quarter or a date for which the report was previously supplied that may cause an adjustment to the risk-based capital determination, the Enterprise shall file with the Director an amended risk-based capital report not later than three days after the date of such adjustment."[489]

Freddie Mac assumes that OFHEO's intent is to require refiling of the risk-based capital report in the event that an adjustment in data might cause a change in the capital classification. Accordingly, Freddie Mac recommends that the phrase "may cause an adjustment to the risk-based capital determination" be changed to "may cause an adjustment to the capital classification." Otherwise, it may be necessary for the Enterprises to refile a risk-based capital report on a weekly or even daily basis.

Director's written instructions for risk-based capital reports

NPR2 provides that the quarterly risk-based capital reports "shall contain information identified by OFHEO in written instructions to each Enterprise."[490] Freddie Mac recommends that the proposed regulation be amended to provide that the risk-based capital report "shall contain information identified *by the Director* in written instructions to each Enterprise."

Changes to data requests that support OFHEO's risk-based capital activities can involve substantial time and investment in systems work. Freddie Mac therefore wishes to avoid situations in which members of OFHEO staff unknowingly make inconsistent requests for changes to OFHEO's standing data requests, or make requests for changes to the data

[488] NPR2 § 1750.12(b).
[489] NPR1 § 1750.12(d).
[490] NPR2 § 1750.12(a).

requests before they have been fully resolved within OFHEO. By providing that it is the Director, or a person to who the Director delegates the Director's authority, who identifies the information that the Enterprises are required to report, the Enterprises can be assured of the consistency and appropriateness of making the investment in the necessary systems changes.

F. One-Year Transition Period

Freddie Mac recommends that OFHEO make clear that during the one-year transition period, when the risk-based capital test has no regulatory effect, an Enterprise may make a capital distribution without OFHEO's prior approval provided the Enterprise is in compliance with the minimum capital requirement.

Background

The Act establishes a one-year transition period in which OFHEO is precluded from classifying an Enterprise based on the results of the risk-based capital test.[491] During that one-year period, "an Enterprise shall be classified as adequately capitalized if the Enterprise meets the minimum capital requirements" of the Act.[492]

The Enterprise charters, by contrast, make no mention of the one-year transition period. They require the prior written approval of the Director for any capital distribution that would decrease the Enterprise's total capital to a level below the risk-based capital level.[493]

Although the Act and its legislative history make clear that Congress intended that the risk-based capital test have no regulatory effect during the one-year transition period, Freddie Mac is concerned that the absence of an explicit reference to the transition period in the charter provisions, combined with the language in the proposed regulation, could cast doubt on the ability of an Enterprise to make a capital distribution without OFHEO's approval if it did not "comply" with the risk-based capital test during the transition period. Although Freddie Mac does not believe this is the correct reading of the Act or the proposed regulation, the appropriate payment of dividends is of such consequence that any potential ambiguity should be clarified.

Proposal

NPR2 states that, for one year from the date the final regulation is published in the Federal Register, "the Director shall determine the capital classification of the Enterprise, based solely on the proposed minimum capital requirement."[494] Paralleling the Act, NPR2 specifies the Enterprises will be classified by OFHEO based upon the minimum capital test and not based on the risk-based capital stress test during the transition period.

In a "general" provision in Subpart B, however, NPR1 provides that the regulation "establishes the RBC requirement for each Enterprise" and that the board of directors of each Enterprise "is responsible for ensuring" that the Enterprise maintains total capital sufficient both to ensure the continued financial viability of the Enterprise and to satisfy the risk-based capital requirement.[495] Those sweeping statements are susceptible to the

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[491] The Act § 1361(e)(1).

[492] *Id.* at § 1364(d); *see also id.* at § 1365(c) (provisions regarding supervisory actions applicable to undercapitalized Enterprises does not take effect for one year after issuance of the final risk-based capital regulation).

[493] Freddie Mac Charter § 303(b)(2); Fannie Mae Charter § 303(c)(2).

[494] NPR2 § 1750.21(c).

[495] NPR1 at 29619.

interpretation that — notwithstanding the inability of OFHEO to base classification decisions or enumerated supervisory actions on the basis of the risk-based capital regulation during the transition period — the Enterprises nonetheless owe a duty to comply with the final regulation during the transition period and cannot make capital distributions without OFHEO's approval unless they have complied with it. Freddie Mac is concerned that this language, read in conjunction with the Charter provisions, might cast doubt on an Enterprise's ability to pay a dividend without OFHEO's approval even though it is classified as adequately capitalized.

Discussion

Although the reading suggested would be inconsistent with the statute and the clear intent of Congress, any slight potential ambiguity in this regard could have serious consequences. Fortunately this is a potentially serious problem with a simple solution: a modification of the proposed regulation to state explicitly that prior approval need not be obtained for capital distributions that reduce an Enterprise's capital level below the level mandated by the risk-based capital test during the transition period as long as the Enterprise meet the minimum capital standard. Such an amendment is appropriate and necessary for several reasons.

First, the legislative history of the Act reveals that the purpose of the transition period is to enable the Enterprises to plan ahead to fulfill the newly created capital requirements. For example, the House Report of September 17, 1991 provides:

> The Committee [on Banking, Finance and Urban Affairs] fully expects that the Enterprises will have little difficulty in achieving and maintaining the regulatory capital required to meet their risk-based capital requirements. To ensure that the Enterprises will be able to meet their respective requirements, the Enterprises are given one year to meet the risk-based capital standard once it is established by regulation.[496]

This report makes clear that the transition period is just that — a "transition" during which the Enterprises adjust to the new test without having it enforced.

Second, the nature of the transition period would be distorted by a rule precluding the Enterprises from making capital distributions without prior approval if those distributions would reduce capital levels below the level dictated by the risk-based capital test. The risk-based capital test would be given immediate and consequential regulatory effect. The Enterprises would be required to comply immediately or risk losing the right to make dividend distributions.

[496] H.R. Rep. No. 102-206, at 64 (1991). Although there is a later House Report, dated July 30, 1992, and a Conference Report, dated October 5, 1992, neither provides any additional commentary on the proposed regulation's transition period. H.R. Rep. No. 102-760 (1992); H.R. Conf. Rep. No. 102-1017 (1992). The House Report of September 17, 1991 thus remains the most authoritative statement as to the House's intent on this issue.

Third, the transition period will serve as a final opportunity for OFHEO and the Enterprises to identify flaws and anomalies in the application of the test. Prohibiting dividend distributions in such transitional circumstances is inappropriate.

Congress expressed in the Act a clear judgment that in the one-year transition period the Enterprises will be deemed adequately capitalized if they comply with the minimum capital requirements. In that period, the risk-based capital regulation is to have no legal effect, and the proposal should be modified to make this fact explicit.

Recommendation

OFHEO should modify the regulation to clarify that the one-year transition period also applies with respect to the Enterprises' Charter provisions relating capital distributions to the minimum and risk-based capital standards. As modified, the one-year transition period section should provide:[497]

> From [insert date of publication of the final rule in the Federal Register] until [insert date twelve months after date of publication of the final rule in the Federal Register], the Director shall determine the capital classification of the Enterprise based solely on the proposed minimum capital requirement, *and the Enterprises shall be required to obtain the Director's prior written approval of capital distributions only if the capital distribution would decrease the Enterprises' capital levels to a level below that necessary to be classified as adequately capitalized.*

[497] The general provision in Subpart B also should be modified accordingly.

V. APA Considerations

OFHEO has stated that, after it reviews comments on the proposal, it will consider whether to re-propose or to issue a final regulation.[498] Re-proposal bears consideration. Re-proposal would eliminate the possibility that the Enterprises and other interested parties will be deprived of the opportunity to comment on unanticipated choices and judgments made by OFHEO in response to the comments submitted in response to NPR2.[499] Moreover, solicitation of public input on a near-final proposal could improve the final regulation. The comment period could be appropriately brief and could even shorten the time to a final regulation.[500]

[498] Statement of Mark Kinsey, Acting Director, OFHEO, Before the House Subcommittee on Capital Markets, Securities, and Government-Sponsored Enterprises (July 30, 1998) at 1 ("If OFHEO decides significant changes are needed, we will be required to re-propose the rule and extend a new comment period.").

[499] The APA imposes duties independent of the Act and is relevant to the risk-based capital regulation in two ways. First, its notice-and-comment provision, 5 U.S.C. § 553, requires that interested parties such as Freddie Mac be afforded the opportunity to submit written comments and that the agency in turn respond "in a reasoned manner" to them. *United States Satellite Broadcasting Co. v. FCC,* 740 F.2d 1177, 1188 (D.C. Cir. 1984). This requirement is an "essential component of 'fairness to affected parties'" because it enables affected parties "to dispute the proposed regulation, as well as the data and assumptions on which it is founded, prior to the rule becoming effective," *Small Refiner Lead Phase-Down Task Force v. EPA,* 705 F.2d 506, 547 (D.C. Cir. 1983) (citation omitted), because it enables affected parties to dispute the proposed regulation as well as the data and assumptions on which it is founded prior to the rule becoming effective and it assures that the agency will have before it the facts and information relevant to a particular administrative problem, as well as suggestions for alterative solutions." *Guardian Federal Savings and Loan Association v. FSLIC*, s89, F.2d 658 662 (C.D.C. Cir. 1978S). For this to happen, however, "[a]n agency must provide sufficient factual detail and rationale for the rule to permit interested parties to comment meaningfully." *National Elec. Manf. Assoc. v. EPA*, 99 F.3d 1170, 1172 (D.C. Cir. 1997). Indeed, when an agency predicates a rule upon an econometric or statistical model, it must "explain[ ] the assumptions and methodology it used in preparing the model," and, if challenged, prove the model produces "reasonably accurate" results and "provide a full analytical defense." *Eagle-Picher Industries v. EPA*, 759 F.2d 905, 921 (D.C. Cir. 1985); *Columbia Falls Aluminum Co. v. EPA*, 139 F.3d 914 (D.C. Cir. 1998).

Second, and related, is the principle that final rules may not deviate significantly from the rule as proposed by the agency absent an additional round of notice and comment. The agency must provide a second notice "when the changes are so major that the original notice did not adequately frame the subjects for discussion," or when, as it is often put, the final rule is not a "logical outgrowth" of the proposed rule. *Connecticut Light & Power Co. v. NRC*, 673 F.2d 525,533 (C.D.C. Cir. 1982). Re-proposal serves "to allow interested parties a fair opportunity to comment upon the final rules in their altered form." *Id.*; s*ee Kooritzky v. Reich*, 17 F.3d 1509, 1513 (D.C. Cir. 1994) (for a final rule to be a "logical outgrowth" of a proposed rule, the agency must have "alerted interested parties to the possibility of the agency's adopting a rule different than the one proposed.")

[500] Freddie Mac notes that OFHEO's efforts parallel those of the federal banking agencies with respect to their complex capital regulations. Those agencies recently released their third joint notice of proposed rulemaking concerning proposed changes to their risk-based capital standards that address the regulatory capital treatment of recourse obligations and direct credit substitutes. The three notices were published in 59 Fed. Reg. 27,116 (May 1994); 62 Fed. Reg. 59,943 (Nov. 1997); and publicly released by the FDIC in February 2000. This six-year effort reflects how difficult it has been for bank regulators to accomplish a more limited risk-based capital rulemaking.

VI. Conclusion

NPR2 represents a substantial accomplishment in the design of a complex regulation. With the recommendations Freddie Mac provides here, we believe that OFHEO's stress test will be a state-of-the-art capital regulation. More challenging will be implementing the systems infrastructure and procedures necessary to make the stress test operational. Freddie Mac offers suggestions to make this implementation accurate, predictable and timely.

Freddie Mac and Fannie Mae serve a fundamental role in the nation's housing finance system. It is therefore vital to homebuyers, mortgage lenders, home builders, real estate professionals and others in the housing industry, as well as to the Enterprises, that OFHEO's final risk-based capital regulation appropriately relate capital to risk, accommodate innovation and operate effectively.

Freddie Mac strongly supports a well-implemented risk-based capital standard that will assure the continued flow of mortgage funds to America's families. We are committed to working with OFHEO to achieve this end.

APPENDIX 1

"Measuring the Capital Adequacy of Financial Firms, with a Particular Emphasis on Freddie Mac"

Mark J. Flannery, Ph.D

1999

Measuring the Capital Adequacy of Financial Firms, with a Particular Emphasis on Freddie Mac

by

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Executive Summary

Qualitatively, Freddie Mac's regulatory structure (capital standards plus the supervisor's oversight and intervention powers) provides better stability than that of other mortgage finance intermediaries (Federal Home Loan Banks, insured commercial banks and thrift institutions, and conventional mortgage pools). The risk-based stress test imposed on Freddie Mac and Fannie Mae captures portfolio risks and the ability of equity capital to absorb losses more accurately and more promptly than the Basel ratios governing banks and thrifts. Quantitatively, Freddie Mac would generally pose less risk of failure than most other mortgage finance intermediaries, even though its capital level represented a smaller proportion of its outstanding obligations. Freddie Mac's relative safety is due to its more geographically diversified mortgage portfolio, and the absence of any interest rate risk exposure from its off-balance sheet mortgage guarantees. In addition, the Office of Federal Housing Enterprise Oversight can accurately monitor its risks and intervene in a timely way to limit those risks.

This report compares and evaluates the capital requirements imposed on U.S. housing finance institutions such as commercial banks, thrift institutions, the Federal Home Loan Bank (FHLB) System, and two government sponsored enterprises (GSEs), Fannie Mae and Freddie Mac. Taxpayer protection, competitive equity, and allocative efficiency require that supervisory capital constraints impose similar burdens on all types of housing intermediaries. However, "equal burdens" do not generally imply equal capital ratios, as they are commonly applied in the U.S.

1. The U.S. Housing Finance System

The current U.S. system for housing finance begins with local institutions (such as commercial banks and thrift institutions), which underwrite mortgages for individual borrowers.[1] Each depository institution (DI) then decides whether to retain the mortgage in its own portfolio, or to sell it to another investor. In retaining a loan, the DI becomes exposed to both interest rate and credit (default) risk, both of which must be managed. Since the typical DI can most readily access shorter-term deposits, it tends to retain adjustable rate mortgages while selling the fixed-rate contracts. Because most DIs' retained mortgage portfolios are concentrated in a relatively small geographic area, their borrowers' economic fortunes will tend to be correlated with one another. Mortgage credit losses on these relatively undiversified portfolios may be quite difficult to predict. In addition, the rate caps included in most adjustable rate mortgage (ARM) contracts leave the typical DI with a surprisingly large interest rate risk exposure (Sendero Institute

[1] Mortgage bankers compete with depository institutions in underwriting, but they have limited funding and must therefore sell their mortgage loans to longer-term investors. Since these institutions are relatively small and receive no federal protection, I will not mention them explicitly in the remainder of

[1996]).

A number of Government Sponsored Enterprises (GSEs) have emerged over the past three decades in order to assure a stable flow of funds to the U.S. housing market. Congress created the system of 12 FHLBs to provide liquidity to member DIs wishing to hold more mortgages than their local deposit markets could reasonably finance. By issuing consolidated debt obligations in the capital market, the FHLBs can provide liquidity to their members and expand the aggregate supply of mortgage funds in the economy.

While the FHLBs expand member institutions' ability to finance mortgages on their own books, the housing finance GSEs (Fannie Mae and Freddie Mac) provide credit enhancement services which make it easier to sell mortgage loans to capital market investors. (The idiosyncratic nature of individual mortgage loans' credit risks effectively precludes a direct sale to long-term investors.) These GSEs evaluate the credit quality of individual mortgage loans, price the apparent default risks, and guarantee the timely repayment of principal and interest to purchasers of their mortgage-backed securities. In this process, the GSEs are exposed to default risks. Unlike most individual DI, however, the housing finance GSEs' nationally diversified portfolio of mortgage loans has more predictable default losses than those from a less geographically diversified portfolio. To the extent that a GSE retains substantial loans in its own portfolio, the intermediary must manage both credit and interest rate risk (just as a DI would have to).

In the wake of the 1980s' thrift crisis, Congress became concerned about the

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this report.

potential impact of financial sector supervision on taxpayers, and on the stability of the U.S. financial system. In December 1990, insured banks and thrift institutions became subject to tighter capital standards under the international Basel Accord.[2] Congress then passed the Federal Deposit Insurance Corporation Improvement Act of 1991 (FDICIA), which was designed to force regulators to intervene more promptly when banks and thrift institutions first showed signs of trouble.

Congress then turned its attention to the housing finance GSEs and passed the 1992 Federal Housing Enterprises Financial Safety and Soundness Act (FHEFSSA) to provide “more effective Federal regulation … *to reduce the risk of failure* of the (Fannie Mae and Freddie Mac) enterprises” (Sec. 1302 (2), emphasis added). The Federal government is appropriately concerned about the financial condition of the housing finance GSEs for two reasons. First, these entities are closely related to the government, and many observers believe that Congress (that is, U.S. taxpayers) might assume a failed GSE’s obligations. Second, the failure of an institution as large as Fannie Mae or Freddie Mac could cause substantial financial system disruptions. Congress therefore wishes to assure that the housing finance GSEs operate in a safe and sound manner.

Capital regulation has a central role in controlling failure risk, and FHEFSSA created the Office of Federal Housing Enterprise Oversight (OFHEO) to evaluate the ability of a Fannie Mae's and Freddie Mac's capital to provide an acceptably low default probability. At the same time, however, regulatory capital requirements can affect a firm's

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[2] The major industrialized countries' central bankers agreed in 1987 to implement a uniform system of bank capital regulation, based on rough estimates of the differences in credit risk between various classes of bank assets. These regulations were implemented in the U.S. in two stages, starting in December 1990. The U.S. full implementation was complete in December 1992.

rate of return on equity. Because the formal capital requirements imposed on banks, thrifts, and the GSEs appear to differ quite substantially, questions naturally arise about comparative stringency of the capital requirements imposed on different types of housing finance intermediaries. While all the U.S. housing finance intermediaries are exposed to similar *types* of risk, the various institutions differ in the *extent* of their exposures and in how they hedge risks. A consistent regulatory system must recognize these differences.

2. A Framework for Evaluating Capital Adequacy

Uncertainty about a firm's ability to repay fixed claims arises because the firm’s end-of-period value will be affected by future developments, which are not known when the debt is issued. Holding constant the firm’s asset side, its ability to repay fixed claims depends primarily on the extent of those claims. The more equity capital with which the firm starts out, the less likely will it fail. The concept of “adequate” capital is not very well defined in the context of a typical corporation. In the context of financial firms, however, adequate equity capital is the amount which reduces a firm’s failure probability to an acceptable level. This notion of adequate capital closely resembles the "value at risk" (VaR) concept which has attained such currency in financial firms' risk management systems. Under VaR, an activity's risk is judged on the basis of the largest likely (usually, the 99% confidence level) loss which might occur over a fixed time period. If the firm holds initial capital equal to this VaR amount, its default probability will be 1%. By adjusting the level of capital relative to the firm's VaR, managers are implicitly choosing the firm’s probability of default.

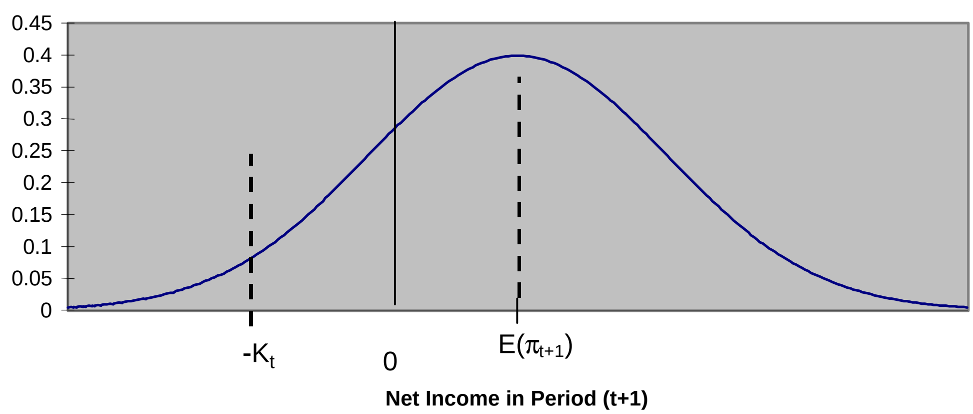
This section first discusses the conceptual determinants of a firm's default probability, then illustrates the quantitative importance of each factor.

2.a) General Determinants of Default Probability

Consider a firm with $\$K_t$ of equity at time t. It has levered this equity (via debt issuance and off-balance sheet obligations), and its risk exposures produce a stochastic income (profit) level for the coming period.[3] Although the firm expects to earn positive profits, its realized profits could be either positive or negative. A sufficiently great loss will, of course, render the firm unable to repay its obligations.

Figure 1 graphs the probability function for the firm's economic income (π_{t+1}) accruing during the period [t, t+1]. The firm will fail at the

Figure 1: Asset Risk and Leverage Determine Default Probability



end of the period if it loses enough money to exhaust its initial equity capital. That is, if

$$\tilde{K}_{t+1} = K_t + \tilde{p}_{t+1} < 0 \quad \text{or if} \quad \tilde{p}_{t+1} < -K_t \,. \qquad (1)$$

[3] The firm's "income" is meant to be economic income (the change in its equity market value), as opposed to (GAAP) accounting income. Similarly, "capital" is meant to be the economic (current market) value of a firm's equity. The Appendix presents a formal model of income uncertainty and default, which

If net income is normally distributed, the probability of this happening is

$$\Phi\left(\frac{-K_t}{s_p\sqrt{t}}\right) \tag{2}$$

where Φ is the standard normal cumulative density function and σ_π is the standard deviation of net income.[4] The firm's failure probability corresponds to the area under the curve in Figure 1 to the left of ($-K_t$). We can assess the failure probability associated with any level of capitalization by assigning reasonable values to the determinants of π and its volatility. This is done in the Appendix, which presents a formal model of a DI/GSE firm's default probability.

Figure 1 clearly illustrates two important determinants of a firm's failure probability.

1. Leverage. Substituting equity for debt lowers the probability of failure. To see this, hold constant the volatility of π and imagine adding additional equity in Figure 1. The critical point ($-K_t$) shifts leftward, reducing the firm's probability of failure. Conversely, removing equity from the firm's capital structure increases its failure probability.

2. Expected Future Income. More profitable firms have a lower probability of failure, for two reasons.

   - First, the firm's loss is less likely to exceed the initial equity level. To see this, imagine shifting the probability curve rightward, by raising $E(\pi_{t+1})$ without changing its variance. The area under the curve to the left of ($-K_t$) will decline.

   - Second, if the firm does experience a loss which exhausts its initial capital, greater expected profits make the firm's owners more willing to contribute additional equity, rather than forfeit the firm to creditors. In other words, a firm with greater franchise value is less likely to default to creditors. (This effect cannot be illustrated in a one-period graph like Figure 1.)

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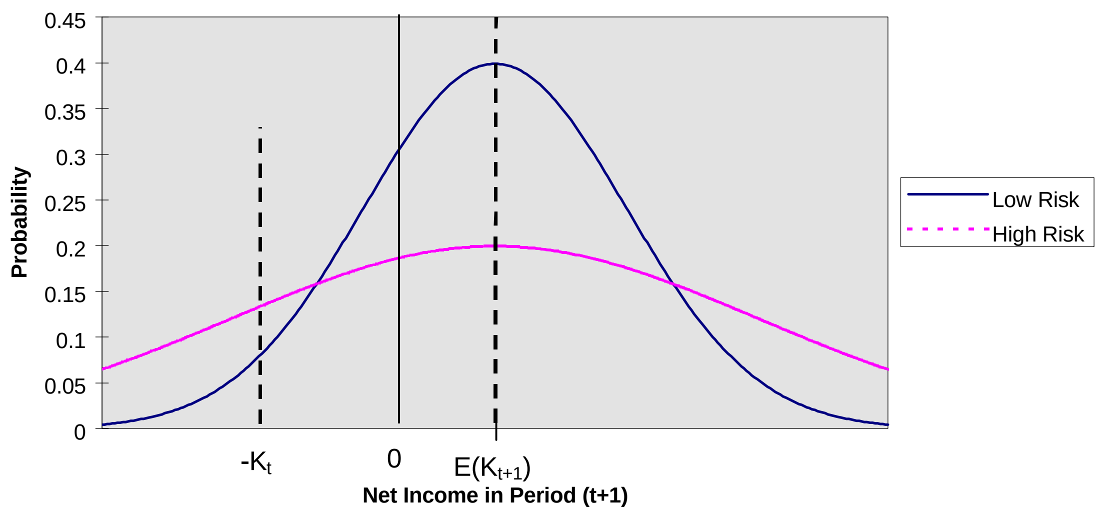
underlies the Figures presented below.

[4] Note that failure depends on the ratio of initial equity to *risk* in (2). This can be represented by the ratio of equity to assets (or some other balance sheet construct) only for a fixed level of asset return volatility. I return to this important issue below.

Figure 2 illustrates another important determinant of a firm's failure probability: risk. Holding constant the level of initial equity capital, the default probability increases with the riskiness of net income. Riskier assets or funding strategies generate a more-widely-dispersed range of possible net income, represented by the flatter probability function in Figure 2. Clearly, a more dispersed outcome for net income implies a higher default

Figure 2: Higher Risk Raises the Chance of Failure



possibility (as measured by the areas under the two curves to the left of ($-K_t$)).

The firm's income can be made more risky in four ways. First, the firm can alter its interest rate risk exposure by changing the maturity (duration) mismatch between its assets and liabilities. Second, it can take on a less diversified set of loans, whose default losses are more widely dispersed.[5] Third, the firm can slacken managerial oversight in a

[5] Note that I say nothing here about the expected default on the loans. So long as the loan rate covers its

way that makes large, negative outcomes more likely. Fourth, the dispersion (volatility) of net income increases with the length of the time period implicit in Figure 2.[6] For regulated financial institutions, this time period corresponds roughly to the interval between detailed regulatory assessments of capital adequacy. (See the discussion of "Time to Action" in Section 4.c below.)

The most appropriate way to assess capital adequacy is directly implied by the failure probability which underlies Figures 1 and 2. A firm's failure probability depends on the level of its initial equity capital *relative to* the volatility of its net income:

$$\Phi\left(\frac{-K_t}{s_p\sqrt{t}}\right) \qquad (2)$$

(Where σ_π is the annual standard deviation of net income and t is the number of years between regulatory assessments of firm solvency.) The common practice of assessing capital adequacy on the basis of a balance sheet ratio – e.g. equity to total assets or equity to risk-weighted assets – implicitly assumes that a firm's income volatility is proportional to its asset size. Suppose, for example, that net income volatility was given by σ_π=σA, where σ is the annual standard deviation of net income per dollar of assets (A). Then a firm's probability of default would be given by

$$\Phi\left(\frac{-\mathrm{K}_\mathrm{t}}{\mathrm{A}\sigma\sqrt{\mathrm{t}}}\right) \qquad (2a)$$

If asset risk (σ) and the time between regulatory assessments (t) were the same for all

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expected default, the loans' default probability has no impact on firm risk unless the expected default rates are related to the variance of portfolio defaults.

[6] If net income is normally distributed and the standard deviation of annual income is σ, the standard deviation of income over a period t years long is $s\sqrt{t}$.

firms, we could reasonably compare different firms' capital ratios (K/A) to assess their relative default probabilities.

In reality, σ is not uniform across firms. Even within the same industry, different firms select different risk levels.

1. Asset composition affects income volatility, and financial firms frequently specialize in different types of loans. To the extent that different loans expose the firm to different levels of uncertainty, the same capital ratio will provide different levels of protection to firms with different portfolio compositions.

2. Even loans of the same general type (e.g., 1-4 family mortgages) can expose a lender to quite different risks.

   a) The variability ("risk") of default losses in a nationally diversified mortgage portfolio is substantially lower than the default risk in a portfolio that is more geographically concentrated.

   b) A portfolio of high-LTV loans will have higher *and more variable* default losses than a portfolio of lower-LTV loans. (See Quigley and Van Order [1991], Table 3.) The high-LTV lender must therefore hold more initial equity capital to equate its default probability with that of a low-LTV lender.

3. An on-balance sheet portfolio may have different combinations (and different amounts) of both credit and interest rate risk than an off-balance sheet portfolio involving similar assets. For example, a GSE absorbs only credit risk when it guarantees MBS, while it absorbs both credit and interest rate risk on the mortgages it finances in its own (retained) portfolio.

Of course, supervisors recognize that asset composition can importantly affect a firm's default probability. But in some cases their ability act on individual firms' perceived risks is limited by procedural constraints or incomplete information.[7]

The other reason capital-to-asset ratios may provide poor indicators of a firm's failure probability is that different types of firms are subject to different intervals between

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[7] Many people believe, for example, that the risk weights used in the DIs' risk-based capital calculations do not adequately reflect the true impact of portfolio composition on a firm's income risk.

the time their initial capital is established and when they are next checked for solvency. The volatility of income increases with the square root of this time interval. Other things held constant, a firm whose solvency is checked less often therefore has a higher probability of failure associated with a given initial capital ratio.[8] In other words, we should not make simple comparisons of required capital ratios across institutions with different scheduled times between solvency evaluations.

More generally, comparing capital ratios across institutions or across types of financial institutions can easily give misleading impressions about relative failure probabilities.

2.b) Quantitative Effects of Default Probability

Although income volatility, time between regulatory assessments, and initial capital have clear *theoretical* effects on a firm's default probability, their empirical importance may be small. To assess the impact of these factors on a stylized DI's failure probability, I have constructed a stochastic model of firm performance, which is described in the Appendix. The model computes failure probabilities for a range of input values which specify credit and interest rate risk, the time between solvency evaluations, and the firm's initial capital ratio. Based on this model, Figures 3 and 4 illustrate the impact of key parameter changes on a firm's failure probability. These simulations, along with others presented in Section 5 and the Appendix, demonstrate that there is no clear relation between a firm's capital ratio and its probability of failure. This statement is valid for a

[8] Pyle [1986] first observed that time between solvency evaluations substituted for initial capital in controlling a firm's expected default losses.

wide range of reasonable parameter values.

Figure 3 illustrates the sensitivity of a stylized thrift institution's default probability to variations in its initial capital ratio and in the volatility of its mortgage credit losses.[9] Reading from right to left across the front axis, the default probability clearly rises with mortgage default risk for any capital ratio. Reading the graph from front to back, lower initial capital ratios are associated with higher default probabilities for any level of asset risk – though this effect is more dramatic for less diversified portfolios. In short, Figure 3 illustrates that both the initial capital ratio and the level of portfolio risk can materially affect a financial firm's default probability.

The impact of time between solvency evaluations is illustrated in Figure 4, which shows that the *evaluation interval* also substantially affects a stylized DI's default probability. Holding constant the initial capital ratio (at 2%) and credit risk volatility (at 0.5% per year), the thrift's probability of default is much higher when its solvency is assessed less frequently. In this example, the annual default probability associated with a 3-year evaluation interval is more than *8 times* larger than the probability if a thrift is examined annually.

3. Institutional Features of Capital Adequacy Requirements

This section describes the capital standards applicable to four components of the U.S. housing finance system: depository institutions (DIs), the FHLBs, conventional (uninsured) mortgage pools, and the two housing GSEs. In the discussion, I emphasize

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[9] The indicated volatilities of default losses in Figure 3 are meant to reflect the effect of geographic diversification on a loan portfolio's credit risk.

the aspects of supervisory oversight which affect default probabilities: asset selection, required capital, and the time between solvency evaluations.

3.a) Depository Institutions

Insured depository intermediaries in the U.S. have been subject to the Basel Accord's risk-based capital standards since December 1990. These standards focus primarily on credit risk. Each broad type of banking asset and off-balance-sheet obligation is assigned a risk weight and each insured institution must hold capital equal to a proportion of its risk-weighted total assets. Equity capital is defined to include

Tier I ("core capital" elements):
- common equity (paid in capital, surplus, and retained earnings)
- noncumulative perpetual preferred stock
- minority interests in consolidate subsidiaries
- LESS: goodwill and other intangible assets

Tier II ("supplementary capital" elements), up to 100% of Tier I:
- general allowance for loan and lease losses (up to 1.25% of risk-weighted assets)
- perpetual preferred stock
- hybrid capital instruments, perpetual debt, mandatory convertible debt, subordinated debt and intermediate-term preferred stock

DIs must hold Tier I capital equal to at least 4% of their risk-weighted assets, and total capital (Tier I plus Tier II) equal to at least 8% of risk-weighted assets. (They must also satisfy a 3% leverage ratio of Tier I capital to unweighted assets.) Limiting the value of the general loan loss allowance which may be included in Tier II capital can be viewed as a crude effort to move equity’s book value closer to its true market value. Except for this adjustment, however, a DI’s capital is measured on a GAAP basis, with all the attendant inaccuracies.

The treatment of interest rate risk exposure differs for commercial banks vs. thrift institutions. The Office of Thrift Supervision uses a generic financial model to measure each thrift's exposure to interest rate risk, and requires additional capital for thrifts with substantial exposures. The banking agencies considered a similar approach for several years, going so far as to publish (in 1995) a Proposed Rule which specified a technique for measuring individual banks' interest rate risk exposures.[10] On June 26, 1996, however, the banking agencies backed away from employing a generic model to evaluate interest rate risk, saying that no single model could accurately assess the majority of banks' exposures.[11] [12]

3.b) Federal Home Loan Banks

Since January 29, 1993, the FHLB System has been permitted to issue consolidated debt obligations and deposits up to 20 times its total capital. (In June 1997, these unsecured liabilities equaled 16.5 times total capital.) The System's (or a FHLB's) "total capital" equals the paid-in value of members' capital stock plus a minimal amount of retained earnings. Unlike the equity capital of the housing finance GSEs and DIs, FHLB

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[10] See Federal Register 60(148), pages 39489-39494 (August 2, 1995). Section 305 of FDICIA required the banking agencies to incorporate interest rate risk exposure into their risk-based capital standards.

[11] The banking regulators have eschewed only a standard measurement for all banks' risk exposures. "[T]he agencies will continue to place significant emphasis on the level of a bank's interest rate risk exposure and the quality of its risk management process when evaluating a bank's capital adequacy." (*Federal Register* 61 (124), page 33166).

[12] The banking agencies have also incorporated "market risk" into their formal risk-based capital standards for a small number of banks with large trading operations. (These rules apply to any bank or banking holding company whose trading activities exceed the smaller of $1 billion or 10% of the institution's total assets. *Federal Register* 61(174), pp. 47361-47362.) Effective January 1, 1998, these firms must hold capital for the market risks of their trading book and the foreign exchange, stock, and commodity price risks in their banking book. The amount of this capital can be specified by the banks' own internal model of the largest loss they can expect to incur (at the 99% confidence level). This capital will be added to the capital required to cover the institution's credit risk on traditional activities.

capital is not permanent. Each FHLB's capital level depends on its member institutions: their number, asset size, "qualifying thrift lender" status, and utilization of FHLB advances.[13]

Of its 6,300 member institutions at midyear 1997, most (83.5%) were voluntary members, which could withdraw from membership with six months' notice. Withdrawal from membership is not a trivial decision, however, since the member will be deprived of access to FHLB advances for ten years following its withdrawal. Nevertheless, "The payment of a competitive dividend is a factor in attracting and retaining FHLBank members." (Federal Home Loan Bank System Quarterly Financial Report, June 30, 1997, page 4). If a FHLB were to suffer large losses, voluntary members might withdraw from the System to avoid the likely dividend cuts. Because voluntary members own more than half (56.3%) of the System's capital stock, their ability to withdraw in the face of FHLB losses could have an important effect on the System's credit-worthiness.[14]

About 55% of FHLB assets are secured advances to members, while about 44% of assets take the form of other investments. Statutorily permitted investments are high-quality, short term securities (term federal funds and RPs, commercial paper, deposits) plus longer-term securities with high credit quality but the potential for substantial interest

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[13] Specifically, each member institution purchases FHLB capital stock in an amount equal to the greater of 1% of their mortgage-related assets, 0.3% of their total assets, or 5% of their outstanding FHLB advances. Non-thrift institutions holding less than 65% mortgage-related assets may have to purchase still more FHLB capital stock in order to borrow.

[14] Moody's explicitly considers the impact of their withdrawable capital on the FHLBs' default probability, and "views this as an important credit issue" for the Bank System (10/96 Moody's Investors Service report on the FHLBs' ratings, page 3). Standard and Poor is less concerned: "As the proportion of voluntary FHLB members has grown, the capital base of each FHLB has theoretically become less stable. The incentives that attract and keep members, however, mitigate this concern." (December 1995 "Bank Ratings Analysis" for FHLB System page 4)

sensitivity.[15] The System's consolidated bonds typically carry fixed interest rates, while member advances pay floating rates. The System participates in swap agreements to hedge the resulting interest rate risk, though there is no strict requirement that it do so, and swaps still leave the Banks exposed to counterparty credit risks. The Federal Housing Finance Board requires that each FHLB maintain its equity's duration in the range of +5 to -5 years, and that it report this duration monthly. Beyond this, there are no restrictions on the type of interest rate risk a FHLB may undertake.

Although the FHLB System seems quite insulated from credit risks, it could take on considerable exposure to interest rate risk. For example, with a (permissible) equity duration of +5 years, a 100 basis point rise in the term structure (from its May 1998 level) would reduce a FHLB's equity market value by about 80%. Current regulations contain no provision to revise a FHLB's capital requirement if its risk exposures change.

3.c) Pools of Conventional Mortgages

A pool of conventional (uninsured) 1-4 family mortgages is frequently sold to capital market investors, with a junior tranche retained by the seller. Pool credit losses initially accrue to the junior tranche; senior claimants are subject to losses only after the junior tranche has been exhausted. Clearly, the senior claims on the mortgage pool are safer when there are more junior claims at origination. OFHEO estimates that private rating agencies would require approximately

2.7% - 4.1% loss coverage for an "A" rating

4.9% - 6.0% loss coverage for an "Aa" rating

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[15]Certain extremely interest-sensitive securities are explicitly prohibited: interest-only or principal-only

8.0% - 9.2% loss coverage for an "Aaa" rating.

for a nationally diversified pool of single-family mortgages, with a given distribution of loan-to-value ratios (OFHEO (1996), page 29599).

Although junior claims on the mortgage pool resemble a GSE's equity in some ways, there are crucial differences. Most importantly, a mortgage pool cannot provide new loss protection after it has been set up. Junior claims are largest on the day the pool is first sold, and can only decline from there. By contrast, an operating intermediary expects to earn a profit each period. Through earnings retention, some of these profits may be available to absorb future credit losses.

3.d) OFHEO's Two Housing GSEs

The Federal Housing Enterprises Financial Safety and Soundness Act of 1992 (FHEFSSA) requires that Freddie Mac and Fannie Mae meet two types of capital requirements. The "minimum capital" level requires that "total capital" (defined below) be at least

2.5% of aggregate on-balance-sheet assets, *plus*

0.45% of unpaid principal balance of outstanding MBS, *plus*

0.45% of other off-balance sheet obligations[16].

(Section 1362 (12 U.S.C. 4612)). The Act does not specify the purpose(s) of this minimum capital level, although it resembles the type of ratio requirements imposed on DIs under the Basel Accord.

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stripped MBS, and the residual tranches of CMOs and REMICs.

[16] The OFHEO Director may adjust this percentage if the risk of the enterprise's other off-balance sheet obligations differs substantially from the risk of their MBS guarantees.

Section 1361 of FHEFSSA requires that the housing GSEs also meet a "risk-based" capital requirement, under which the enterprise's total capital must be sufficient to keep it from becoming book value insolvent during a ten-year "stress period". The stress test is currently being designed by OFHEO, who will administer the test at least quarterly for each GSE. FHEFSSA specifies that this stress test is meant to simulate an extremely adverse set of conditions:

1. Credit Risk. Mortgage default losses in the GSEs' portfolios are assumed to resemble the highest rate ever attained in a substantial, contiguous region of the U.S.

2. Interest Rate Risk. Market interest rates are assumed to move sharply up or down, "whichever would require more capital for the enterprise".[17]

Individually, each of these shocks is meant to be severe.[18] Moreover, the legislation does not fully specify how the simulations should incorporate the potential correlation between interest rate risk and credit risk. Generally, high interest rates will be accompanied by high (expected) inflation, which should reduce mortgage defaults by raising the value of the underlying collateral. However, the 1992 Act mandates recognition of the house price appreciation only if "the constant maturity Treasury yield is assumed to increase by more than 50 percent over the average yield during the preceding 9 months" (Sec. 1361(a)(2)(E)). This appears to permit a 10-year rise in Treasury rates from 10% to 14%

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[17] Specifically, FHEFSSA requires OFHEO to simulate a decrease in the 10-year Treasury rate of about 600 basis points or 40% of the recent average level (whichever change is larger) or an increase in the 10-year Treasury rate of 600 basis points or 60% of the recent average level (whichever change is larger). OFHEO must then base capital adequacy calculations on the simulation which implies larger GSE losses over the 10-year simulation period.

[18] In evaluating the appropriateness of OFHEO's proposed stress test properties GAO concludes "that the key assumptions on interest rate movements and accompanying credit losses, while severe, appear reasonable to achieving the purpose of a stress test. Such tests are designed to estimate the effects of adverse conditions, which are not necessarily the most probable or likely". (Bothwell [July 31, 1996], page 3).

with no corresponding change in (simulated) house prices. Such a phenomenon would be unprecedented in U.S. history.[19]

An enterprise's required, risk-based capital level equals the amount of total capital needed to survive the 10-year stress period, *plus* an additional 30% of that amount "To provide for management and operations risk" (Sec. 1361(c)). The legislation does not explain the intended interaction between this added 30% capital and the scale-based minimum capital standard, nor does it justify the implicit assumption that managerial/operations risk increases with the GSE's measured exposure to interest rate and credit risks.

The types of equity capital required by FHEFSSA are permanent sources of funds, which are likely to be available to absorb future losses.[20] GSEs' required capital must be held as the book (GAAP) value of "total capital" (as defined in Section 1303, paragraph 18):

par or stated value of outstanding common stock
par or stated value of outstanding perpetual, non-cumulative preferred
paid-in capital

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[19] The legislation permits OFHEO to assume house price appreciation for less dramatic interest rate increases, but there is no requirement unless yields rise by 50 percent.

[20] The Act states that GSE capital "shall not include any amounts that the enterprise could be required to pay, at the option of investors, to retire capital instruments". (Section 1303, paragraph (4)).

retained earnings
general allowances for mortgage loan foreclosure losses[21]
any other amounts permitted by the Director of OFHEO.

These components of equity capital can only be withdrawn from the GSE via dividend payments or share repurchases. However, the Director of OFHEO can restrict dividends for a GSE with low capital (Sections 1365, 1366).

4. Capital Requirements and Default Probabilities

We can now combine Section 2's stylized discussion of default with the capital requirements imposed on DI and GSEs. Failure probability depends on three factors: initial capitalization, income volatility, and time to action. I discuss each of these in turn.

4.a) Initial Capitalization

The appropriate measure of capital adequacy is the amount of equity per unit of *income volatility*. (See equation (2) above.) As I discussed in Section 2, the firm's ability to absorb losses depends on the current *market* value of its equity. Yet DI's capital requirements are stated in terms of *book* values, which can diverge quite substantially from market values. Specifically, GAAP generally biases book values of equity upward,[22] and these biases are particularly severe when the DI is most vulnerable to failure. Consider a simple example.

[21] These loss allowances must explicitly *exclude* allowances made in recognition of likely losses on specific loans or assets. Thus, these allowances are available to absorb any type of unforeseen loss.
[22] Managers possess a number of important options under GAAP which permit them to increase their reported book value of equity. For example, they can understate potential loan losses, or they can realize embedded capital gains on selected securities, even if the securities portfolio is generally under water. Accordingly, book equity ratios will tend to overstate an institution's ability to absorb losses.

A (1980's style) thrift institution holds fixed-rate mortgages funded by short-term deposits, as reflected in the following (GAAP) accounting statement:

Assets	**Liabilities**
Loans: $100 @ 10%	Deposits: $90 @ 10% Equity: $10

To keep the calculations simple, assume a flat term structure and risk neutrality. The fixed-rate mortgages mature in 10 years, while deposits will be repriced annually by an amount which exactly reflects the change in market discount rates. Mortgages are assumed to pay only interest until maturity. Ignore taxes.

Provided interest rates don't change, this thrift will earn $10 - $9 = $1.00 annually, generating a fair (given risk neutrality) market ROE of 10%. Suppose, however, that interest rates spike upward and the thrift stops doing new business. If the interest rate rises instantaneously to 12.5%, the thrift's reported profits will become negative: $10 - $11.25 = ($1.25) in the first year. If the term structure is expected to remain at its new level for the next ten years, the present value of its expected cash flows immediately becomes negative ($3.84).[23] In other words, the thrift's $10 book equity value at t=0 exceeds its true (market) value by $13.84. In contrast to this economic reality, the thrift's *book* equity value will fall only gradually:[24]

[23] Limited liability prevents the market value of equity from falling below zero, and the call option features of equity would likely keep its market value positive. Nevertheless, the expected cash flows to assets are $13.84 lower than the expected cash flows to depositors following the interest rate change.

[24] These calculations assume that the thrift institution pays annual losses out of equity, and therefore

Year	Equity	Deposits	Profit
1	$10.00	$90.00	($1.25)
2	$8.75	$91.25	($1.41)
3	$7.34	$92.66	($1.58)
4	$5.76	$94.24	($1.78)
5	$3.98	$96.02	($2.00)
6	$1.98	$98.02	($2.25)
7	($0.27)	$100.27	($2.53)
8	($2.81)	$102.81	($2.85)
9	($5.66)	$105.66	($3.21)
10	($8.87)	$108.87	($3.61)

Under existing (post-FDICIA) procedures, federal supervisors would seize the firm and close it when its tangible (GAAP) capital fell below 2% of total assets. But this does not happen for six years! (See shaded cell in table.) Despite the fact that this firm *is market value insolvent at t=0*, its owners can continue operating the firm.

The thrift's owners will seek to avoid the certain insolvency that awaits them in Year 6. As we learned in the 1980's thrift crisis, "zombie" firms may expand rapidly and take on risky projects in a gamble for resurrection. The 1980's thrift crisis further illustrates that the longer a market-value insolvent firm is permitted to operate, the larger is the expected loss when it finally fails. Forcing federal supervisors to follow book-value-based rules for closing insolvent firms effectively increases the losses that are likely to be associated with a DI's failure.[25]

The housing GSEs are subject to a much more forward-looking type of capital standard than that which applies to DIs. If our illustrative thrift institution were subject to the OFHEO stress test, the impact of a permanent change in market rates (from 10% to

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issues additional deposits each year to continue financing its $100 loan portfolio.

[25] The Sendero Institute [1996] analysis of the thrift industry's ability to survive a stress test similar to that proposed for the GSEs concludes that a typical thrifts' exposure to interest rate risk would render it

12.5%) would immediately generate a higher required level of equity capital. The stress test would project ten years of true operating losses, whose present value is $13.84.[26] Since the firm's current equity capital ($10.00) is smaller than these expected losses, the thrift would have to raise additional equity or be subject to regulatory sanctions. Thus, despite the fact that both DIs and GSEs measure their equity capital in book value terms, OFHEO's forward-looking stress test has the effect of "marking to market" accumulated gains and losses in the GSEs' portfolios. Indeed, the OFHEO stress test is likely to be more conservative than a mark-to-market valuation of the firm's equity capital. The stress test simulates extreme adverse conditions (GAO testimony, 7/31/96), while market values are based on the events that seem most likely to occur. An extremely rigorous stress test thus forces a GSE to operate with higher risk-based capital ratios than market investors would require for the same level of risk exposure.

Finally, there is one way in which equity's book value tends to *under*state the true value of capital: franchise value is generally not reflected in book values.[27] A firm with substantial franchise value has a lower probability of failure because the firm's investors will rationally contribute additional equity in order to preserve their access to future profits. By contrast, if a firm with low franchise value suffers large losses, investors will contribute little additional equity because there is less prospect of high future profits.

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insolvent even if it began the stress period with equity equal to 8% of assets.

[26] My simplified example includes no default risk, but the same principles would apply.

[27] This statement applies to a "home grown" franchise value. If the firm's anticipated excess profits derive from assets acquired in the open market (e.g. through merger), the franchise value may be included as goodwill in GAAP financial statements.

4.b) Income Volatility

The Basel-type capital adequacy standards assume that all regulated DIs have the same income volatility per dollar of risk-weighted assets. This is a crude assumption, necessitated by the large number of depository intermediaries to which the Basel standards apply. The two housing finance GSEs' risk exposures will be monitored by a complex, customized model which will be much more accurate than the Basel-type assumptions underlying DI capital adequacy guidelines.

A financial firm's income volatility is uncertain because of three main risks:

a) Credit Risk. Any portfolio of mortgage loans will experience defaults and the associated collection expenses. Enough default losses can exhaust an intermediary's equity, leaving it unable to repay creditors fully.

b) Interest Rate Risk. Changes in market rates affect a firm's income unless its asset and liability durations are exactly equal. Because rate changes cannot be predicted (at least, not in an efficient market), imperfectly hedged firms will have income volatility due to unanticipated rate changes.[28]

c) Managerial/Operations Risks. Equity capital must absorb losses resulting from judgmental errors or failure of the firm's "back office" procedures. This risk category includes the "strategic risk" that a firm's product(s) will become obsolete, or that competitors will innovate methods of producing similar products at lower cost. Such events threaten a firm's solvency if it cannot react promptly enough.

In competitive loan markets, the *expected* level of default losses, interest rate changes, or operational errors will be built into the mortgage's contract rate or the guarantee fees charged on MBS. "Risk" reflects the extent to which actual outcomes differ from their *ex ante* expected values, and the sum of these risks determines a firm's overall income volatility.

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[28] With prepayable mortgages, this risk exposure exhibits an important convexity: rate increases will lengthen the maturity of outstanding mortgages, while rate decreases will induce substantial prepayments.

The probability of failure over a specific time frame depends on the firm's *average* income volatility over that time. This volatility has two important components: its current value and the extent of likely (possible) changes in risk over the time frame. While the initial volatility constitutes one estimate of the firm's average volatility, this measure will necessarily be imperfect.[29] As time passes, the risk of any business strategy may change with economic conditions. In addition, managers may *choose* to vary risk exposures with changes in their operating results. A firm which loses money early in a time period may rationally decide to "gamble for resurrection" by changing policies in a way that produces more risk.[30] The more permissive is a firm's charter, the greater are its opportunities for risk-enhancing changes in operations. How long it takes supervisors to recognize that a risk shift has occurred depends on the type of monitoring technology they utilize.

4.c) Time to Action

Regulators can seize a firm only after they have determined its capital to be sufficiently low. (The 1991 Federal Deposit Insurance Corporation Improvement Act (FDICIA) sets the critical capital level at 2% of assets.) Similarly, they can mandate that a firm increase its capitalization only after detecting that its capital is indeed deficient. A firm which is evaluated frequently, and which is forced to re-capitalize itself promptly if its capital has fallen too low, has very little chance of failing. By contrast, if the firm's

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This phenomenon, which is not explicitly considered in my model of firm default, makes it substantially more complex to hedge interest rate risks.

[29] Volatility estimation errors can materially affect the accuracy of solvency probability estimates, particularly for highly levered firms (Flannery [1991]).

[30] Higher risk can be rational for firms with lower equity value because risk increases the probability of a very good outcome. Regulators dislike risk, of course, because it also increases the probability of bad outcomes. Since equityholders enjoy limited liability, they may prefer higher risk under some

solvency is tested only infrequently, or if the firm is permitted to operate with inadequate capital for a substantial time after being identified as under-capitalized, the creditors' (or guarantors') *ex ante* expected loss rises. This occurs for two reasons. First, as the accrual interval for net income increases, its volatility does as well. (See footnote 6 above.) Second, managers may change their income's volatility as the institution's fortunes evolve over time. Between evaluations the regulator cannot know if a guaranteed firm is increasing or decreasing its risk exposure.[31] A longer interval between evaluations therefore makes strategic asset substitution more likely.

Once regulators have identified a capital-deficient institution, they will require that it either raise equity or reduce its risk exposures. Either action takes time. Firms differ widely in their ability to sell new equity claims to market investors. At one extreme, mutual thrift institutions cannot raise any new equity without changing their corporate form. Smaller corporations will generally encounter thinner markets for their equity issues, particularly if regulators have required the stock issue. Many firms will therefore restore their capital ratios by reducing the firm's size – which reduces the volatility of total income. But a firm cannot generally cease doing new business—even temporarily—without endangering its long run viability.

Define a regulator's "time to action" as the sum of the evaluation interval and the time required for a deficient capital position to be remedied. "Time to action" importantly affects a firm's default probability. In a slightly different context, Pennacchi [1987]

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circumstances, particularly when a firm has relatively little franchise value.

[31] Regulators can assess a DI's capital adequacy only after they have verified the accuracy of its loan loss allowance accounts. Analogously, OFHEO must run its risk-based capital model in order to determine a GSE's current riskiness.

explicitly considered the impact of this variable on the value of large banks' deposit insurance contracts. He compared the fair value of deposit insurance under the alternative (extreme) assumptions that a capital deficient bank would:

1. immediately remedy the deficiency vs.
2. maintain the same insurance with the same premium, without (ever) raising additional equity capital.

(In both cases, banks would be examined annually, and insolvent institutions would be immediately closed.) Pennacchi estimated the actuarial value of deposit insurance for a sample of 23 large banks and found that the average bank's fair insurance premium was more than *16 times larger* if capital deficiencies were never remedied than if they were rectified immediately after the examiner identified the problem. Clearly, the speed with which capital-deficient firms are forced to raise new equity substantially affects the institution's failure probability.

FDICIA prominently addressed the "time to action" issue, because long action lags were associated with some of the most expensive bank and thrift failures in the 1980s. FDICIA required the regulatory agencies to examine each DI at least annually, and to employ a system of Prompt Corrective Action (PCA) under which capital-deficient institutions are subjected to increasingly tight (and costly) restrictions as their capital ratio falls below pre-specified levels. Even under these new policies, however, the typical DI's solvency is accessed much less frequently than a GSE's – for which OFHEO must administer its stress test at least quarterly.

4.d) Comparative Assessment of Freddie Mac's Capital Requirement

This section assesses the severity of Freddie Mac's capital standard *relative to* that of the other housing-related intermediaries. I first evaluate the qualitative (theoretical) differences in default probabilities, based on each intermediary's initial capital requirement, income volatility, and time to action. I then combine the effect of these three factors to show that simple capital ratios can provide extremely misleading comparisons of the different housing intermediaries' default probabilities.

Qualitative comparisons between Freddie Mac's and other housing-related intermediaries' capital standards are summarized in Table 1. Four other classes of institutions are considered:

1) Publicly Traded DI, which can access capital markets to raise new equity if needed.

2) Mutual Thrifts, which can augment their equity positions only by retaining earnings or reducing the size of their balance sheets.

3) Mortgage Pools, for which senior tranches receive higher credit ratings when there are larger junior tranches available to absorb default losses.

4) The FHLBs.

A "+" in Table 1 indicates that Freddie Mac's "stress test" capital standard is more strict than the comparison institution's standard, a "0" indicates that the two standards are about equivalent, and a "-" indicates that the Freddie Mac standard is less strict. The discussion separately considers each type of housing intermediary.

Table 1: Relative Severity of Freddie Mac's Risk-Based (FHEFSSA) Capital Standards

	Publicly Traded DI	Mutual Thrift	Mortgage Pool	FHLBs
1) Initial Capital Requirement				
• **Compared to firm assets**	-	-	-	-
• **Compared to firm risk**	?	?	+	?
• **"Quality" of capital**	+	+	-	+
2) Regulator's ability to assess income volatility accurately	+	+	0	+/0
3) Time to Action				
• **Supervisory recognition of change in condition**	+	+	na	+
• **Ability to raise new equity quickly**	?	+	+	+/0
Overall Evaluation	+	+	?	?

A "+" entry means that the Freddie Mac standard is more stringent, a "0" means there is little difference between the two standards, and a "-" indicates that the Freddie Mac standard is less stringent. “na” means “not applicable.”

Comparison to DIs. The first two columns in Table 1 pertain to depository institutions (DI), which are discussed here jointly. The initial impression gleaned from reading the DI and GSE capital regulations might be that Freddie Mac is required to hold appreciably less capital than the DIs. DIs must satisfy a leverage requirement that book equity be at least 3% of on-balance sheet assets, while Freddie Mac must have at least 2.5% of its on-book assets plus 0.45% of its off-book obligations. Under the Basel standards, DI must hold at least 4% equity per dollar of mortgage loans which, again, exceeds the GSE's minimum capital level (2.5%) and (even more so) the level likely to be implied by OFHEO stress tests.

Despite these differences in minimum capital-asset ratios, however, the GSEs may be required to hold more equity per unit of *risk*. GSE portfolios are likely to be less risky than the DIs' for several reasons. First, GSE mortgage portfolios are diversified nationally, which should give them lower default rate uncertainty than regional (or intra-state) DI mortgage portfolios. Second, if a DI is exposed to appreciable interest rate risk, this exposure applies to its entire portfolio. By contrast, Freddie Mac holds about $5 of off-balance sheet (OBS) mortgages for each dollar retained in its own portfolio. Interest rate risk applies only to the retained portfolio, yet the capital Freddie Mac holds against OBS default risk may be available to absorb interest-rate related losses on its retained portfolio.[32] Finally, Freddie Mac's ability to earn positive profits from its OBS guarantee business adds to the firm's value and makes investors more willing to contribute additional equity in the wake of potential losses. Although the net effect of these differences is an

[32] This statement assumes that interest rate risk and default risk are not highly correlated. Moreover, note that Freddie Mac does not currently accept much interest rate risk in its retained book of business.

empirical matter, it seems plausible that Freddie Mac's required ratio of capital to portfolio risk is not less than the level required of DI. (See Section 5 below.)

A final difference between DIs and GSEs concerns the quality of their regulatory capital, which is stated in terms of book (not market) values. (See Section 4.a.) Furthermore, banks and savings institutions may count some subordinated debt and limited-term preferred stock as "capital". Under some circumstances, therefore, capital investors could flee the DI before losses were realized. Even if DIs and GSEs maintained the same ratio of regulatory capital to income volatility, therefore, the GSEs' effective protection would almost surely be greater.

There is little doubt that regulators can assess GSE risk exposures more accurately than they can assess the risk exposures of DIs. Given the multitude of insured institutions, DI regulators cannot customize their risk assessments to the extent that OFHEO has. In addition, GSEs are permitted a more limited range of activities, which reduces the extent of possible asset substitution (strategic or otherwise) and makes it more likely that today's assessment of GSE risk will remain accurate throughout the period between solvency evaluations.

Finally, OFHEO's supervisory powers seem to permit more timely responses to problem situations than can be expected of the DI regulators. This begins with a more timely recognition of changes in firm condition. OFHEO is required by legislation to conduct a detailed, custom-designed stress test for each GSE, at least once per quarter (FHEFSSA, Section 1364(c)). Banks and thrifts submit quarterly financial reports, but these reports are less analytical than OFHEO's stress test is likely to be. As a practical matter, the greatest effect these quarterly reports might have for insured DI would be to hasten the scheduling of an on-site evaluation – and such an exam could easily last for a calendar quarter, particularly for a larger DI. In short, OFHEO must conduct meaningful analyses of the GSEs' condition much more frequent than can be expected for even the largest DI.[33] [34]

Finally, Freddie Mac should be able to remedy capital deficiencies more quickly than all but a few large banking firms should, because it is widely followed in the market and has many investors. (Mutual thrifts stand at the opposite extreme: they can accrue new equity only slowly, via earnings retention.) Pennacchi [1987] shows that the speed with which solvent firms remedy capital deficiencies materially affects the value of a loan guarantee – and hence materially affects the adequate amount of equity capital.

<u>Comparison to Privately-Securitized Mortgage Pools</u>. The OFHEO has suggested that the reasonableness of Freddie Mac's capital standard might be judged by comparing it with the rating agencies' loss coverage requirements for a securitized pool of conventional mortgages (OFHEO [1996], pages 29598-29599). These "equity" contributions exceed likely risk-based capital levels under OFHEO's stress test. But what does this differential really imply about default probabilities?

The net stringency of "capital requirements" for a GSE vs. a Mortgage Pool is difficult to assess because different factors affect their default probabilities. The credit-enhanced mortgage pool seems less risky because:

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[33] The OCC has stationed on-site examiners permanently in a number of large national banks, and GSEs are scheduled to have on-site examiners starting sometime in 1998. Even with on-site examiners monitoring management reports on a continuing basis, it is unlikely that substantial supervisory actions would be taken without an explicit examination designed to assess the firm's condition. Taken all together, DI supervision seems very unlikely to have a shorter time to action than OFHEO will.

[34] DI supervisors implicitly acknowledge the value of shorter-term guarantees when they schedule on-site

- its "equity" level is higher,
- its equity is valued at current market rates, and
- it has (virtually) no possibility of subsequent asset substitution to increase the investors' risk of default.

However, three other factors tend to offset the preceding effects:

- 40% of the mortgage pool discussed by OFHEO [1996] has loan-to-value ratios above 80% and no private mortgage insurance (PMI). By contrast, Freddie Mac requires PMI on loan amounts exceeding 80% of the property's assessed value. Freddie Mac's default losses should therefore be smaller *and less variable* than the losses underlying rated pools.
- Freddie Mac expects to earn a profit, part of which will be retained to augment the firm's future capital base.
- OFHEO evaluates Freddie Mac's capital adequacy quarterly and can quickly *force* the addition of new equity to the firm's capital structure. By contrast, a mortgage pool's equity level can only decline over time, as it absorbs credit losses. Accordingly, a mortgage resembles Pennacchi's [1987] unlimited term insurance, while Freddie Mac's government guarantee more closely resembles his limited-term insurance.[35]

The net effect of these features on GSE vs. Mortgage Pool defaults can only be determined via the simulation model described in Section 5 below.

<u>Comparison to FHLBs</u>. The current limitation of Bank System consolidated debt to 20 times capital corresponds to about a 5% equity requirement, which exceeds the statutory requirements imposed on GSEs. However, FHLB equity provides less protection against failure, for two reasons. First, its book valuation reflects neither current market values nor current risk exposure. Second, it may not be available to absorb future losses if FHLB members withdraw from the System. Both Freddie Mac and the

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examinations more frequently for banks in poor condition.

[35] Recall that the implied risk differences are very large: Pennacchi estimates that the default losses

FHLBs are regulated by a specialized government agent, which could carefully monitor and model the institutions' risk exposures. However, OFHEO is required to do far more active monitoring, making its assessments of GSE income volatility more accurate than the Federal Housing Finance Board's assessment of FHLB risk exposures. Furthermore, OFHEO will subject Freddie Mac to quarterly stress tests, while the FHLBs receive only annual evaluations. Freddie Mac and the FHLBs seem to have equivalent abilities to shift their risk exposures quickly, because most of their investments trade in liquid markets. However, Freddie Mac can respond to a capital deficiency by *either* raising additional equity *or* by reducing the size of its retained or guaranteed portfolios. By contrast, the Home Loan Banks cannot control their capital stock and would have to remedy any capital deficiency by selling off investments. This may be problematic if the asset portfolio includes unbooked losses, or if the investments are needed for liquidity.

Overall, it is difficult to judge the comparative stringency of Freddie Mac's vs. the FHLBs' capital standards. Offsetting the FHLBs' higher capital requirement is Freddie Mac's higher-quality capital, more accurate risk assessment, and quarterly assessment interval. As they are presently operating, the FHLBs' default risk seems very small. However, nothing prevents a sharp increase in the FHLBs' risk exposures.[36] Since FHLB capital requirements are not tied to risk, their default probabilities would tend to rise if the FHLB shifted into riskier activities.

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associated with the unlimited term deposit insurance are about 16 times larger than those associated with the limited term insurance.

[36] Indeed, the GAO has expressed concern that the System's fixed obligation to REFCorp forces it to lever its equity and take on investment portfolio risks in order to assure itself of sufficient revenue. (GAO 1993, page 3). Note also the Chicago FHLB's recent foray into guaranteeing pools of mortgages assembled by its member institutions.

Summary. Qualitative comparisons suggest that the GSEs' capital standards are more stringent than the DIs', though this largely reflects an assessment about the relative riskiness of GSE vs. DI mortgage portfolios. The qualitative comparison of Mortgage Pools' market-based standards vs. the GSE supervisory rules is less clear-cut. For both of these comparisons, however, we can sharpen our assessments by quantifying the salient dimensions of each institution's typical risk exposures. This analysis is presented in the next section.[37] By contrast, a definitive comparison of the GSE and FHLB capital standards' stringency cannot be provided, because the ability of FHLBs to take on additional risks is very large. Without a detailed understanding of the FHLB management's incentives to take additional risks, we cannot determine whether their current capital standards assure a sufficiently low default probability.

5. Quantitative Comparison of Housing-Related Institutions' Capital Standards

The Appendix describes a financial model which computes the default probability of a stylized DI/GSE firm. Utilizing reasonable estimates of the parameters underlying the firm's risk exposures, the model can compute default probabilities for alternative types of firms, under a range of capital standards. (In other words, these simulations can indicate the net importance of the qualitative differences across capital standards identified in Table 1.) Simulated default probabilities are presented in Figures 5 - 8 for DI vs. GSE, and in

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[37] To preview these numerical comparisons: a GSE has a much lower default probability than either the DIs or the Mortgage Pools when they all start out with similar capital levels. As this report has repeatedly emphasized, when institutions differ substantially in their risk exposures, simple equity ratios will not accurately indicate relative safety.

Figure 9 for Mortgage Pools vs. GSE.[38] Although the simulations are not calibrated to predict actual default levels, they do illustrate the plausible *variation* in default probabilities associated with inter-firm differences in capitalization and risk. Specific assumptions underlying these Figures are described in the Appendix, which presents some additional simulation results. The qualitative results presented in Figures 5 – 8 are robust to reasonable variations in the underlying parameters.

Figure 5 illustrates how a firm's initial (market value) capital level and the evaluation interval affect failure probabilities. A stylized DI is described in the leftmost two rows, for two levels of initial capital: the 4% Basel minimum and a 2% capital ratio to allow for the possibility that GAAP measurements of DI equity will be biased upward. The rightmost two rows in Figure 5 describe a stylized GSE. Reading from front to back in each row indicates that a firm's default probability increases quite radically with longer evaluation intervals. (Figure 4 illustrates the same principle.) Comparing the two DI rows (or the two GSE rows) further illustrates that a higher initial capitalization reduces the probability of default. Figure 5 clearly illustrates the important interaction between initial capital and evaluation intervals. Since GSEs are evaluated quarterly, their relevant default probabilities are located toward the *front* of this Figure, where the evaluation interval is 0.25 or 0.50 years.[39] By contrast, DIs are generally examined no more than annually, making the *middle to back* elements of these graphs most relevant to real-world institutions.

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[38] I provide no Figure comparing the FHLBs to a GSE because the Banks' portfolio risks are so difficult to quantify.

[39] Recall that an evaluation permits the supervisor to assess a firm's solvency, and to close it if necessary.

Table 2: Default Probabilities Plotted in Figure 5

Time Between Evaluations	GSE, 1%	GSE, 0.5%	DI, 4%	DI, 2%
0.25	0.0000%	0.0432%	0.0000%	0.0396%
0.5	0.0000%	0.5239%	0.0000%	0.7296%
1	0.0022%	1.3100%	0.0042%	2.4410%
2	0.0214%	1.3582%	0.0703%	3.3643%
3	0.0334%	1.0513%	0.1519%	3.1926%

The joint impact of evaluation interval and initial capitalization can be seen more precisely in Table 2, which reports the default probabilities underlying Figure 5.[40] The annualized default probability for a GSE with equity equal to 1.0% of its total portfolio (retained mortgages plus outstanding, guaranteed MBS) is 0.0% under a regime of quarterly evaluations. By contrast, a DI with 4% initial capital – as required for a mortgage portfolio – experiences a higher failure probability (0.0042%) if it is examined annually. Three features of the simulation account for the fact that the GSE with a 1% capital ratio has a lower default probability than the DI with a 4% capital ratio.

1) The GSE's mortgage portfolio has lower default risk, reflecting its national diversification. Figure 6 illustrates the importance of this assumption.

2) As noted in Section 4.c, if the firm's solvency is evaluated more frequently its income volatility will be lower. Accordingly, any given level of equity capital provides more protection against failure, the shorter is a firm's evaluation interval.

3) The GSE earns expected profits on its OBS guarantee business, which can be used to absorb losses if necessary. By contrast, the stylized thrift has no OBS source of expected profits. Figure 7 illustrates the importance of these profits to the GSE's default rate.

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[40] Note that the default probabilities sometimes decrease with the exam interval. The mathematics balances the additional income volatility associated with a longer exam interval against the higher expected value (in dollar terms) of income over longer time periods. In some cases, the latter effect comes to dominate the former effect.

The possibility that a DI's book equity value overstates its market value suggests that DI with 4% book equity would not be able to absorb that much loss. A more relevant comparison in Table 2 may therefore juxtapose the first and *fourth* columns (instead of the first and third). Now the GSE looks even safer than the DI, further reinforcing the impression that a simple capital ratio can poorly reflect a firm's credit quality.

Figures 6 and 7 compare the DIs against GSEs with different economic features. In Figure 6, the GSE’s mortgage default risk is doubled from its level in Figure 5: GSE credit risk volatility equals half of the DIs’ volatility in Figure 6, compared to one-quarter in Figure 5. Comparing Figures 5 and 6 (or Tables 2 and 3) indicates that mortgage default risk has a major affect on firm solvency. The increased credit risk exposure drives GSE default probabilities up sharply, most dramatically for the 0.5% GSE. Even at this relatively high credit risk level, however, the 1% GSE’s default probabilities are less than half those of the 2% DI. Comparison of Figures 5 and 6 therefore clearly indicates that the value of national diversification importantly affects the amount of GSE risk exposure per dollar of on- or off-balance-sheet assets.

Table 3: Default Probabilities Plotted in Figure 6

Time Between Evaluations	GSE, 1%	GSE, 0.5%	DI, 4%	DI, 2%
0.25	0.0119%	7.9115%	0.0000%	0.0396%
0.5	0.3038%	12.0219%	0.0000%	0.7296%
1	1.1506%	10.7880%	0.0042%	2.4410%
2	1.5779%	7.0920%	0.0703%	3.3643%
3	1.4171%	5.0032%	0.1519%	3.1926%

Figure 7 illustrates the effect of a reduction in the GSE's OBS guarantee fee on its default rates. (For example, increased competition and entry to the MBS market could exert downward pressure on Freddie Mac guarantee fees.) Starting again from the parameters underlying Figure 5, I have simulated a 50% cut in the annual guarantee fee – from its initial level of 23 basis points (which reflects Freddie Mac's recent charges) to 11.5 basis points. The assumed deterioration in Freddie Mac's future profitability translates into substantially higher default probabilities. However, the 1% GSE remains much less likely to fail than the 2% DI, even ignoring the likely difference in Years Between Capital Evaluations. As above, however, the more relevant comparisons – between the shaded cells in the first and third columns – suggest that the 1% GSE is not much more likely to fail than the 4% DI which is examined every other year.

Table 4: Default Probabilities Plotted in Figure 7

Time Between Evaluations	GSE, 1%	GSE, 0.5%	DI, 4%	DI, 2%
0.25	0.0115%	8.7338%	0.0000%	0.0396%
0.5	0.3648%	14.4115%	0.0000%	0.7296%
1	1.6040%	13.9798%	0.0042%	2.4410%
2	2.5267%	10.1212%	0.0703%	3.3643%
3	2.4973%	7.6953%	0.1519%	3.1926%

So far, we have ignored the impact of interest rate risk on DI/GSE default probabilities. (The parameters underlying Figures 5 – 7 specify that both types of firms are duration matched.) Figure 8 illustrates the impact of interest rate risk exposure on DIs' and GSEs' default probabilities. For a 1% GSE and a 4% DI, Figure 8 illustrates the impact of doubling the asset duration ("γ") from 1.0 to 2.0. Since the simulations assume that the liability duration is 2 years, the "gamma = 2" rows in Figure 8 reflect an asset-liability duration mismatch of about 2 years. As shown in the Figure (and presented with more precision in Table 5), a duration gap is much more dangerous for the DI than for the GSE.

The reason for this differential sensitivity to interest rate risk exposure is not far to seek: the assumed duration mismatch generates interest rate risk proportional to the DI's entire book of business, because the model assumes that DIs have no OBS commitments. By contrast, the GSE's addition of interest rate risk affects *only a portion* of its total business; its aggregate risk exposure does not rise so sharply as it does for the DI. The substantial proportion of total capital, which Freddie Mac holds against its OBS credit risks, is likely to be available to absorb interest-related losses. In addition, the GSE earns a positive expected return on its OBS operations, and these profits are available to absorb any type of loss.

Table 5: Default Probabilities Plotted in Figure 8

Time Between Evaluations	GSE, 1% $\gamma = 1$	GSE, 1% $\gamma = 2$	DI, 4% $\gamma = 1$	DI, 4% $\gamma = 2$
0.25	0.0000%	0.0002%	0.0000%	0.0337%
0.5	0.0000%	0.0330%	0.0000%	0.6684%
1	0.0022%	0.2950%	0.0042%	2.3208%
2	0.0214%	0.6115%	0.0703%	3.2596%
3	0.0334%	0.6187%	0.1519%	3.1128%

Figure 9 compares a stylized Mortgage Pool to a stylized GSE. This Figure plots the annualized default probability of a mortgage pool over its lifetime, where the lifetime is permitted to vary from very short to eight years. (Extending the maximum time horizon in Figure 9 has no qualitative effect on the POOL default values.) The relevant comparison between a GSE and a mortgage POOL is between the Figure's "front, right" and its "back, left" elements.

Table 6: Default Probabilities Plotted in Figure 9

Time Between Exams	GSE, 1%	GSE, 0.5%	POOL, 5%	POOL, 3%
0.25	0.000%	0.043%	0.000%	0.000%
0.50	0.000%	0.524%	0.000%	0.000%
1.00	0.002%	1.310%	0.000%	0.003%
3.00	0.033%	1.051%	0.000%	0.121%
8.00	0.016%	0.272%	0.002%	0.185%

Table 6 reports the default probabilities underlying Figure 9, with the shaded cells identifying the most relevant entries in each column. Once more, the shorter examination interval mandated by FHEFSSA has a substantial impact on GSE soundness. In this case, a mortgage POOL with 5% "equity" protection has a slightly higher default probability than a GSE operating with equity equal to 1% of its total mortgage principal exposure and a quarterly evaluation interval.

In summary, the results in Figures 5 - 9 clearly indicate the foibles of relying on a simple capital-asset ratio to judge a financial firm's default probability. The simulated GSEs have little chance of failure, even starting out with a capital ratio far below FHEFSSA's so-called "minimum" required ratio. Similarly, under at least some circumstances, it seems that GSEs can safely operate with substantially less capital than a typical DI requires. Freddie Mac's ability to operate safely with relatively low capital ratios derives from three main factors. First, Freddie Mac's nationally diversified portfolio of low-LTV mortgages is well diversified against default losses. Second, Freddie Mac holds equity capital in proportion to *all* of its commitments (both on- and off-balance sheet), although it accepts no interest rate risk for the OBS component of its activities. Finally, OFHEO evaluates Freddie Mac's risk exposure on a quarterly basis with a purpose-built financial model.

6. Conclusions

Measuring a regulated firm's capital adequacy is a complex task. Setting capital standards too low exposes U.S. taxpayers to potential losses and U.S. financial markets to failure-related disruptions. Excessively high standards may cause regulated firms to increase their risk exposures in order to earn a fair return on invested equity, with little or no net effect on expected default losses. Inappropriately high *or* low capital levels distort financial market prices and, ultimately, make the society's allocation of real resources less efficient.

We cannot hope to implement a perfect system of capital regulation, completely free from distortive effects. However, we can design capital requirements which avoid obvious mistakes, and we can avoid being mislead by inappropriate cross-institutional comparisons. Housing-related firms differ in their risk exposures and in their intensity of regulatory oversight. Mandated capital levels should reflect each institution's asset risk, the quality of its equity capital, its ability to raise additional capital in the wake of substantial losses, the accuracy with which supervisors can measure risks, and the frequency with which supervisors evaluate the firm's position. The simulations presented in this report indicate that cross-industry differences in each of these areas can substantially affect the amount of equity capital required to assure that U.S. housing-related financial institutions operate in a safe and sound manner.

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Appendix: Model of Default Probabilities for a DI / GSE

In the normal course of business, a firm's equity increases over time with retained earnings. But unforeseen events make actual income diverge from its expected level. Failure occurs when the value of a firm's assets falls below the value of its liabilities – that is, when its equity (K_t) becomes negative. This requires negative earnings ($\pi_t < 0$). Algebraically,

$$\tilde{K}_{t+1} = K_t + \tilde{p}_{t+1} \tag{A-1}$$

The probability of failure thus depends on the initial level of equity:

$$\text{Prob(Failure)} = \text{Prob}\left(\tilde{p}_{t+1} < -K_t\right) \tag{A-2}$$

By identifying the sources of uncertainty about $\tilde{p}_t$, we can quantify the probability that K_{t+1} will be negative, given K_t.

Freddie Mac earns money from both its on- and off-balance sheet obligations. Its income can be written

$$\tilde{p}_t = A\left(\tilde{r}_{At} - \tilde{c}\right) - L\tilde{r}_{Lt} + OBS\left(f - \tilde{c}_t\right) + \tilde{X}_t \tag{A-3}$$

where A = dollar value of on-balance sheet assets

L = dollar value of on-balance sheet liabilities

OBS = dollar value of off-balance sheet guarantees

$\tilde{r}_{At}$ = the (stochastic) holding period return on average assets in period t [41]

$\tilde{r}_{Lt}$ = the (stochastic) cost (holding period between) of liabilities in period t

f = the per-period fee earned for guaranteeing payment of off-balance sheet mortgages

$\tilde{c}_t$ = the losses on guaranteed mortgages, and

[41] The holding period returns in this model include both interest income and the capital gain (loss) associated with interest rate changes during the period.

$\tilde{X}_t$ = the income effect of "managerial and operational" factors.

Assuming that firm liabilities are riskless, $\tilde{r}_{Lt}$ reflects changes in the discount rate applied to L. The return on assets includes three components:

$$\tilde{r}_{At} = g\tilde{r}_{Lt} - \tilde{c}_t + d \tag{A-4}$$

where γ = the sensitivity of assets to interest rate changes, *relative to* the sensitivity of liabilities,[42]

δ = expected return premium earned on assets held on the balance sheet.

This specification implies that Freddie Mac's on-book assets are subject to the same default risk as ($\tilde{c}_t$) as their guaranteed mortgages. Substituting (A-4) into (A-3) gives

$$\tilde{p}_t = A(g\tilde{r}_{Lt} - \tilde{c}_t + d) - L\tilde{r}_{Lt} + OBS(f - \tilde{c}_t) + \tilde{X}_t$$

which simplifies to

$$\tilde{\pi}_t = \tilde{r}_{Lt}(\gamma A - L) - (A + OBS)\tilde{c}_t + A(\delta) + OBS(f) + \tilde{X}_t \tag{A-5}$$

Assuming that managerial/operations risk $\left(\tilde{X}_t\right)$ is uncorrelated with changes in interest rates or default losses, it follows directly that the standard deviation (volatility) of income is

$$s_p = \left[(gA - L)^2 s_L^2 + (A + OBS)^2 s_c^2 - 2(gA - L)(A + OBS)s_{cL} + s_x^2\right]^{\frac{1}{2}} \tag{A-6}$$

where σ_L is the annual standard deviation of the holding-period return on a the riskless liability,

σ_c is the annual standard deviation of mortgage default losses,

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[42] For example, $\gamma = 2$ indicates that a firm's assets have twice the duration of its liabilities. Many thrift institutions presently sell their FRMs and retain only ARMs. While this policy would largely insulate them from interest rate risk under many scenarios, the DI’s exposure to IRR remains relevant for two reasons. First, some thrifts might decide to retain FRMs in order to enhance their expected return on equity. Second, rate caps on a typical thrift institution’s ARM will tend to increase its asset duration when market rates rise sharply (Sendero Institute [1996]).

σ_{cL} is the correlation between interest rates and default losses, and

σ_X is the annual standard deviation of income due to managerial and operations uncertainty.

If the random variables in (A-5) are normally distributed, substituting (A-5) and (A-6) into (A-2) quantifies the firm's probability of failure:

$$\text{Prob(Failure)} = \Phi\left(\frac{-K_t}{s_p\sqrt{t}}\right) \tag{A-7}$$

where Φ = the cumulative standard normal density function, and

t = the time between evaluations (solvency determinations).

Note that (A-7) compares initial equity to the standard deviation of *income*. By contrast, Basel-type capital standards compare the firm’s initial equity to the dollar value of *assets* (including some off-balance sheet items). The Basel standard implicitly assumes that the standard deviation of income is proportional to assets. For example, consider a firm with homogeneous assets whose return volatility is $\sigma_{A.}$ The firm is partially funded with riskless liabilities whose maturity (duration) exactly matches that of its assets. Then the volatility of net income would be $A\sigma_A$, and we could re-write (A-7) as

$$\text{Prob(Failure)} = \Phi\left(\frac{-K_t}{As_A\sqrt{t}}\right) \tag{A-7a}$$

Under these circumstances, we could reasonably assess capital adequacy in terms of the ratio K/A. However, comparing K/A across firms would be appropriate *only if* the institutions had identical asset risks (σ_A).

If institutions differ in their asset volatilities, simple equity ratios cannot be used to compare capital adequacy. Furthermore, if supervisors can directly measure a firm’s income volatility, doing so may provide more accurate estimates of a firm's default probability than simply assuming that its asset risk is proportional to an aggregate of balance sheet items.

Figures 3 through 9 reflect specific assumptions about all the parameters in (A-5) and (A-6), though only a few of these parameters are explicitly shown in the Figures. I assume that mortgage contract rates carry a premium (δ) over riskless rates equal to the expected default losses $\bar{c}$. I have taken the value of $\bar{c}$ from Freddie Mac's 1996 Annual Report, computing the ratio of "charge offs" and "REO operating expense" to "Average 1996 Mortgage Portfolio". For the annual standard deviation of credit losses (σ_c), I first took the inter-temporal standard deviation of the proportion of defaulted loan percentage within each FHLB Region over the period 1974-1985 (see Ogden *et al*. [1989]). The appropriate values for σ_c were then centered around the mean of these Regional standard deviations. An individual institution's σ_c should be much higher than this number, because its mortgage portfolio is not diversified across an entire FHLB Region.[43] The liability portfolio's duration (D_L) is assumed to be approximately 2 years, and the annualized liability return volatility is set equal to that for the return on 2-year Treasury bonds (1.8%) over the period 1990-1996. I also assume that the asset portfolio's duration equals that of the liability portfolio (that is, γ=1), though this assumption is relaxed in Figure 8 below. The correlation between credit losses and treasury rates is assumed to be zero, and managerial/operational risk (σ_X) is 50% of income per year.[44]

The tables below list the "background" parameters for each Figure. The qualitative

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[43] The importance of mortgage portfolio diversification is considered by Ogden *et al*. [1989] and Quigley and Van Order [1991].

[44] This managerial/operational risk parameter is a very rough estimate. Note that the magnitude of σ_X is much larger than that of σ_L or σ_c. σ_X measures uncertainty about dollars of income, which is an order of magnitude smaller than asset/liability volumes.

effects are robust to reasonable variations in these parameter values.

Model Parameters Underlying Figure 3										
δ	**γ**	**f**	$\bar{c}$	**D_L**	**σ_L**	**σ_c**	**σ_{cL}**	**σ_X**	**T**	**K/A**
.104%	1	0	.104%	2	1.8%	*	0	50%	1	*

* = varies in the Figure.

Figure 3 illustrates the impact of leverage and default volatility on a stylized DI's failure probability. While mortgage default risk does not substantially affect the probability of default when the firm's initial capital ratio is 4%, for lower capital rates higher asset risk clearly raises the DI's probability of default. Further, reading from front to back in Figure 3 indicates that lower initial capital levels correspond to much higher probabilities that the firm will be insolvent when examiners arrive at the end of one year.

Model Parameters Underlying Figure 4										
δ	**γ**	**f**	$\bar{c}$	**D_L**	**σ_L**	**σ_c**	**σ_{cL}**	**σ_X**	**T**	**K/A**
.104%	1	0	.104%	2	1.8%	0.5%	0	50%	*	2%

* = varies in the Figure.

Figure 4 illustrates the impact of evaluation interval on a stylized thrift which starts the period with a relatively low capital ratio (K/A = 2%). To emphasize the impact of evaluation interval on default probability, default uncertainty (σ_c) has been set to a relatively high value (1%

per year). (The other parameters underlying Figure 4 are the same as in Figure 3.)

	Model Parameters Underlying Figure 5										
	δ	γ	**f**	$\bar{c}$	D_L	σ_L	σ_c	σ_{cL}	σ_X	**T**	**K/A**
GSE	0.1%	1	.23%	.104%	2	1.8%	.25%	0	50%	*	*
DI	.104%	1	0	.104%	2	1.8%	1.0%	0	50%	*	*

* = varies in Figure.

Figure 5 compares a GSE to a depository intermediary (DI) for various evaluation intervals and levels of initial capitalization. The firm's balance sheets are as follows:

GSE with 1% Capital		DI with 4% Capital	
Assets	**Liabilities**	**Assets**	**Liabilities**
100	94	100	96
OBS = 500	Equity = 6	OBS = 0	Equity = 4

The GSE earns guarantee fee income (f) which I set equal to the ratio of Freddie Mac's 1996 "management and guarantee fees" to their "average Participation Certificates (PCs) outstanding". (The DI earns no guarantee fees.) The impact of diversification on default losses is captured in the variable σ_c. The GSE is assumed to have a nationally diversified mortgage portfolio, while the DI's portfolio is assumed to be subject to larger (regional) default shocks. Both types of firms are subject to the same operational risks, though one might reasonably anticipate that this risk would be larger for the DI, whose ability to substitute into non-mortgage activities is greater.

Figure 6 provides some sensitivity analysis for the results in Table 5, by changing (only) the amount of credit risk confronting the GSE. As noted in the shaded cell below, the only parameter changed from Figure 5 is σ_c, which is doubled from 0.25 to 0.5.

	Model Parameters Underlying Figure 6										
	δ	**γ**	**f**	$\bar{c}$	**D_L**	**σ_L**	**σ_c**	**σ_{cL}**	**σ_X**	**T**	**K/A**
GSE	0.1%	1	.23%	.104%	2	1.8%	.5%	0	50%	*	*
DI	.104%	1	0	.104%	2	1.8%	1.0%	0	50%	*	*

* = varies in Figure.

Figure 7 provides further sensitivity information about Figure 5, this time by reducing the GSE's OBS guarantee fee by 50%. See the shaded cell below.

	Model Parameters Underlying Figure 7										
	δ	**γ**	**f**	$\bar{c}$	**D_L**	**σ_L**	**σ_c**	**σ_{cL}**	**σ_X**	**T**	**K/A**
GSE	0.1%	1	.115%	.104%	2	1.8%	.25%	0	50%	*	*
DI	.104%	1	0	.104%	2	1.8%	1.0%	0	50%	*	*

* = varies in Figure.

Interest rate risk is added to both the DI and the GSE in Figure 8, by altering the parameter γ. The other parameters are unchanged from Figure 5.

	Model Parameters Underlying Figure 8										
	δ	**γ**	**f**	$\bar{c}$	**D_L**	**σ_L**	**σ_c**	**σ_{cL}**	**σ_X**	**T**	**K/A**
GSE	0.1%	*	.23%	.104%	2	1.8%	.25%	0	50%	*	1%
DI	.104%	*	0	.104%	2	1.8%	1.0%	0	50%	*	4%

* = varies in Figure.

Figure 9 compares a GSE's default rate against that of a publicly traded mortgage pool. The Pool (obviously) earns no on-going guarantee fees, nor is it subject to funding risk (γ, D_L, σ_L, σ_{CL}) or operational risks (σ_X). Mortgages are priced to include a premium for expected default losses. The risk of default is set higher for the Pool than for the GSE, reflecting the GSE policy of requiring private mortgage insurance for any loan amount above 80% of the property's assessed value.

	Model Parameters Underlying Figure 9										
	δ	γ	**f**	$\bar{c}$	D_L	σ_L	σ_c	σ_{cL}	σ_X	**T**	**K/A**
GSE	0.1%	1	.23%	.104%	2	1.8%	.25%	0	50%	*	*
POOL	.104%	na	na	.104%	na	na	.80%	na	na	*	*

* = varies in Figure

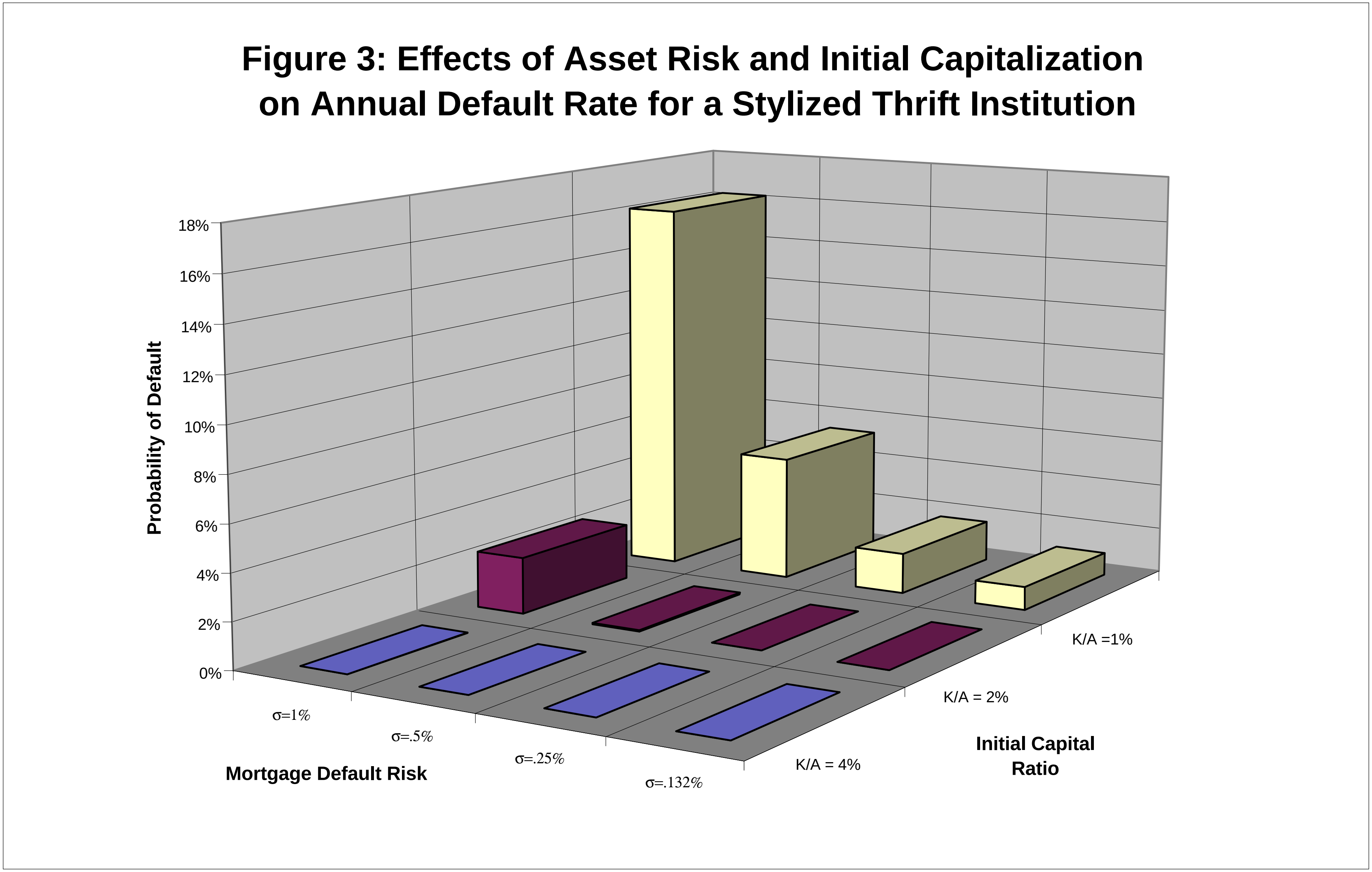


Figure 3: Effects of Asset Risk and Initial Capitalization
on Annual Default Rate for a Stylized Thrift Institution
Probability of Default
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
σ=1%
σ=.5%
σ=.25%
σ=.132%
Mortgage Default Risk
K/A =1%
K/A = 2%
K/A = 4%
Initial Capital
Ratio

Figure 4: Effect of Evaluation Interval on Annual Default Rate for a Stylized Thrift Institution

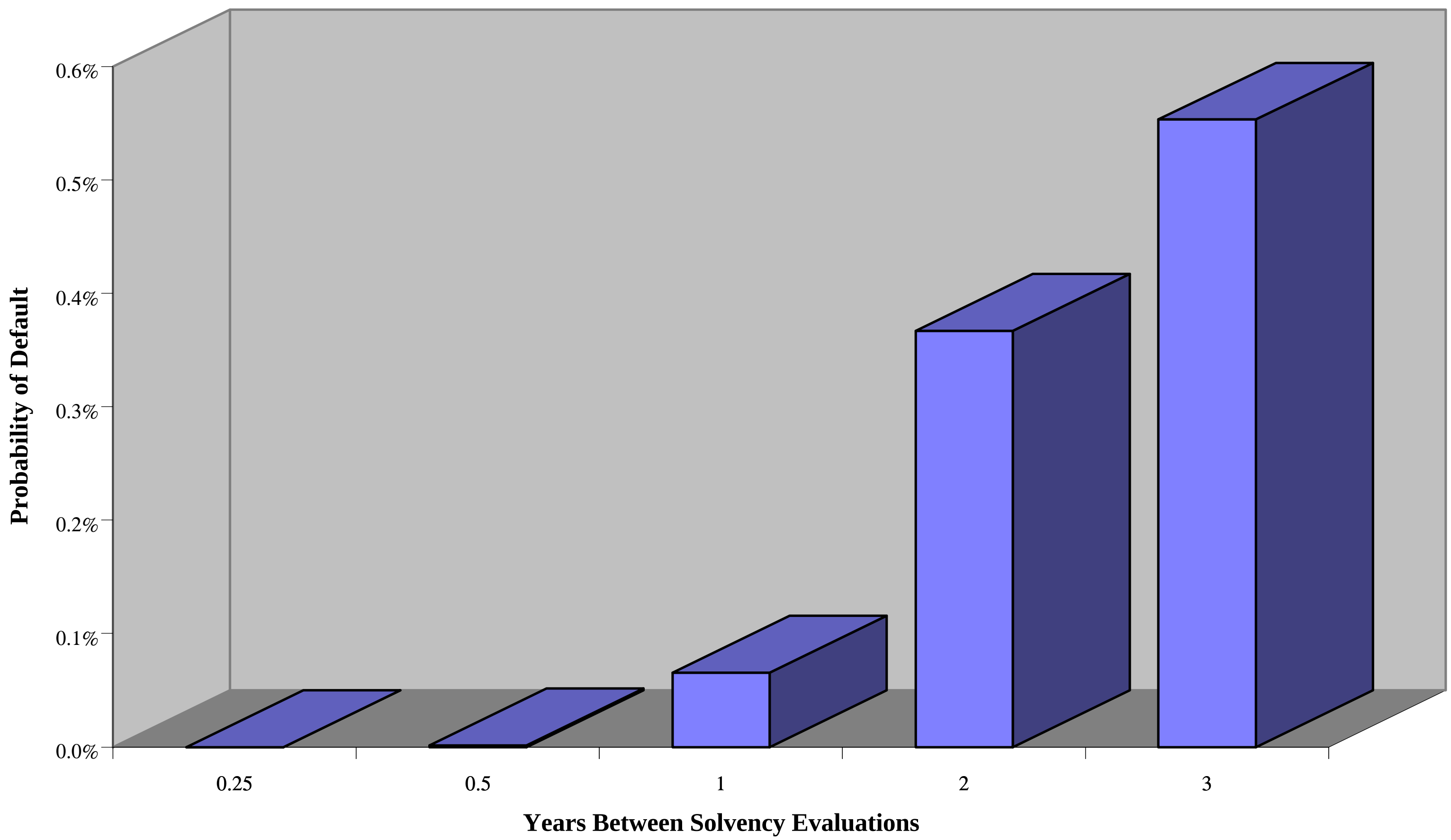
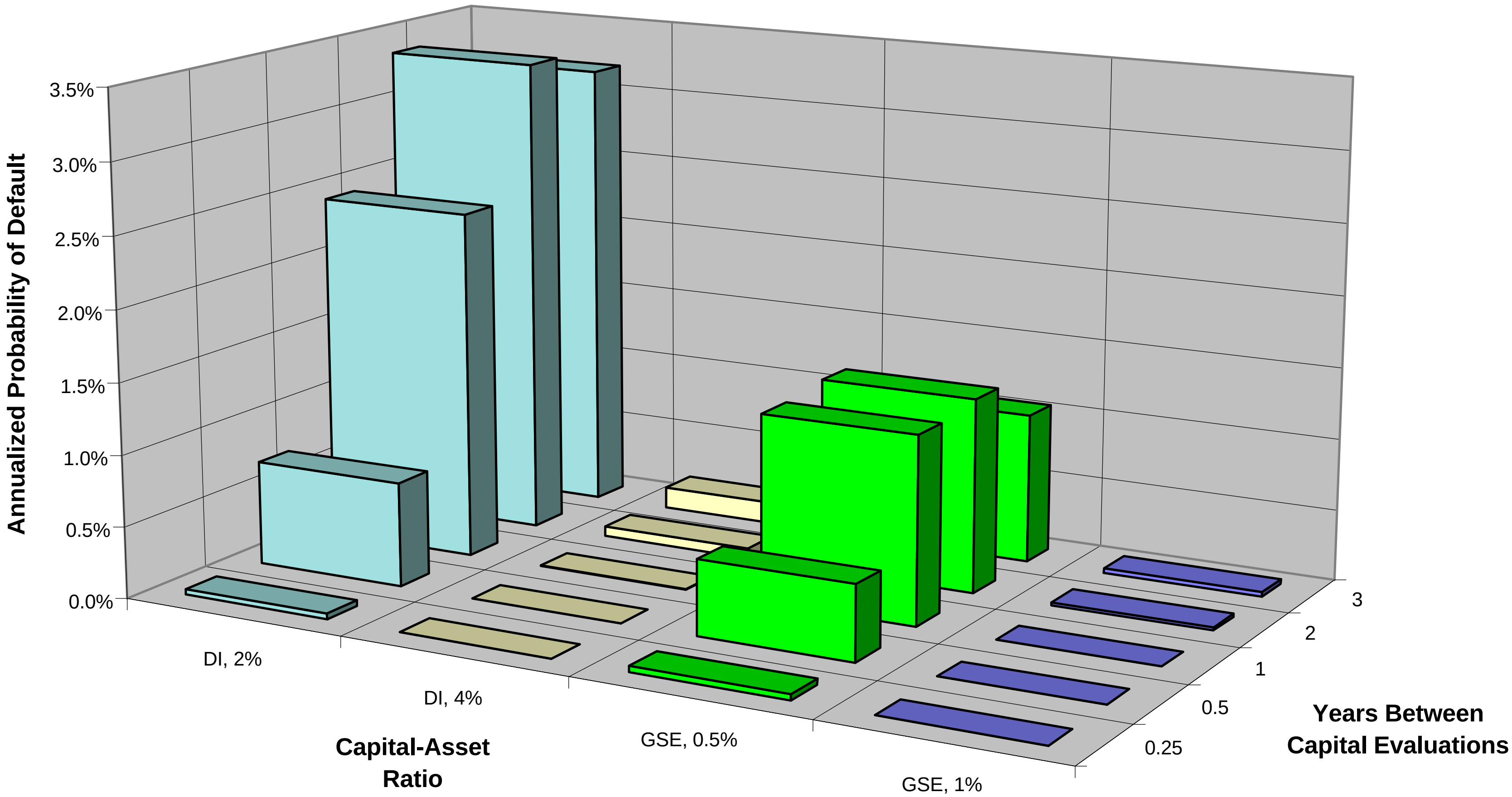


Figure 5: Annual Default Probabilities for a Stylized Thrift vs. a Stylized GSE



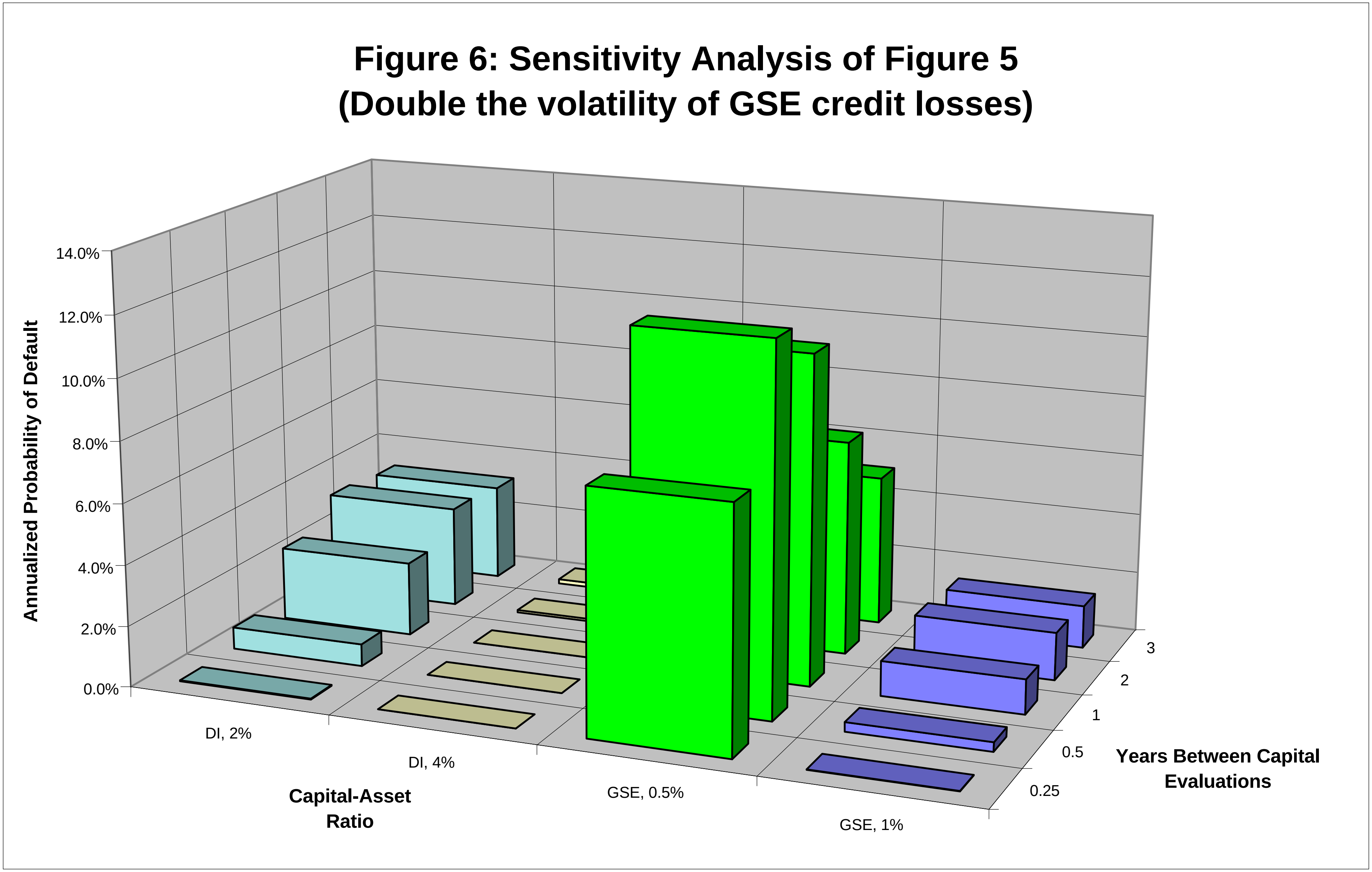


Figure 6: Sensitivity Analysis of Figure 5
(Double the volatility of GSE credit losses)
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
Annualized Probability of Default
DI, 2%
DI, 4%
GSE, 0.5%
GSE, 1%
Capital-Asset
Ratio
3
2
1
0.5
0.25
Years Between Capital
Evaluations

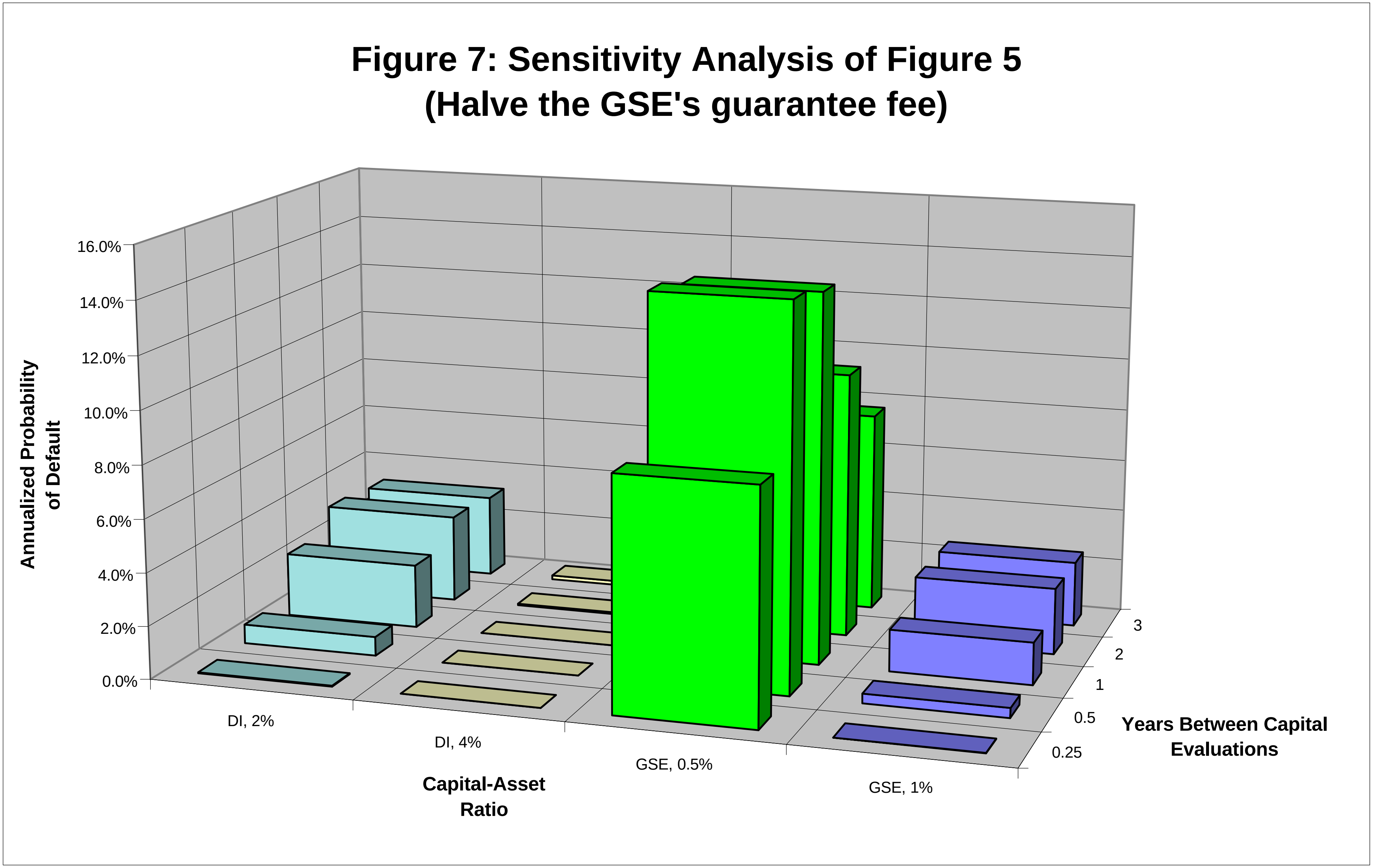


Figure 7: Sensitivity Analysis of Figure 5
(Halve the GSE's guarantee fee)
Annualized Probability of Default
16.0%
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
DI, 2%
DI, 4%
GSE, 0.5%
GSE, 1%
Capital-Asset Ratio
3
2
1
0.5
0.25
Years Between Capital Evaluations

Figure 8: Effect of Interest Rate Risk on Default Probability
(Capital Asset Ratios: GSE = 1%, DI = 4%)

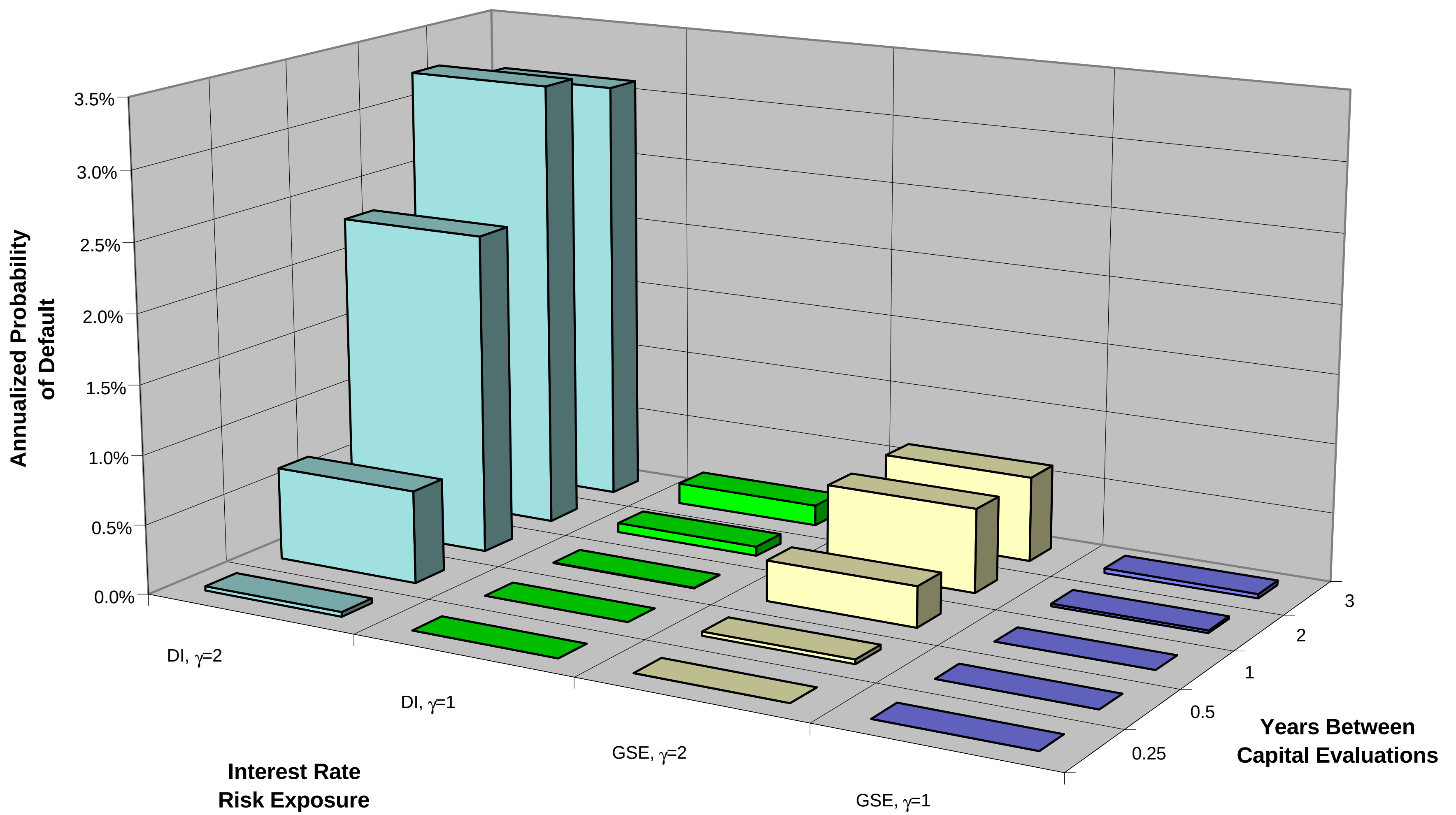
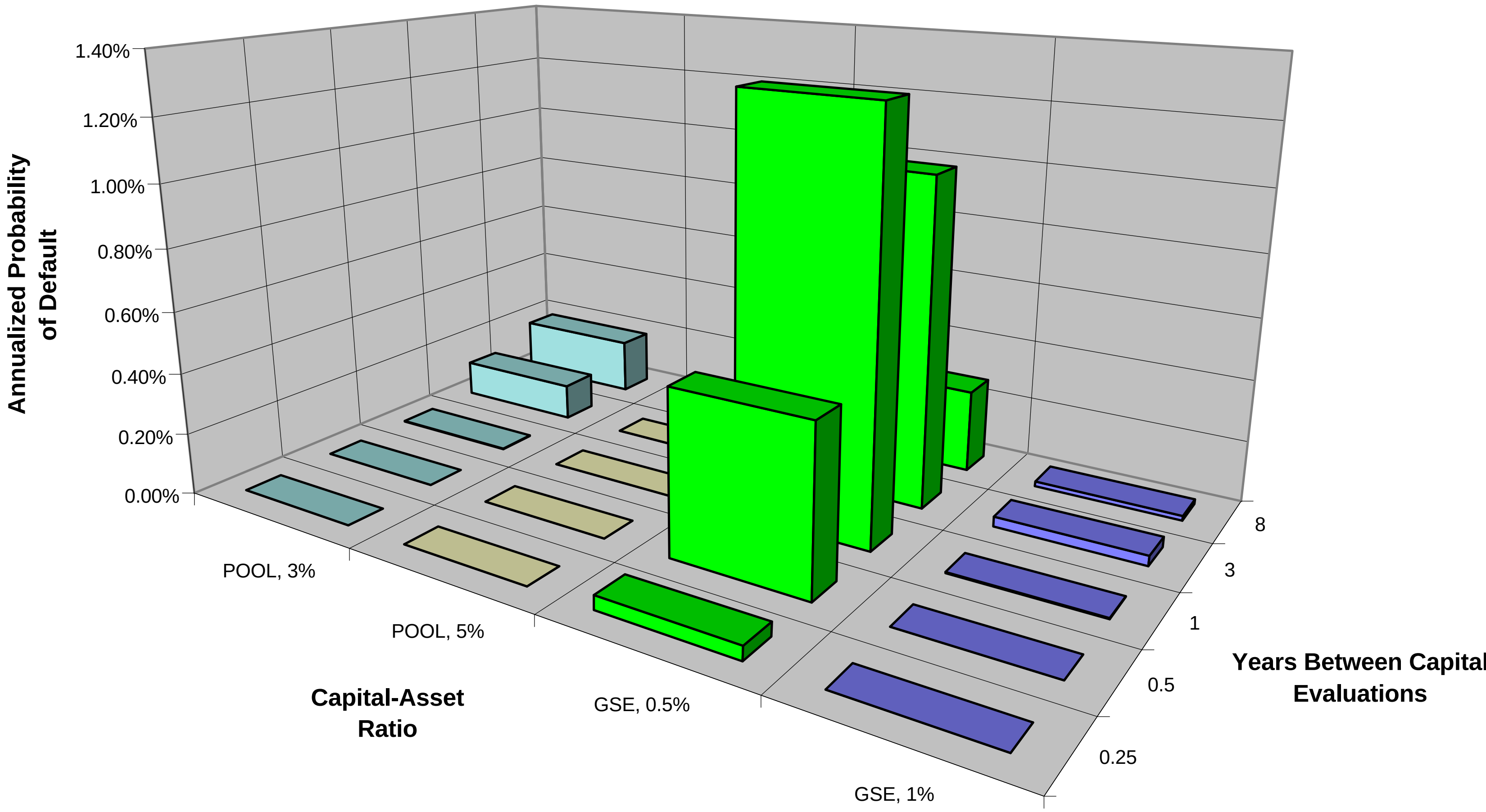


Figure 9: Default Probabilities for a Stylized Mortgage Pool vs. a Stylized GSE



APPENDIX 2

"Risk-Based Capital Proposal: Freddie Mac's Preliminary Comments on OFHEO's Proposed Approach to Projecting Non-Treasury Interest Rates"

Freddie Mac

1999

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**RISK-BASED CAPITAL PROPOSAL:
Freddie Mac's Preliminary Comments
on OFHEO's Proposed Approach to Projecting
Non-Treasury Interest Rates**

October 1, 1999

TABLE OF CONTENTS

INTRODUCTION

Pursuant to the Federal Housing Enterprises Safety and Soundness Act of 1992[1], OFHEO has proposed for comment a risk-based capital requirement ("NPR2"[2]) for Freddie Mac and Fannie Mae (the "Enterprises"). The 1992 Act mandated creation of a risk-based capital standard, the first regulatory capital standard to be based on a stress test. Freddie Mac supported that approach to capital regulation at the time of the legislation, and we continue to believe it represents a sound method to assure that the Enterprises remain financially strong and continue to serve the important mission for which they were chartered.

NPR2 is lengthy and complex, reflecting OFHEO's considerable efforts in developing the initial version of an unprecedented approach to capital standards. While we intend to address NPR2 in its entirety in a subsequent comment, we believe the rulemaking process will be best served by providing now some technical comments concerning a small component of the proposal – the manner in which non-Treasury interest rates are projected. Non-Treasury rates are critical to determining stress period cash flows of the Enterprises. Accordingly, Freddie Mac has prepared the following preliminary comments which are limited to an evaluation of OFHEO's proposed projection of these non-Treasury interest rates.

We emphasize that these preliminary comments address only a small fraction of NPR2. Freddie Mac is still analyzing NPR2 in anticipation of submitting a comprehensive comment at a later date.

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[1] The Federal Housing Enterprises Financial Safety and Soundness Act of 1992 (the "1992 Act" or the "Act"), Pub. L. No. 102-550.

[2] The term "NPR2" collectively refers to OFHEO's Notice of Proposed Rulemaking: Risk-based Capital, 64 Fed. Reg. 18084 (April 13, 1999) and subsequent revisions announced in OFHEO's "Notice of Availability of Supplemental Information," 64 Fed. Reg. 32828 (June 18, 1999), all of which are contained on OFHEO's web site *http://www.ofheo.gov*.

I. EXECUTIVE SUMMARY

OFHEO's risk-based capital proposal is based on a stress test, mandated by the 1992 Act, and designed to answer a straightforward question: Are the current resources and capital of an Enterprise sufficient to meet all of its existing financial obligations for 10 years, notwithstanding losses created by severe economic stresses?

The capital adequacy stress test is built on the foundation of two statutorily specified severe stresses: a mortgage credit risk stress and an interest rate stress. To answer the capital sufficiency question, OFHEO needs to specify all of an Enterprise's cash inflows and outflows over 10 years. Many of these cash flows depend on characteristics of the stress test environment that are not specified in the 1992 Act, such as prepayment experience, dividend policies and non-Treasury interest rates. The 1992 Act requires OFHEO to determine these unspecified characteristics consistently with the stress period and on the basis of available information. Therefore, OFHEO must choose these unspecified characteristics to be consistent with the general change in interest rates and with the mortgage credit loss experience during the stress period.

In these preliminary comments, we consider OFHEO's proposal with regard to non-Treasury interest rates, which are among the many characteristics that OFHEO must specify to implement the stress test. The London Interbank Offered Rate ("LIBOR") and the interest rates paid by Freddie Mac on its own borrowings are examples of such non-Treasury interest rates. In NPR2, OFHEO proposes to specify a total of 19 different non-Treasury interest rates using historical data on these interest rates and a set of Autoregressive Integrated Moving Average ("ARIMA") models.

OFHEO proposes to project non-Treasury interest rates during the stress period by applying 19 separate ARIMA models, one for each interest rate. An ARIMA model projects a non-Treasury interest rate for each month of the stress period based on information such as the historical average for that interest rate (relative to Treasury rates) and recent month-to-month changes in that interest rate. On any given date, the ARIMA model projections use the recent history of an interest rate, plus its longer term historical patterns, to specify how that interest rate might behave in a stress test initiated on that date.

We applaud OFHEO's intent to use historical data to estimate non-Treasury interest rates during the stress period, as well as its proposed requirement to update these estimates each quarter as new data become available. In these ways, we believe OFHEO's proposed stress test represents a significant improvement over the risk measurement techniques used by other financial regulators.

However, our analysis to date indicates that OFHEO's proposed use of ARIMA models is poorly suited to the task of estimating non-Treasury interest rates in the stress period. For example, many of the ARIMA models proposed by OFHEO do not fit historical data well – in part because historical data exhibit changes in behavior that ARIMA models *cannot* capture – and also because the ARIMA models ignore relationships *among* rates. Accordingly, ARIMA models do not provide a good basis for projecting stress period rates. In fact, we believe that in many instances the proposed ARIMA models *introduce* errors into the interest rate projections. These errors can ultimately produce erratic changes in an Enterprise's regulatory capital requirement that are unrelated to risk. The ARIMA models introduce these errors in part because they miss important changes that occurred in the behavior of these non-Treasury interest rates in the 1980s and because they incorrectly extrapolate recent interest rate trends by assuming that these trends persist for 10 years.

In addition, the inherent complexity of the ARIMA models hinders incorporation of the proposed capital requirement into the capital management and compliance systems of an Enterprise. Furthermore, this complexity creates substantial obstacles to any innovative products or instruments where cash flows are related to interest rates other than the 19 non-Treasury interest rates specified in NPR2.

In the preliminary comments that follow, we focus on the proposed use of historical data and ARIMA models in greater detail. The weaknesses that we identify arise largely because ARIMA models are not well-suited for their intended purpose in NPR2. In place of the ARIMA models, Freddie Mac recommends that OFHEO project differences between non-Treasury and Treasury interest rates over the stress period by using a two-year rolling average. Not only would a two-year rolling average create a less erratic capital requirement, it also would not on average either increase or decrease the required capital compared with using the proposed ARIMA models. Thus, we believe OFHEO can obtain a comparable capital result with fewer unacceptable side effects by using a two-year rolling average.

Again, these preliminary comments address only a small fraction of NPR2 (roughly 8 of the 647 pages of the proposal posted on OFHEO's web site). Freddie Mac is still analyzing NPR2 in anticipation of submitting a comprehensive comment at a later date.

II. OBJECTIVES USED TO EVALUATE THE RISK-BASED CAPITAL RULE

Four principal objectives guide Freddie Mac's evaluation of a risk-based capital rule.[3] These objectives are as follows:

- The risk-based capital rule should be consistent with the 1992 Act.
- The capital rule should tie capital to risk.
- An Enterprise should be able to incorporate the capital rule into its business processes – so that it can effectively operate under the rule on a daily basis.
- The capital rule should accommodate innovation.

Each of these four objectives is discussed below in detail. We intend to evaluate all of NPR2, including OFHEO's proposed methodology for projecting non-Treasury interest rates, in light of these objectives. We also note that OFHEO has established similar objectives for a risk-based capital rule.[4]

A. Maintaining Consistency with the 1992 Act

The 1992 Act created OFHEO and provided the agency with a variety of regulatory tools, including examination authority, and minimum and risk-based capital rulemaking authority. The risk-based capital rule contemplated in the 1992 Act is an unprecedented, forward-looking standard that should align capital requirements and risk better than any other capital rule has ever done.

While the detailed implementation of the risk-based capital rule is complex, the basic structure of the stress test is not. The 1992 Act specifies that OFHEO's stress test should expose each Enterprise to two severe stresses – a mortgage credit risk stress and an interest rate risk stress – during a 10 year period.[5] Under the 1992 Act, the interest rate stress is imposed in the form of two alternative paths for the 10-year constant maturity Treasury ("CMT"),[6] one in which the CMT rises substantially and another in which that rate falls substantially.

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[3] See remarks by Leland C. Brendsel, Chairman and CEO of Freddie Mac, before the Prudential Securities Reform and Regulation Conference, Washington, DC (March 25, 1999).
[4] See, *e.g.*, remarks by Mark Kinsey, Acting Director of OFHEO, before the Federal Agency Committee of the Bond Market Association (May 6, 1999) (hereinafter Kinsey Speech, dated May 6, 1999); Statement of Mark Kinsey Before the Subcommittee on Capital Markets, Securities and Government Sponsored Enterprises of the House Banking Committee (May 12, 1999) (hereinafter Kinsey Testimony, dated May 12, 1999).
[5] 1992 Act §§ 1361(a)(1) and (2), 12 U.S.C. §§ 4611(a)(1) and (2).
[6] 1992 Act § 1361(a)(2)(A)-(C), 12 U.S.C. § 4611(a)(2)(A)-(C).

Significantly, all other stress-period characteristics are to be consistent with the specified characteristics of the 1992 Act, based on available information.[7] For example, prepayment rates, dividend policies, counter party credit losses, and non-Treasury interest rates (the subject of this preliminary comment) should be what one would reasonably expect them to be under the specified conditions. The statute does not provide for those characteristics to introduce new, independent stresses (*i.e.*, unrelated to the two specified stresses).

One way to describe this statutory language in statistical terms would be to say that the unspecified stress-period characteristics should be based on "conditional expectations," *i.e.*, the *unspecified* characteristics should be conditioned on the *specified* stress-period characteristics. OFHEO's proposal for non-Treasury interest rates moves in this direction by using statistical forecasting techniques. Assumptions for non-Treasury rates are unspecified characteristics, but they are subject to the statutory requirement that they be consistent with the characteristics specified (*i.e.*, the general change in interest rates), based on available information. Accordingly, the direction of the 1992 Act requires OFHEO to determine some basis for identifying non-Treasury interest rates, consistent with the stressful Treasury rate scenarios prescribed in the 1992 Act.

B. Tying Capital to Risk

A risk-based capital rule should tie capital to risk. In NPR2, OFHEO has expressed essentially the same objective for the rule.[8] Also, OFHEO has pointed out that creation of perverse incentives would be inconsistent with this objective.[9] We agree.

The application of this objective may be most easily identified in cases where a capital rule fails to meet it. For example, a rule would not meet this objective if an Enterprise's capital requirement could increase or decrease significantly for reasons unrelated to risk, or where the capital requirement could change disproportionately to changes in risk. Similarly, the rule would not meet this objective if the sensitivities across risks were disproportionate to observed and understood relationships. We believe that OFHEO shares this perspective.[10]

C. Incorporating the Rule In Enterprise Business Processes

Implementation is one of the more difficult challenges in the development of a risk based capital rule. In this regard, OFHEO should consider whether an Enterprise can incorporate the regulatory requirement into its business operations and forecast compliance. Even a perfect model is of little regulatory use if there is no reasonable way for an Enterprise to (a) determine in real time whether it is in compliance with its capital requirements and (b) forecast whether it will remain in compliance. An Enterprise should be able to forecast confidently whether it will be in compliance for the next quarter – given

[7] 1992 Act §§ 1361(a)(4) and 1361(b)(2), 12 U.S.C. §§ 4611(a)(4) and 4611(b)(2).
[8] See NPR2 at 18090 ("In creating the proposed stress test, OFHEO had to ensure that … it accurately and appropriately captured the risks related to the business of the Enterprises.").
[9] Id.
[10] See, *e.g.,* Kinsey Speech dated May 6, 1999.

its forecast of purchase activities, interest rates and house prices. If a stress test model is highly sensitive to small changes in dozens of inputs, forecasting a capital requirement becomes extremely difficult.

We are pleased to note that OFHEO has indicated throughout NPR2 that it intends to avoid complexity that is not justified by a corresponding benefit.[11] In addition, the structure of the 1992 Act makes it unnecessary to capture every possible aspect of risk. Congress specified credit shocks and interest rate shocks that are extreme. As an additional cautionary measure, the 1992 Act included a 30 percent add-on for management and operations risks.

Given this extreme stress test *plus* a hefty 30 percent premium for management and operations risk, it would serve no regulatory purpose and would likely hinder effective implementation if OFHEO were to attempt to design a stress test model that accounted for every possible change that could reduce the profitability of an Enterprise. We believe the modeling of non-Treasury interest rates should be no more complex than is necessary to meet the requirements of the Act and the objective of tying capital to risk.[12] This approach would allow the Enterprises to build compliance into their business processes and would facilitate effective and efficient implementation of the capital rule.

D. Accommodating Innovation

As one of its objectives for NPR2, OFHEO has said that the stress test must be "flexible enough to address innovation," adding that "this type of flexibility keeps the stress test from becoming obsolete over time."[13] We agree. The risk based capital rule should be flexible enough to adapt to innovations in an Enterprise's business processes, including new methods of risk management and new activities. Ideally, an Enterprise should be able to determine in advance whether and how the capital rule would be applied to an innovation under consideration, without an application or a regulatory amendment.

III. PRELIMINARY COMMENTS

A. NPR2's Non-Treasury Interest Rate Proposal

The method selected by OFHEO to set non-Treasury rates is crucial to the outcome of the stress test. A significant portion of Freddie Mac's asset and liability payments are based on the 19 non-Treasury interest rates modeled in NPR2 (see Table 1), and on differences among such rates. These interest rates directly affect the cash flows of an Enterprise's portfolio (assets, liabilities and derivatives), and therefore affect any assessment of the

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[11] See, *e.g.*, NPR2 at 18088 ("[I]n developing this proposed regulation, OFHEO sought to achieve a level of complexity and realism in the stress test that appropriately balanced the associated benefits and costs.").
[12] The avoidance of unneeded complexity is consistent with the principle of "Occam's razor," which dictates that models should be parsimonious with respect to non-essential elements. Moreover, OFHEO recognizes that implementation costs (time and resources) tend to rise with increased complexity. See NPR2 at 18088.
[13] See Kinsey Testimony dated May 12, 1999.

Enterprise's ability to weather financial risks. If a stress test sets these rates inappropriately, the resulting unreliable projections of cash flows could cause the stress test to create artificially high or low stress-period income or expenses, and thus could provide a distorted assessment of an Enterprise's exposure to interest rate and mortgage credit risk.

In NPR2, OFHEO proposes to use ARIMA models to project 19 non-Treasury interest rates.[14] As proposed, OFHEO uses a separate ARIMA model for each of the non-Treasury interest rates it has selected. Each ARIMA model actually projects the spread between the non-Treasury interest rate and the CMT of comparable maturity for each month of the stress period.[15] On any given date, the ARIMA model projections use the recent history of the interest rate spread, as well as the longer term historical patterns of the spread, to determine how that spread – and resulting rate – may behave in a stress test initiated on that date.[16]

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[14] The OFHEO proposal for projecting non-Treasury interest rates is set forth in NPR2 at Section 3.3.3.4, as revised, and is further illustrated in Table 3-12, as revised. NPR2 at 18234-36; *see also* 64 Fed. Reg. 18084 (April 13, 1999) and corresponding corrections to § 3.3.3.4 and Table 3-12 on OFHEO's Web site. OFHEO's revised text for § 3.3.3.4 deletes the coefficient estimates that were used in the original proposal and instead describes the ARIMA process in terms of model specification and data sources. On its Web site, OFHEO explains, "[T]he ARIMA model specifications are fixed, but the equation coefficients change with the addition of new historical data." OFHEO further notes that the coefficients used in the two stress test simulations are consistent with the revised text but differ from those contained in the version of Table 3-12 in the original proposal.

[15] In this document, we use the term "spread" to denote the difference between a given non-Treasury rate and the yield on the Treasury security of comparable maturity, expressed as a percentage of the Treasury yield. For example, the six-month LIBOR spread is defined as the difference between the six-month LIBOR rate and the six-month Treasury yield, divided by the six-month Treasury yield:

$$6\ month\ LIBOR\ spread = \frac{6\ month\ LIBOR\ rate - 6\ month\ Treasury\ yield}{6\ month\ Treasury\ yield}$$

[16] In a related section of NPR2, OFHEO indicates that the stress test adds a 50-basis-point credit spread to the federal agency cost of funds index to project Enterprise borrowing costs for the last nine years of the stress test. NPR2 at 18236 (§ 3.3.3.5.). Freddie Mac does not address the additional 50-basis-point credit spread in this preliminary comment; however, we intend to address this issue later, in our overall comment on NPR2. In addition, this preliminary comment does not address OFHEO's proposal in § 3.9.3.3(m) of NPR2 concerning unhedged foreign exchange transactions. NPR2 at 18292.

Table 1: Non-Treasury Rates Included in NPR2

Abbreviation*	Non-Treasury Rate
ONFFD	Overnight Federal Funds Rate
FFD07	7-Day Federal Funds Rate
LBR01	1-Month LIBOR (Mid-Market Yield)
LBR03	3-Month LIBOR (Mid-Market Yield)
FA003	3-Month Federal Agency Cost of Funds**
PRIME	Prime Rate
LBR06	6-Month LIBOR (Mid-Market Yield)
FA006	6-Month Federal Agency Cost of Funds **
FF180	180-Day Federal Funds Rate
COF11	FHLB 11th District Cost of Funds
LBR12	12-Month LIBOR (Mid-Market Yield)
FA012	12-Month Federal Agency Cost of Funds **
FA024	24-Month Federal Agency Cost of Funds **
FA036	36-Month Federal Agency Cost of Funds **
FA060	60-Month Federal Agency Cost of Funds **
CONVR	Conventional Mortgage Rate
FA120	120-Month Federal Agency Cost of Funds **
FRM15Y	15-Year, Fixed-Rate Mortgage
FA360	360-Month Federal Agency Cost of Funds **

* The abbreviations for various rates are used in subsequent tables and illustrations in these preliminary comments.

** To be consistent with NPR2, we use the term “Agency” in connection with the interest rate series related to the debt of GSEs.

B. Comments on the Use of Historical Data

In NPR2, OFHEO expresses an intent to use historical data to estimate non-Treasury interest rates during the stress period.[17] Further, OFHEO indicates an intent to "capture the average historical relationships between specific CMTs and non-Treasury interest rates." [18]

1. Overview

Freddie Mac agrees with OFHEO's intent to use historical data as the basis for projecting non-Treasury spreads into the stress period. The use of historical data can satisfy the four objectives for the capital rule.

The use of an historical basis can be consistent with the 1992 Act's requirement that non-Treasury rate assumptions be consistent with other stress test assumptions because non-Treasury spreads do not appear to change systematically as Treasury rates vary. Support for this assertion is presented in the next section (see "Analysis," below).

Use of historical data can also help satisfy the other objectives for the capital rule. The use of historical data can tie capital to risk, as evidenced by standard practices in the financial services industry (where historical data commonly form the basis for assessing risk and measuring capital). The use of historical data also can be incorporated into the Enterprises' business systems, because historical data are objective, verifiable, and easily accessible. Finally, the use of historical data can accommodate innovation, because applicable historical data are generally available when new products (or terms) are integrated into mortgages, derivatives, and other securities relevant to the Enterprises.

However, we do have some preliminary reservations about the reliability of some of the data sources used in NPR2. For example, we noted that DRI[19] data used in the stress test indicated a 29 basis point increase in the six-month Agency rate relative to LIBOR from May to June 1997. However, data from another prominent data source (Bloomberg[20]) indicated that this spread changed by less than one basis point from May to June 1997. Our internal data are most consistent with Bloomberg.

2. Analysis

In this section, we provide support for the assertion that historical non-Treasury spreads do not appear to change systematically as Treasury rates vary, and hence provide a reasonable basis for projecting non-Treasury rates for the stress period.

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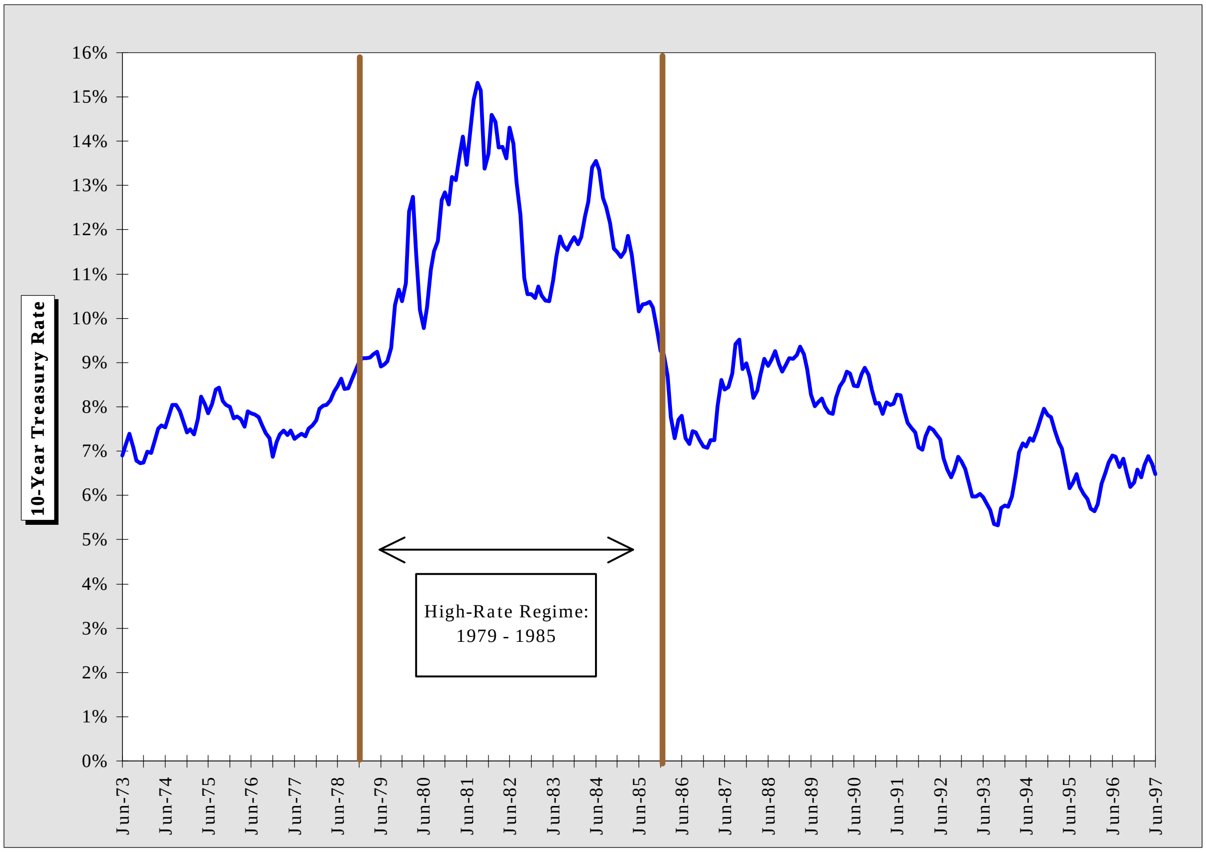
[17] NPR2 at 18091 and 18149.
[18] NPR2 at 18149.
[19] Standard & Poor's DRI is a Division of The McGraw-Hill Companies.
[20] "Bloomberg" is a trademark of Bloomberg, L.P.

As shown in Figure 1, historical rates for the 10-year Treasury bond can be characterized by a "high-rate regime" from 1979 through 1985, with (by comparison) "low-rate regimes" in the earlier and later years.

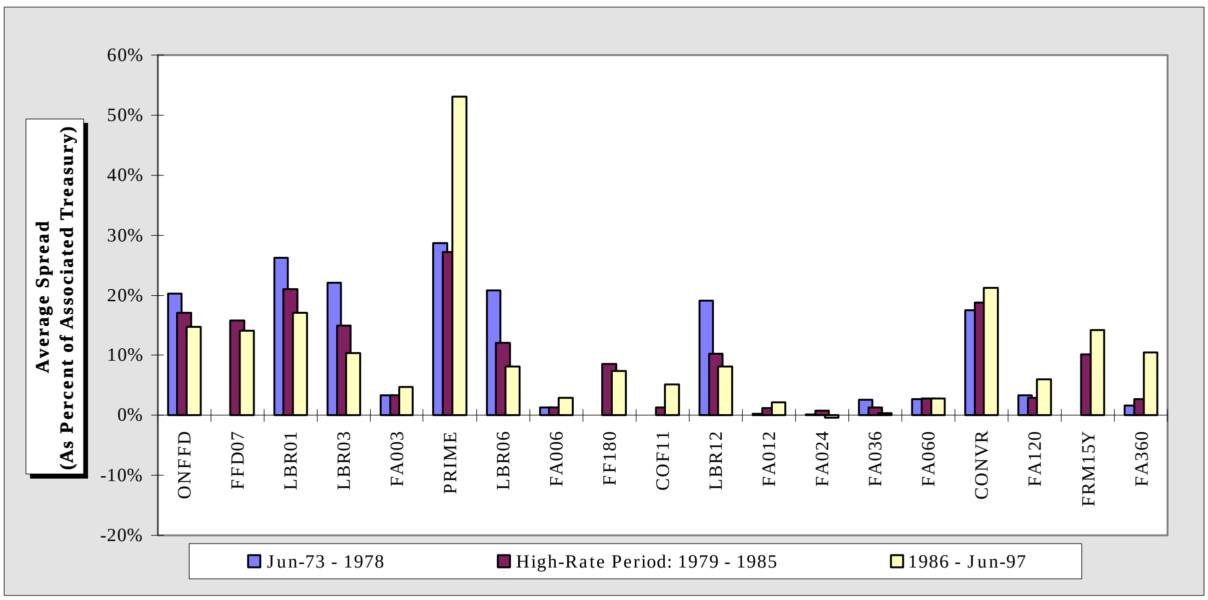
Figure 1: Historical 10-Year Treasury Rates, June 1973 to June 1997



Historical data on Treasury interest rates show three regimes.

The behavior of non-Treasury spreads over these high-rate and low-rate regimes is shown in Figure 2. Notice in Figure 2 that, for most non-Treasury rates, the average spread during the high-rate regime of 1979-1985 is *between* the averages of the two lower-rate regimes. In other words, spreads do not appear to be systematically higher or lower during high-rate regimes than they are during low-rate regimes. Thus, absent objective and supportable information about the unprecedented Treasury rate scenarios posed by the stress test, it is reasonable to assume that the severe increases or decreases in Treasury rates hypothesized in the stress test would not generate systematic changes in non-Treasury spreads.

Figure 2: Average Spreads, By Regime



Historically, spreads during the high-rate regime are not systematically different from those in low-rate regimes.

3. Recommendations

We recommend that OFHEO retain its goal of using historical data as the basis for projecting non-Treasury spreads for the stress period. We also recommend that OFHEO explore alternative data sources and data-screening procedures to eliminate questionable or erroneous data.

4. Summary

Freddie Mac agrees with OFHEO's intent to use historical data as the basis for projecting non-Treasury spreads into the stress period. As shown in the above analysis, non-Treasury spreads do not appear to change systematically as Treasury rates vary. Therefore, the use of historical data can be consistent with the 1992 Act's requirement that non-Treasury rates be consistent with the stress period assumptions. Further, the objectivity, verifiability, and availability of historical data will allow the capital rule to tie capital to risk, and can support implementation of the capital rule and innovation by the Enterprises.

C. Comments on the Use of ARIMA Models

To achieve its objective of capturing historical spread relationships in the stress test, OFHEO proposes in NPR2 the use of ARIMA models. ARIMA models are a class of statistical time series models used to describe historical data and to forecast future values.

In NPR2, OFHEO uses separate ARIMA models in projecting stress period levels for each of 19 non-Treasury spreads used in the stress test. Specifically, OFHEO assumes that ARIMA models adequately describe the behavior of the spreads between each non-Treasury interest rate and the Treasury rate of comparable maturity. The behavior of each non-Treasury spread is assumed to be independent of the behavior of all of the other non-Treasury spreads. Non-Treasury rates in the stress test are determined by combining the spreads (obtained using the ARIMA models) with the Treasury rates assumed for the stress period. [21]

1. Overview

Freddie Mac strongly disagrees with NPR2's application of ARIMA models to project non-Treasury spreads for the stress period. We believe the use of ARIMA models would result in erratic capital requirements that were not sufficiently tied to Enterprises' true risk. Moreover, the complexity of the ARIMA models would unnecessarily hinder implementation of the capital rule and impede innovation by the Enterprises.

We believe these perverse results would be generated by numerous specific problems with the ARIMA models.[22] We support our criticisms in the next section (see "Analysis," below). We group these issues into three general problems for purposes of exposition:

a) Use of ARIMA models in NPR2 does not adequately capture the historical behavior of non-Treasury spreads, and hence provides unreliable and erratic projections of non-Treasury rates.

b) The ARIMA models cannot be incorporated readily into a system for forecasting capital requirements and managing capital.

[21] For example, after using the ARIMA models to forecast the six-month LIBOR spread (defined in footnote 15), the six-month LIBOR rate is calculated as

$$6\,month\ LIBOR\ rate = 6\,month\ Treasury\ rate \times (1 + 6\,month\ LIBOR\ spread)$$

[22] Our objections do not imply that we believe there is anything wrong with ARIMA modeling methods in general; ARIMA models are appropriate in many applications in finance, economics, and other fields. Instead, we believe simply that the ARIMA models used in NPR2 are inappropriate (for the reasons described) for projecting non-Treasury rates for the stress period.

c) The ARIMA models in NPR2 cause significant uncertainty regarding the modeling of new indices – which will hamper innovation by the Enterprises.

These problems make the use of NPR2's ARIMA models inconsistent with Freddie Mac's four objectives for the capital rule.

The first of the above general problems (a) contradicts the first two objectives for the capital rule. As discussed below, ARIMA models *cannot* capture important changes that occasionally occur in the behaviors of interest rates. In addition, the ARIMA models used in NPR2 ignore important historical relationships among rates; building these relationships into the models would not be practicable because of the high number of spreads modeled and data limitations.[23] The inability of the ARIMA models to adequately capture relevant historical behaviors of non-Treasury spreads implies that they will not reliably lead to non-Treasury spread projections that are consistent with assumptions for the stress period. This implication contradicts the first objective – that the capital rule be consistent with the direction of the 1992 Act. Further, the unreliable and erratic nature of the rates projected using the ARIMA models implies that capital requirements also will be erratic, and will fluctuate for reasons unrelated to the risks borne by the Enterprises. Accordingly, use of the ARIMA models does not satisfy the objective that the capital rule tie capital to risk.

The second and third problems above (b and c) contradict, respectively, the objective that the capital rule be readily incorporated into the operations of the Enterprises and the objective that the capital rule accommodate innovation.

We believe a simpler method of projecting non-Treasury spreads would better serve regulatory goals. Specifically, we recommend that OFHEO base non-Treasury rates on a two-year rolling average of the spreads that occurred in the two years immediately preceding the start of the stress period. The two-year averaging method captures historical rate relationships as well as the ARIMA models while better satisfying the four objectives.

The next two sections provide analysis of the general problems listed above, followed by a description of our proposed two-year averaging method and its benefits.

2. Analysis

In this section, we document and support the three general problems (listed in the "Overview," above) that result from NPR2's use of ARIMA models. As discussed above, we believe these problems will cause capital requirements to be erratic for reasons unrelated to Enterprises' true risk, and will hinder implementation of the capital rule and impede innovations by the Enterprises.

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[23] For example, see footnote 43.

Some Definitions

A few definitions may help readers understand the problems we note with the use of ARIMA models in NPR2.[24]

The ARIMA models used in NPR2 are of two basic types. The first type, "stationary" models, focus on explaining and forecasting the *level* of a given variable. A stationary ARIMA model assumes that the level of the variable in any given period equals a weighted sum of its average level and its levels in previous periods (the "lags" of the variable), plus a random shock.[25] The weights used in summing the lags are called the ARIMA model "coefficients." The lags that have non-zero coefficients are collectively referred to as the "lag structure" of the model.

In contrast to these stationary models, "first-difference" ARIMA models focus on explaining and forecasting the *change* in the variable's level from one period to the next rather than on the level itself. Except for this difference, the definitions used with first-difference models are the same as those used with stationary models: First-difference ARIMA models assume that the *change* in a variable's level in any given period equals a weighted sum of the average *change* and the *changes* in previous periods (the "lags" of the *changes*), plus a random shock. The weights used in summing the lags are called the ARIMA model "coefficients." The lags that have non-zero coefficients are collectively referred to as the "lag structure" of the model.

The term "functional form" is used to describe the overall structure of an ARIMA model. The functional form of an ARIMA model comprises its lag structure and whether the model is a stationary or first-difference model. The selection of the functional form appropriate for modeling a variable depends substantially on the behavior of the variable over time.

Stationary models are appropriate for modeling variables that are well-behaved in a statistical sense, *i.e.*, they have an average level, and, after being shocked (or stressed), they will (over time) tend to revert back to that average level. This reversion tendency is important for forecasting, because the forecaster can count on the variable to remain close to its average far into the future.

By contrast, variables that are appropriately modeled using first-difference ARIMA models behave less conveniently for forecasting purposes. Statisticians describe first-difference models as "non-stationary," meaning roughly that they have no average level, nor even any preferred range. In short, first-difference models (or other non-stationary models) are used when there is no such thing as a "normal" level for the variable. With this absence of any normal level, first-difference models lead to imprecise (and volatile)

[24] A more detailed (and technical) description of ARIMA models is given in chapters 3 and 15 of *Time Series Analysis* by James D. Hamilton (1994).
[25] In some cases, the random shocks are themselves modeled as weighted sums of the shocks incurred in preceding periods plus a random component.

forecasts of future levels of a variable. In contrast to stationary models, the forecaster using a first-difference model cannot count on a variable remaining close to any average or normal level.

With these definitions, we turn to our analysis of the problems we note in the use of ARIMA models in NPR2.

a) Use of ARIMA models in NPR2 does not adequately capture the historical behavior of non-Treasury spreads, and hence provides unreliable and erratic projections of non-Treasury rates

There are five specific weaknesses of the ARIMA models in NPR2 that prevent such models from adequately capturing the historical behavior of non-Treasury spreads.

1) *Use of ARIMA models in NPR2 contradicts the simple, intuitive Treasury yield curve assumptions.*

2) *The ARIMA models miss structural changes in the data.*

3) *The ARIMA models do not consider inter-rate spreads.*

4) *The functional forms of some of the ARIMA models are inconsistent with behaviors of historical data and with the functional forms of other ARIMA models.*

5) *NPR2's ARIMA models are sensitive to software choices; forecasted rates are overly sensitive to small differences in techniques buried in the software.*

Each of these weaknesses is discussed below.

1) *Use of ARIMA models in NPR2 contradicts the simple, intuitive Treasury yield curve assumptions*

The reliability of any forecasting model is limited by its least refined component. The use of ARIMA models to project non-Treasury interest rates layers a set of complex models (ARIMA) for spreads on top of simple, intuitively derived estimates of Treasury yield curves. (For example, the Treasury yield curve in the up-rate path is flat.)[26] The simplicity of the underlying yield-curve model limits reliability in forecasting non-Treasury rates. Therefore, using complex ARIMA models to increase precision in forecasts of spreads will do little to increase the reliability of the projected interest rates.

[26] We will comment on the appropriateness of this assumption at a later time.

2) The ARIMA models miss structural changes in the data

In using ARIMA models, OFHEO implicitly assumes that the behavior of spreads can be expressed by equations that are unchanging over time. If behaviors of spreads change over time, they *cannot* be reliably described by such rigid ARIMA models. In such a situation, the models would be misspecified, meaning that the models simply do not fit the manner in which the data behave. Projections based on a misspecified model are necessarily unreliable.

There is strong indication that the behaviors of spreads *do* change over time. Broad evidence of these changes was presented above in the discussion of the data, where we showed that average spread levels *have* changed over time (See Figure 2). As discussed in Section III-B (above), these changes in average spread levels do not owe to changes in Treasury rates. Instead, the changes in these spreads are attributable to changes in the risk and liquidity characteristics of the underlying debt instruments. For example, in the 1980s, the development of LIBOR markets was accompanied by a general reduction in LIBOR spreads.

In contrast to the changing behaviors of historical spreads, ARIMA models assume that spread behaviors are constant. The ARIMA coefficients obtained in an estimation based on incorrect assumptions of constancy will not describe reliably the behavior of the spreads in the stress period.

3) The ARIMA models do not consider inter-rate spreads

The ARIMA models used in NPR2 do not explicitly model the spreads *among* non-Treasury rates (or "inter-rate spreads"). Instead, NPR2 estimates 19 individual models, which are selected without regard to their implications for inter-rate spreads. This technique *implicitly* models inter-rate spreads as composites of the 19 individual ARIMA models. Because the ARIMA models ignore historical inter-rate spreads, their forecasts of inter-rate spreads over the stress period can be inconsistent with historical data.[27]

This weakness is important to the stress test because inter-rate spreads can be as important as the rates themselves to an Enterprise's financial position. For example, the inter-rate spread between Freddie Mac's borrowing rate and LIBOR directly affects the net cost of borrowing.[28]

[27] OFHEO's use of the ARIMA models is partially consistent with the work of W. Passmore (1989), which is referenced by Freddie Mac in its response to OFHEO's Advanced Notice of Proposed Rulemaking (ANPR) as an example of interest rate modeling procedures. However, Passmore's work included extensive consideration of the relationships among different rates. Such consideration is not reflected in NPR2's use of ARIMA models. The ANPR is located at 60 Fed. Reg. 7468, 7469-70 (Feb. 8, 1995). See also Freddie Mac's comment on the ANPR at 137-38 (May 9,1995).

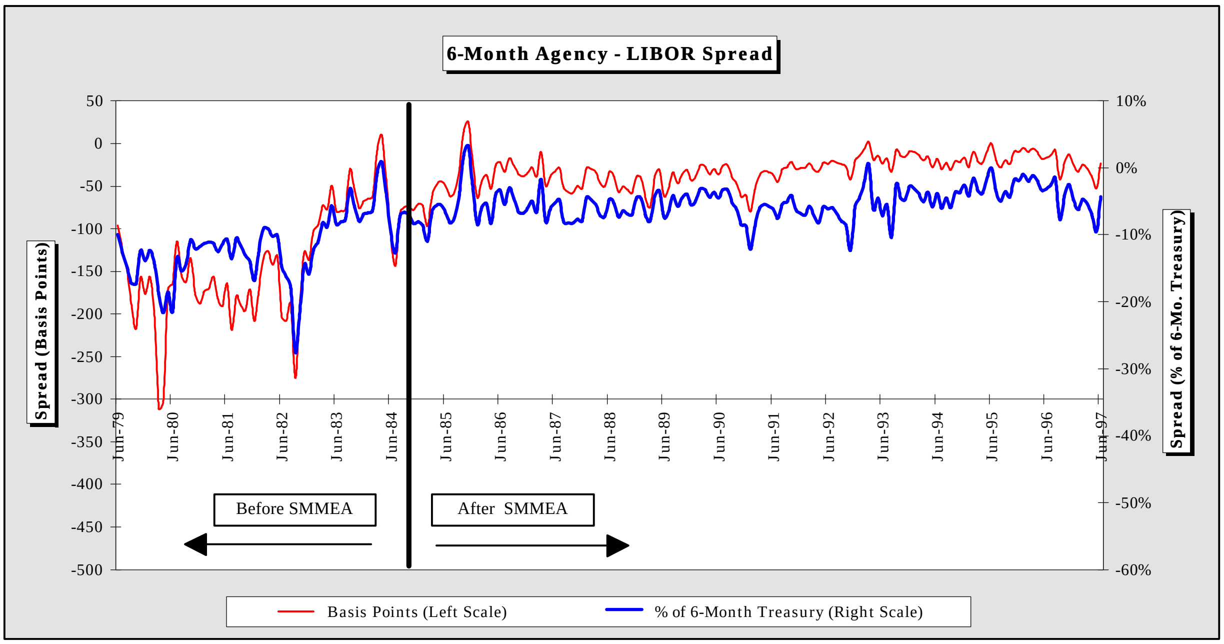
[28] As a result, Freddie Mac devotes considerable effort toward monitoring portfolio positions and market conditions (rates, prices, spreads and their relationships) and rebalances or enters other transactions to reduce risk exposure and to achieve lower effective financing costs.

A clear example of such distortion is found in the inter-rate spread between the LIBOR and Agency six-month rates. NPR2 uses a first-difference ARIMA model for the LIBOR spread, while modeling the Agency spread as stationary.[29] As a result, the inter-rate spread is implicitly modeled as non-stationary.

This implicit non-stationary model of the Agency-LIBOR inter-rate spread contradicts relevant historical data. Until the mid-1980s, this spread was quite volatile; however, since the restructuring of the GSE environment and development of LIBOR markets in the 1980's, the Agency-LIBOR spread has been stable within a tight range.

The change that occurred in the Agency-LIBOR spread in the 1980s is apparent in Figure 3 and Table 2, which split the Agency-LIBOR historical data before and after the Secondary Mortgage Market Enhancement Act of 1984 ("SMMEA").

Figure 3: Six-Month Agency-LIBOR Inter-Rate Spread, June 1979 to June 1997



Since the 1980's, the Agency-LIBOR spread has been stable – in contrast to the properties implied by the ARIMA models in NPR2.

[29] Consistent with the time-series literature, we use the term "stationary" (also referred to as "covariance stationary") to describe models in which the unconditional mean and variance of the variable are well-defined and constant over time. This definition encompasses both of the terms "mean-stationary" and "variance stationary" used by OFHEO in NPR2. NPR2 at 18149, n.149.

Table 2: Mean and Standard Deviation of Six-Month Agency-LIBOR Inter-Rate Spread

	Before SMMEA: (Jun 1973 - Sep 1984)	**After SMMEA:** (Oct 1984 - Jun 1997)	**Entire Sample:** (Jun 1973 - Jun 1997)
Basis Points			
Mean	-140	- 33	- 83
Standard Deviation	75	19	76
% of Treasury Rate			
Mean	- 15.6	- 5.1	- 10.1
Standard Deviation	8.3	2.4	7.9

The Agency-LIBOR spread increased (on average) after the mid-1980s, while the volatility (measured as the standard deviation of the spread) decreased.

The data suggest that there was a structural change in the 1980's. Since then the inter-rate spread has been very stable. By contrast, the ARIMA models in NPR2 assume that the inter-rate spread is a non-stationary time series. The models thus assume that the spread between LIBOR and the borrowing rates for the Enterprises will be volatile and without a reasonable long-term mean.

4) *The functional forms of some of the ARIMA models are inconsistent with behaviors of historical data and with the functional forms of other ARIMA models*

The diverse functional forms used by OFHEO for the ARIMA models are not coordinated with one another; almost every non-Treasury spread has its own unique functional form.[30] Some are first-difference models, others are stationary models. Some have lag structures that assume that future changes in rates are influenced by only the last few months; others assume that future changes depend on the distant past.

The use of first-difference models and the inconsistent choices of lag structures reduce the reliability of the ARIMA models – both for capturing the historical behavior of spreads and for forecasting future rates.

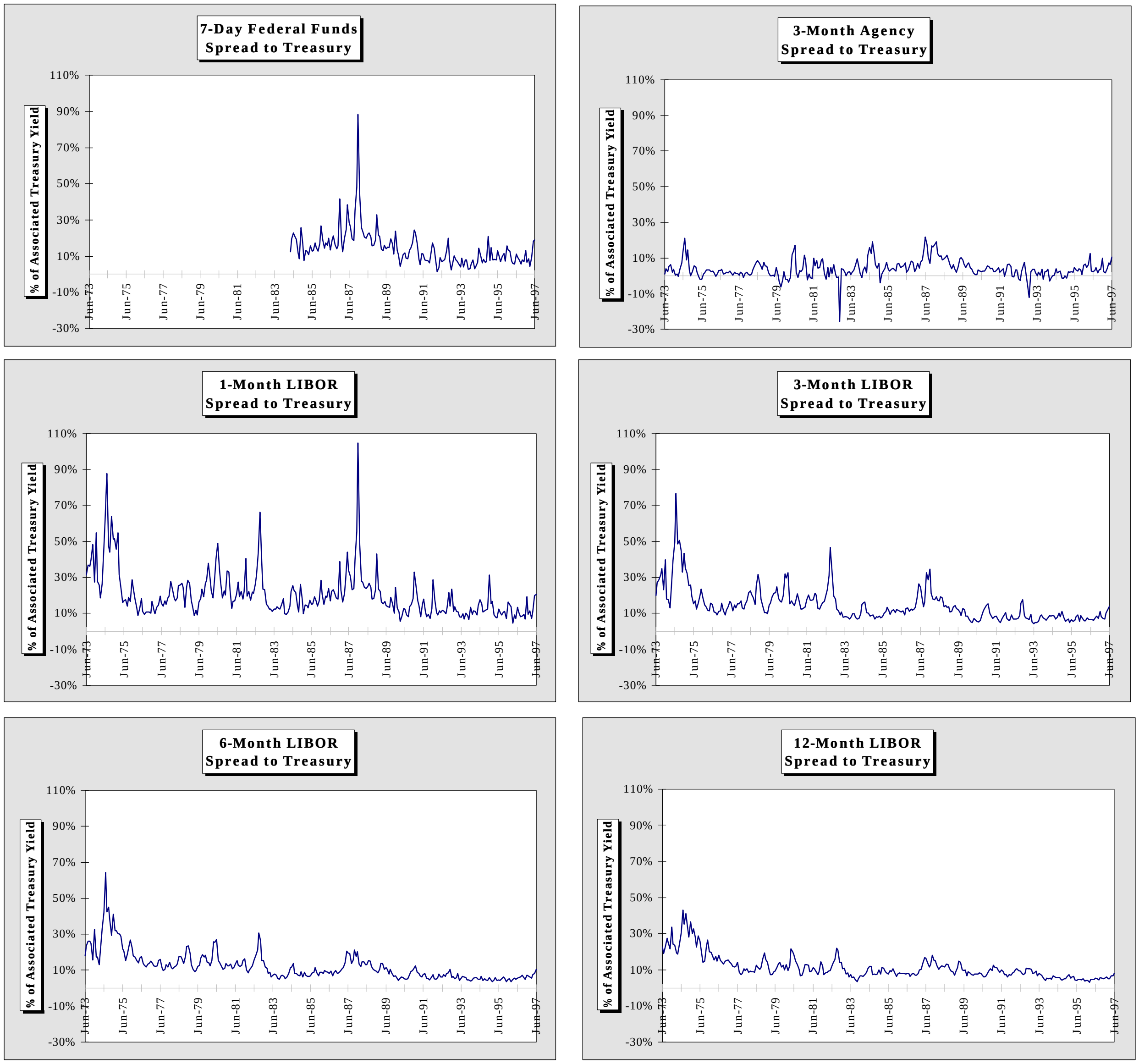
First-difference models

NPR2 models six of the 19 non-Treasury spreads using first-difference ARIMA models. However, the historical data suggest that the proposed first-difference form is inconsistent with the general historical behavior of each of the six spreads.

[30] Among the 19 interest rates, there are 14 different functional forms.

The historical data for each of the six spreads are shown in Figure 4 (below).

Figure 4: Spreads Modeled Using First-Difference Models, June 1973 to June 1997



The spreads have remained within a relatively narrow range, a property inconsistent with first-difference models.

As shown by the graphs in Figure 4, each of the six spreads has maintained a reasonably well-defined average and range, especially in recent years. Even the occasional spikes in these series tend to reverse out; after a sharp increase or decrease, the spreads display a tendency to revert back to more “normal” levels.

This reversion tendency displayed by the data is antithetical to first-difference models. One of the defining characteristics of a first-difference model is that it will tend not to revert to any particular value or range.

The most common first-difference model is the simple "random walk." In a random walk, the variable changes in level from one period to the next solely as a result of a random shock that is unrelated to the level of the variable. The historical levels and movements of the variable are of no use in determining the next change in the variable in a random walk, so the behavior of the variable will be no more predictable than the random staggering of an inebriated person. For example, one data series that might be modeled appropriately as a random walk is the minute-by-minute price of a heavily traded stock over the course of a day.

Other first-difference models will share many of the same traits as a random walk.[31] Over time, a true first-difference model will display no average (*i.e*., no statistical mean) or preferred range of values. For any true first-difference model, there is no such thing as a "normal" level.[32]

The absence of an average causes forecasts of first-difference models to be extremely volatile and imprecise. The forecasts are made by extrapolating the variable's recent movements (or, in the case of a simple random walk, the variable's most recent level) far into the future. These extrapolations are not balanced by any notion that certain levels (or ranges) are more likely than any others.

By choosing the first-difference form for these six non-Treasury spreads, the ARIMA models in NPR2 ignore important information (*i.e*., the stability and range-bounded nature of the spreads) that is critical to producing a forecast that is consistent with historical data. As a result, forecasts of these spreads using NPR2's ARIMA models will be extremely imprecise and volatile, and could be inconsistent with reasonable expectations.[33]

To estimate the imprecision and volatility of the first-difference models, we performed the estimation and forecasting procedures prescribed by NPR2 (including both the re-estimation of coefficients and the forecast of rates for the ensuing 120 months) for each month from January 1978 to June 1997. We then isolated the long-term forecast (*i.e*., the forecast for the 120th month following the month for which the procedures were performed) made of each non-Treasury spread that is modeled in NPR2 using a first-difference model.

We compared these long-term forecasts to the actual spreads that were ultimately realized 10 years after each forecast month. For each of the six models, we then calculated the root

[31] First difference models are also used to model variables that exhibit a "deterministic drift," such as an upward time trend (such as the monthly levels of stock indexes such as the Dow-Jones Industrial Average) or a downward time trend. However, the first-difference models in NPR2 do not include a trend component; therefore this discussion excludes first-difference models with trends.

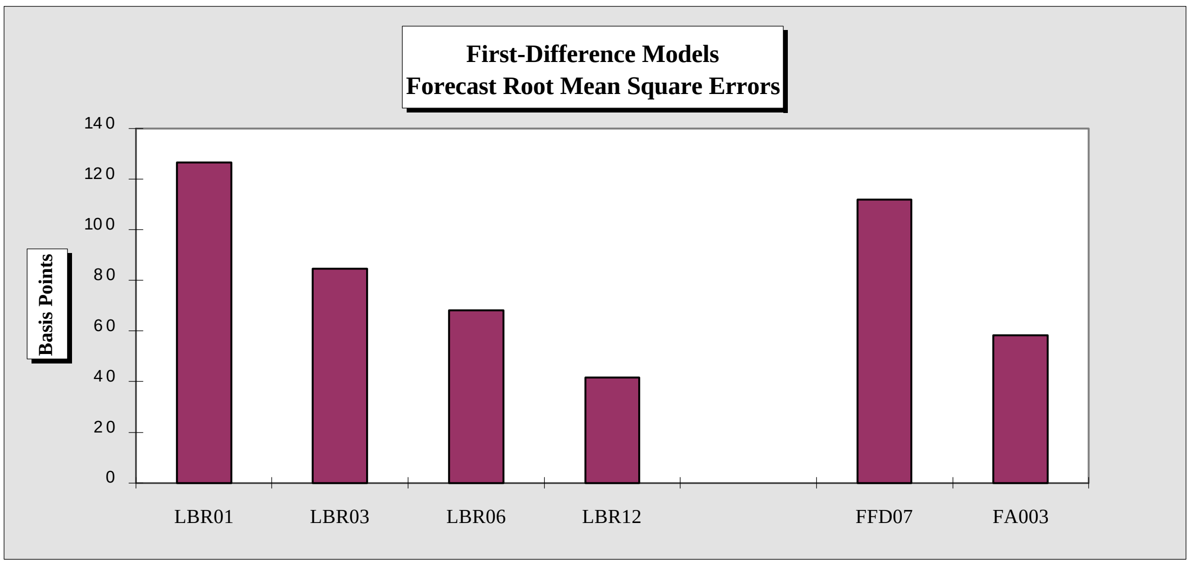
[32] In statistical terms, all first-difference models are "non-stationary"; they have no unconditional mean, and an undefined (*i.e*., infinite) unconditional variance.

[33] The extent of the forecasting problems in any given stress test will be determined by the coefficients of the first-difference model. Because NPR2 calls for the ARIMA coefficients to be re-estimated each quarter, it is not possible to use the coefficients from any one stress test to quantify a theoretical range of possible problems in future stress tests.

mean square error (RMSE) of the forecasts.[34] The RMSE is an estimate of the average absolute difference between the forecasted spread and the actual spread. Using results from statistics, we can say that approximately 30 percent of the time, the absolute forecast error will be *at least* as large as the RMSE.[35]

Figure 5 charts the RMSEs obtained for each of the first-difference spreads, expressed in basis points.[36] The high levels of the RMSEs suggest that the projections of the ARIMA models are extremely imprecise. For example, the 120 basis point RMSE for the one-month LIBOR spread (LBR01) implies that the long-term forecast will be wrong by at least 120 basis points in nearly a third of all forecasts made using the ARIMA model in NPR2, even when the corresponding Treasury rate is forecasted correctly.

Figure 5: Long-Term Forecast Imprecision – First-Difference Models



High forecast errors demonstrate the imprecision of the first-difference models.

As a measure of volatility, Figure 6 (below) shows the standard deviation of the one-month changes in the long-term spread forecasts. The standard deviation measures the extent to which the long-term forecast will (on average) change as a result of adding a single month's value for the spread. As with RMSEs, statistical methods suggest that

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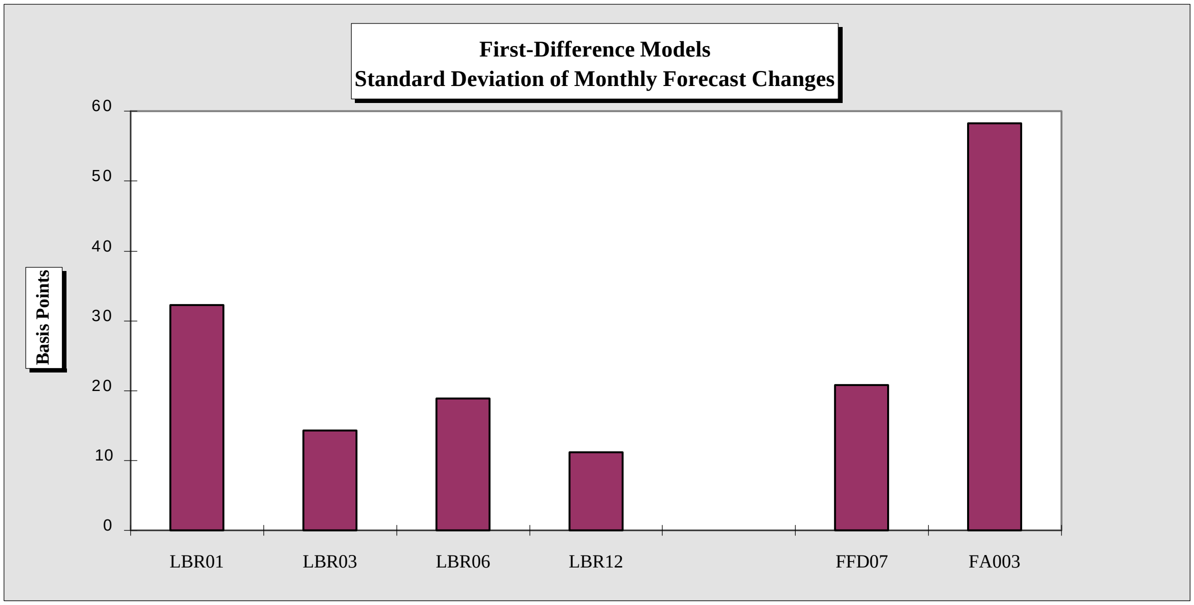
[34] Because of the need to compare to actual data 10 years after the forecast, only the forecasts made between January 1978 and June 1987 were used in this comparison.

[35] Mathematically, the RMSE is calculated as the square root of the average squared difference between the 10-year-ahead forecast made in a given month and the actual spread that was ultimately realized 10 years later. Assuming that the forecast errors are normally distributed with a mean of zero, 31.7 percent of all forecast errors will be larger (in absolute value) than the RMSE.

[36] Because the ARIMA models measure spreads as a percent of the comparable Treasury yield, the calculated RMSEs are technically stated as percents of the Treasury yields. In Figure 5 (and for subsequent figures), the RMSE's have been displayed in basis points, using the Treasury rate (11.44 percent for all maturities) that was used in the up-rate path in OFHEO's stress test for the second quarter of 1997.

approximately 30 percent of the time, the monthly change in the forecast will be *at least* as large (in absolute value) as the standard deviation.[37]

Figure 6: Long-Term Forecast Volatility – First-Difference Models



The projections of non-Treasury spreads are highly volatile month to month.

The standard deviations shown in Figure 6 indicate that the long-term forecasts of non-Treasury spreads that will be used in a stress test cannot be anticipated reliably as close as one month prior to the beginning of the stress test period. For example, the 32 basis point standard deviation shown for the one-month LIBOR indicates that in approximately 30 percent of all stress tests, the long-term LIBOR rate used in the stress test in any given month will be at least 32 basis points different from the rate that would have been expected a month before the stress test.

The imprecision of the first-difference ARIMA models in estimating stress period spreads suggests that the ARIMA models are not effectively capturing the behavior of the underlying spreads. The high volatility of the estimates from month to month indicate that this inability to capture history will result in erratic non-Treasury rate assumptions in the stress test.

Inconsistent lag structures

The lag structures of some of the proposed ARIMA models appear inconsistent with one another. It appears likely that these lag structures were influenced by spurious relationships in a data sample rather than by any reliable economic relationships – we are

[37] As with the RMSEs, this relationship is based on an assumption that the monthly forecast changes have a mean of zero and are normally distributed.

aware of no economic theory that would explain or support the differences in lag structures. Therefore, we question the appropriateness of such models for describing spread behaviors during the stress period.

For example, the two-year Agency spread is modeled as a counterintuitive function of its long-term average, its levels from one, six, and eighteen months past, a random shock in the current month, and the random shocks from five and eleven months past. By contrast, the one-year Agency spread is modeled as a simpler function of its long-term average, its level in the previous month, and a random shock that occurs in the current month. As a result, the proposed independent models for the one-year and two-year spreads can imply behavior of the inter-rate spread that differs from its economically relevant historical patterns.

5) NPR2's ARIMA models are sensitive to software choices; forecasted rates are overly sensitive to small differences in techniques buried in the software

The ARIMA models are unstable in the sense that seemingly immaterial differences in statistical procedures can generate material differences in the forecast results. Time-series literature includes many books and articles detailing alternative sets of assumptions and methods that can be used to estimate ARIMA models.[38] For example, estimation of ARIMA models requires assumptions on how to treat missing variables, assumptions as to which periods to include in the estimation sample, and assumptions on how to disentangle rate movements during the sample period that may represent the lingering effect of shocks that occurred before the sample period.[39] No single estimation method is universally preferred as correct.

This abundance of techniques is reflected in statistical software; different software packages make different technical assumptions, each resulting in different estimates and forecasts of a given ARIMA model. For example, the software packages EViews and SAS – both of which are well accepted econometric packages – differ in their assumptions about how to handle missing data and how to represent the lingering effect of shocks that occurred before the sample period.

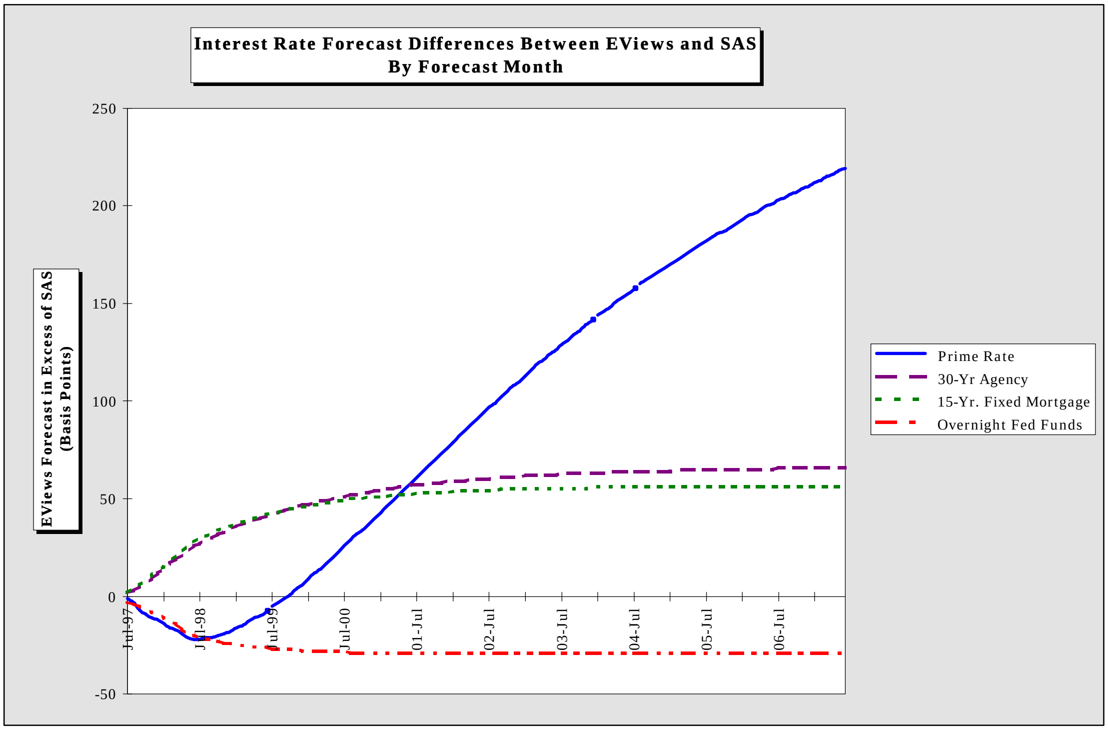
Freddie Mac found that these software packages gave significantly different forecasts of non-Treasury rates. The largest forecast differences between the two software packages

[38] See, *e.g.*, *Time Series: Theory and Methods* by Peter J. Brockwell and Richard A. Davis (1991), p. 273 (discussing a sample of different techniques used with ARIMA models).

[39] As OFHEO points out in NPR2, shocks to an ARIMA model are persistent; they affect the value of the variable not only in the period in which the shock occurs, but also in some (or possibly *all*) future periods. See NPR2 at 18149, n.149. With a finite supply of data, the shocks in ARIMA models are unobservable; it is impossible to fully know how much of the variable's change in any given period owes to a new shock and how much owes to the persisting effect of a shock from a previous period. In particular, the modeler has *no* direct information about the shocks that occurred *before* the sample period, or how they may have influenced the path of the variable during the sample period. As a result, estimation of ARIMA models requires assumptions about how new and old shocks can be disentangled.

are graphed in Figure 7.[40] As shown, these differences were substantial. For example, EViews' forecast of the prime rate exceeded that of SAS by over 200 basis points near the end of the stress period. Neither of these software packages is "correct" or "incorrect" in its method. The material differences in estimations and forecasts between the software packages owe solely to *technical assumptions*.

Figure 7: Software-Sensitivity of Rate Forecasts, June 1997 to June 2007



Different technical assumptions embedded in different software packages can cause substantial differences in non-Treasury interest rate forecasts.

Thus, stress test results using the ARIMA models would depend on technical assumptions as well as economic assumptions. While OFHEO might be able to document the many relevant technical assumptions, this sensitivity to those assumptions suggests that a stress test using ARIMA models may not capture the economically relevant risks faced by the Enterprises and would not reliably relate capital to risk.

[40] The differences shown pertain to the up-rate path for the stress test of the second quarter of 1997.

b) The ARIMA models cannot be incorporated readily into a system for forecasting capital requirements and managing capital

The weaknesses of the ARIMA models demonstrate that the models do not adequately capture historical behavior of non-Treasury spreads. Models that do not capture historical behavior tend to do a poor job forecasting future rates. The forecasts are likely to be unstable and erratic for reasons unrelated to economic factors.

The imprecise and erratic nature of the spread projections of the ARIMA models will cause capital requirements to be unstable. Fluctuations in capital requirements will be difficult to predict, verify, and explain – and will often result from factors not associated with the risks borne by the Enterprises.

As evidence of this general problem, we note three specific weaknesses of the ARIMA models in NPR2:

1) *Use of the ARIMA models in NPR2 leads to unstable and counterintuitive capital requirements.*

2) *Use of the ARIMA models in NPR2 makes the capital requirement overly sensitive to data discrepancies.*

3) *Use of the ARIMA models in NPR2 requires quarterly re-estimation of 19 models.*

We next discuss each of these weaknesses in detail.

1) *Use of the ARIMA models in NPR2 leads to unstable and counterintuitive capital requirements*

The use of ARIMA models in NPR2 will cause the stress test to include arbitrary gains and losses that have no discernible relationship to the Enterprises' true interest rate and mortgage credit risks. We demonstrate this with the example below.

An example

As part of our work discussed in connection with Figures 5 and 6 (above), we performed the estimation and forecasting procedures prescribed in NPR2 (including re-estimating the ARIMA coefficients) with data through May 1997 and compared the results to those of the same procedures using data through June 1997 (the data used for the stress test of the second quarter of 1997).

We found that forecasted stress test interest rates from May to June moved in the opposite direction of actual rate movements over the same period. Specifically, the projected long-term six-month Agency rate *decreased* 14 basis points relative to the six-month LIBOR rate in the up-rate scenario between May and June. By contrast, the *actual* six-month Agency rate *increased* by 29 basis points relative to the six-month LIBOR between May and June.[41]

To understand the importance of such fluctuations, suppose that an Enterprise funds its activities by issuing $10 billion of 6-month debt that it reissues every six months. To hedge its refunding risk, the Enterprise enters into pay-fixed, receive-floating swaps with notional value of $10 billion, and with the floating rate tied to the six-month LIBOR rate.

With this funding strategy, the 14-basis-point decline in the projected long-term Agency-LIBOR spread would *increase* the Enterprise's projected net annual after-tax cash flows by $9 million; the approximate effect on the stress test would be to decrease the Enterprise's required capital by $64 million.[42] By contrast, an uninformed extrapolation of the 29-basis-point increase in the actual rates between May and June 1997 would have led a forecaster to expect a $19 million *decrease* in the Enterprise's projected annual cash flows, for an approximate stress test result of a $133 million increase in required capital. Thus, the forecaster would have underestimated annual cash flows by $28 million and overestimated the capital requirement by $198 million.

These results suggest that the stress test would not effectively relate capital to risk – the $198 million difference in capital requirements has no apparent relationship to any changes in risk. Moreover, the volatility of the capital requirement to such monthly changes in spreads and the inability to forecast these changes before the close of a quarter would unduly complicate the management of capital.

2) *Use of the ARIMA models in NPR2 makes the capital requirement overly sensitive to data discrepancies*

The use of ARIMA models for spreads assumes that the values of the spreads are precisely measured, so that the statistical behavior of the spreads can be accurately determined. If historical data are not precise, the estimation and projection of the ARIMA models will not be reliable. Small mistakes in the data can be magnified by the ARIMA models – especially in the first-difference models, where small changes can be compounded into the future.

The need for precision is not satisfied by available historical interest rate data. As discussed above (see footnote 41), we found instances in which DRI's historical data differed as much as 29 basis points from the six-month Agency-LIBOR inter-rate spread

[41] Not all data sources agree that actual rates moved so dramatically. See footnote 19 and accompanying text.

[42] In this example, after-tax cash flows are estimated by multiplying the relative interest rate change (0.14 percent or 0.29 percent) by the notional value, and subtracting taxes at a 35 percent marginal rate. Effects on the capital requirement are estimated as the present value of a nine-year annuity of the after-tax cash flows, using a discount rate of 11.44 percent (matching the Treasury rate from the up-rate path of the stress test for the second quarter of 1997), plus the 30 percent add-on for management and operations risk.

data of other sources. These discrepancies, when used with ARIMA models, can translate into differences in the capital requirement of hundreds of millions of dollars.

Such differences among data sources are common for securities that are not heavily traded every day. When trading in a security is light, rates observed in trade data will be volatile. Different data sources are likely to obtain different estimates of the rate on any given day, and rates are likely to change significantly from day to day as a result of "noise" rather than from any economically relevant change in interest rates. In projecting future rates, ARIMA models can propagate the noise to future periods, thereby hindering the precision and stability of the capital requirement.

3) Use of the ARIMA models in NPR2 requires quarterly re-estimation of 19 models

NPR2 requires that the coefficients of each ARIMA model are to be re-estimated every quarter. This need to re-estimate coefficients each quarter is inconsistent with a belief that the ARIMA models capture the essential behavior of rates. If one cannot be reasonably certain that any given coefficients will be stable for more than one quarter, one must doubt the ability of those coefficients to describe spread behaviors 10 years into the future. Moreover, in the absence of any theoretical justification for chosen lag structures, it is not clear why one would expect the *coefficients* to change while the *lag structure* does not.

In addition, re-estimating the models every quarter would increase the time required to generate quarterly stress test results. The time needed to perform and verify each estimation would consume scarce resources of both OFHEO and the Enterprises that are better employed at monitoring and managing risk. Further, any instability in stress test results that is induced by the re-estimation would further complicate the process of verifying and explaining capital requirements.

c) The ARIMA models in NPR2 cause significant uncertainty regarding the modeling of new indices – which will hamper innovation by the Enterprises

Using the ARIMA models in NPR2, if Freddie Mac were to introduce a product that referenced a non-Treasury rate not currently included in OFHEO's list of ARIMA models, we would be unable to gauge the effect on regulatory capital requirements until OFHEO studied and published the lag structure for the new rate's ARIMA model. Moreover, use of the ARIMA models in NPR2 would require OFHEO to commence a rulemaking procedure to amend its capital rules to add a new rate. Further, distortions in stress test results (such as the false gains or losses that could result from the ARIMA models' lack of attention to inter-rate spreads) would skew evaluation of innovations – in instruments, rates or techniques – discouraging otherwise beneficial innovation to the detriment of Freddie Mac's service to homeowners and renters.

3. Recommendations

Rather than relying on the ARIMA models in NPR2, Freddie Mac suggests that OFHEO assume, for each of the last nine years of the stress period, that each non-Treasury spread equals its average value over the two years immediately preceding the start of the stress period. During the first year of the stress period, the spreads would be modeled as moving from their initial (actual) values to their historical two-year averages on a straight line basis.[43]

Despite its simplicity, the averaging approach is superior to the ARIMA models in meeting the 1992 Act requirement for consistency and in capturing *qualitatively* the essential historical behaviors of spreads. For example, the averaging approach would preserve historical inter-rate spread relationships – when individual rates' spreads are set to their historical averages, inter-rate spreads automatically would be set to their own historical average (as a percent of the comparable Treasury rate). The averaging approach would be less susceptible to distortions caused by changes in behaviors over time; data from old, irrelevant regimes preceding the most recent two years would not enter into calculations, and therefore would not influence the assessment of stress test spreads.

In addition, the averaging method appears at least as precise as the ARIMA models in capturing *quantitatively* the historical behavior of spreads. For example, as shown in Figure 8, the averaging method is at least as precise as the ARIMA models when used to forecast most spreads 10 years into the future.

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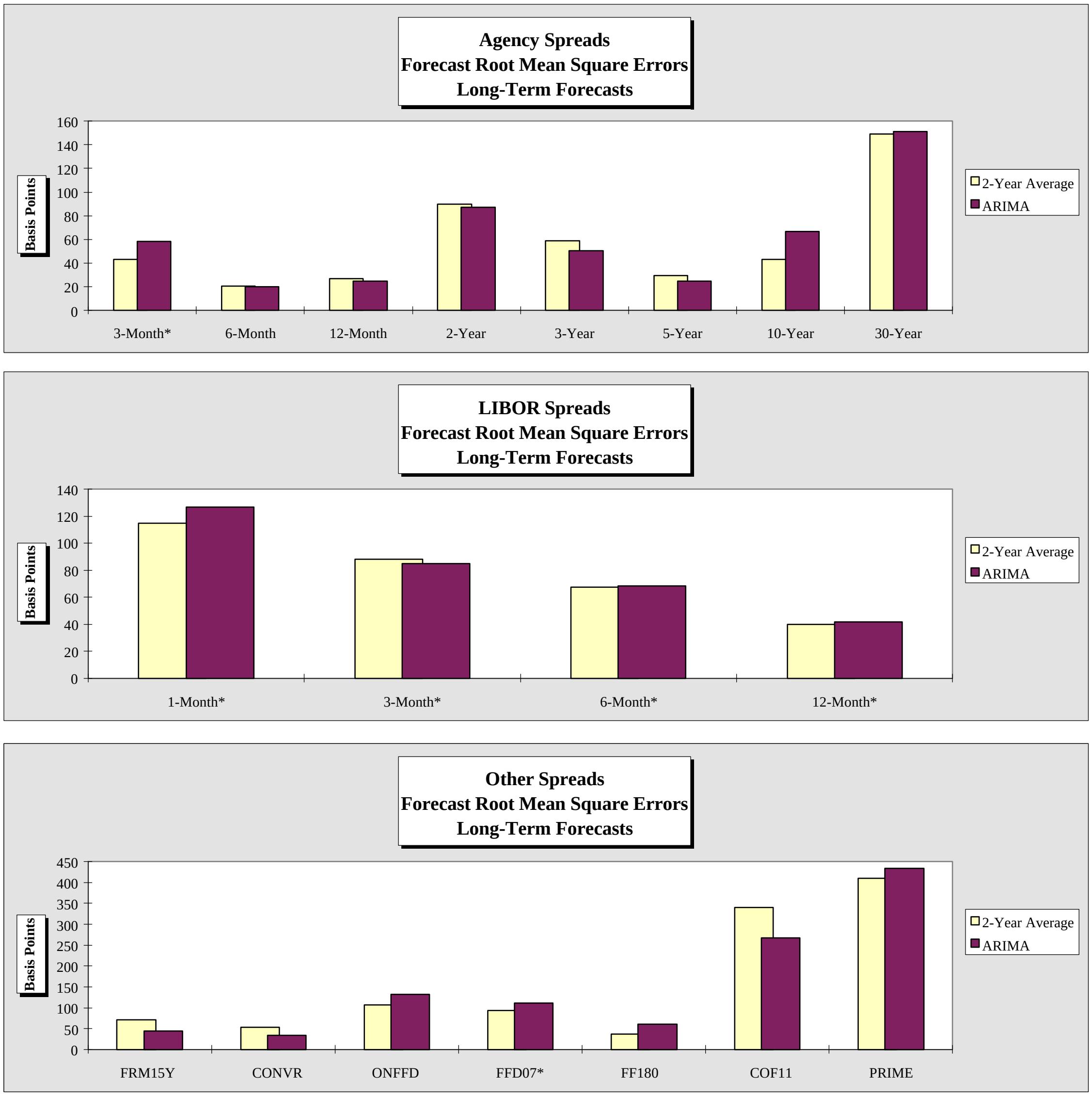
[43] We believe that the two-year averaging method is preferable to two alternative methods also considered by Freddie Mac. One approach that would be similar to the two-year averaging method – but slightly more complicated – is exponential weighting of historical spread percentages, with the same weights used for each non-Treasury spread series. Exponential weighting, which puts greater weight on more recent experience when computing the average, is an accepted technique used in risk-management models in Wall Street firms. Like the simple two-year average proposed above, exponential weighting would preserve historical interrelationships among the non-Treasury securities and maturities, as long as the weights were uniform across securities. However, the use of exponential weights is more complicated than the use of simple averages, and there is no theory or other evidence to suggest that weights can be chosen that are superior to the weights used in averaging. Thus, the simple two-year average approach appears preferable to exponential weighting.

One approach to mitigating the distortion of relationships among rates would be to *increase* complexity by estimating all 19 non-Treasury spreads jointly as a vector autoregressive (VAR) model. However, this approach would require estimation of far more parameters than is feasible using available interest rate data. (For example, the covariance matrix for a VAR model of 19 variables would have 190 distinct elements.) At the same time, the VAR approach could be even more sensitive to the choice of estimation software and assumptions, and would be just as inflexible in dealing with changes in rate behaviors as the ARIMA methods of NPR2. Renowned econometrician Arnold Zellner has pointedly observed that "…complicated VARs (*v*ery *a*wful *r*egressions) have not been very successful in explanation and prediction." *Journal of Economic Perspectives*, Vol. 13, No. 2, Spring 1999, p. 234. Because of these problems, VAR methods would not be appropriate for non-Treasury rates.

Figure 8: Long-Term Forecast Precision of Two-Year Average vs. ARIMA



Asterisks (*) denote first-difference ARIMA models

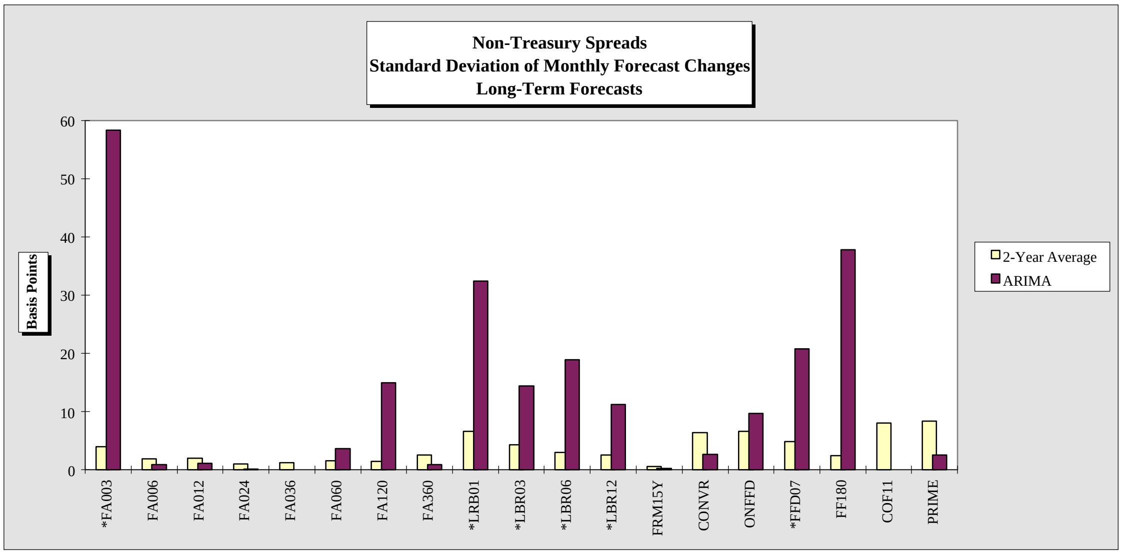
A forecast based on a two-year average has precision comparable to a forecast based on the ARIMA models.

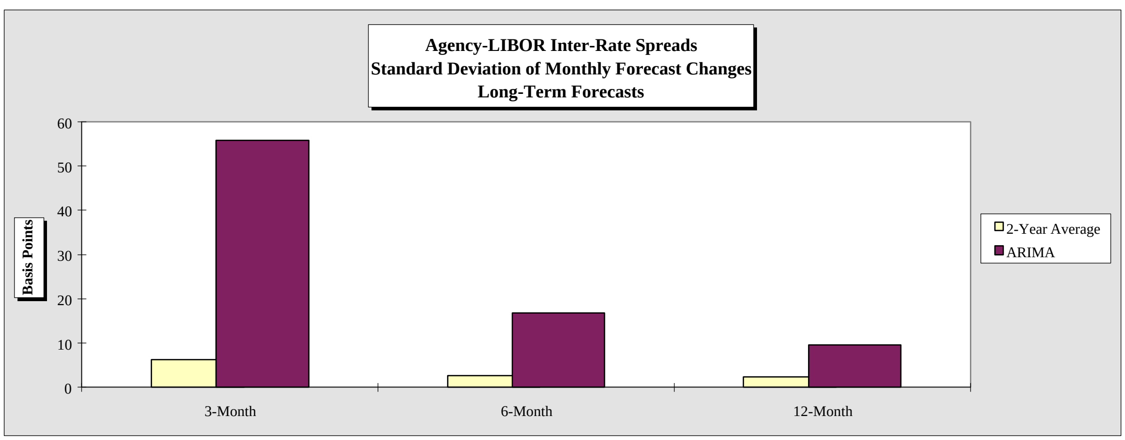
In each of the three charts in Figure 8, the bars represent the root mean square error (RMSE) for the ARIMA models proposed in NPR2 and the 2-year averaging method proposed here. These RMSEs are calculated using the same procedures presented in the discussion of Figure 5 (page 21).

Note in Figure 8 that the two-year averaging method generally performs as well or better than the ARIMA models in forecasting non-Treasury rates. This forecasting performance suggests the simple averaging method captures the essential historical behavior of spreads at least as well as do the more complex (and difficult) ARIMA models.

Finally, the averaging method would be considerably more stable than the ARIMA models used in NPR2. This is demonstrated in Figure 9 (below), which compares the forecast stability of the two-year averaging method and the ARIMA models. In each of the three charts in Figure 9, the bars represent the standard deviations of the one-month changes in spread predictions for both forecast methods, for each non-Treasury spread variable modeled in NPR2. These standard deviations are calculated using the same procedures as were presented in the discussion of Figure 6 (page 22).

Figure 9: Long-Term Forecast Volatility – Two-Year Averaging vs. ARIMA





Asterisks (*) denote first-difference ARIMA models

A forecast based on a two-year average has substantially lower volatility than a forecast based on the ARIMA models, resulting in a more predictable capital requirement that is more closely tied to risk.

As shown, the two-year averaging method consistently has a much lower standard deviation in its monthly changes than do the NPR2 ARIMA models. The advantages of the averaging method apply both to the non-Treasury rates (the top chart of Figure 9) and inter-rate spreads (such as the Agency-LIBOR spreads, shown in the bottom chart of Figure 9). As a result, the averaging method will be less susceptible to erratic changes based on a single month's data, and will generate forecasts that can be more readily forecasted, verified, and explained by both OFHEO and the Enterprises.

Further, stress test results under the averaging method would be less affected by erratic fluctuations caused by technical modeling assumptions than under the ARIMA models, and therefore would more closely link capital to risk. In addition, OFHEO and the Enterprises could better forecast capital requirements for each quarter, and could more readily verify and explain stress test results.

Finally, this simple averaging approach clearly would be easier and less costly to implement – for OFHEO and for the Enterprises. It would, for example, remove the need to perform and verify complex re-estimations of the 19 ARIMA models in each stress test. It also would reduce OFHEO's burden of documenting the specific statistical software and technical assumptions necessary for the ARIMA estimations. The averaging approach also would accommodate innovation; new rates could be introduced by the Enterprises without waiting for OFHEO to develop or use an ARIMA model to estimate the new rate's spread – or for amendment of the capital rule. The simplicity of the averaging approach also would be more consistent with the simple and intuitive estimates of the Treasury yield curves.

Thus, as summarized in Table 3 (below), the simpler two-year averaging approach would surpass the use of ARIMA models in meeting the objectives of a capital requirement.

Table 3: Comparison of the Averaging and ARIMA Methods

Objectives	Two-Year Averaging Method	ARIMA Method
Most consistent with the Act	✓	
Best ties capital to risk	✓	
Most readily implemented	✓	
Best accommodates innovation	✓	

4. Summary

We disagree strongly with NPR2's use of ARIMA models because we believe they would result in erratic capital requirements that were not sufficiently tied to historical rate behavior or the actual risks of the Enterprises. Moreover, the extraordinary complexity of the ARIMA models would hinder implementation of the capital rule and impede innovation by the Enterprises.

In lieu of the ARIMA models used in NPR2, we recommend that OFHEO project non-Treasury rates over the stress period based on a rolling average of spreads that existed over the two years immediately before the beginning of the stress period. The averaging approach captures historical relationships at least as well as the ARIMA models while better satisfying the four objectives.

IV. CONCLUSION

We applaud OFHEO's focus on historical data as the basis for setting non-Treasury spreads in the stress test. At the same time, we strongly disagree with the use of ARIMA models in NPR2 to project stress period spreads; we believe that rate projections based on two-year rolling averages of non-Treasury spreads would alleviate the significant problems noted with NPR2's ARIMA models.

Our comments in this response are preliminary and limited. Freddie Mac intends to respond to NRP2 in its entirety in a later submission. To the extent that any of our subsequent comments are inconsistent with these preliminary comments, our subsequent comments will supersede these preliminary comments.

APPENDIX 3

"The Yield Curve and Proposed Stress Tests for Freddie Mac"

John Y. Campbell and Analysis Group/Economics

1998

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May 5, 1998

BY FEDERAL EXPRESS

Devajyoti Ghose, Ph.D.
Freddie Mac
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Dear Doc:

Enclosed please find our completed report on the implications of the proposed interest rate stress tests for Freddie Mac for the shape of the yield curve. Our report is rather detailed and presents the results of statistical and econometric investigations using a number of different approaches. The alternative models all produce similar results, indicating that our conclusions reliably interpret the patterns in the actual data. If we were to select a single model to illustrate our findings, we would rely on the vector autoregression (VAR) based on the entire sample of data from 1952 to 1997. These results are summarized in Exhibit 25 of the report.

In Exhibit 25(a) it is seen that even a shock of nearly 500 basis points in the 10 year CMT, which reflects our simulation of the stress test as of mid-1997, has only modest implications for the shape of the yield curve. In particular, the spread between the 10 year CMT and the 3 month CMT narrows by about 90 basis points in the first year but then rapidly reverts to its long run average. We note that the standard deviation of the spread historically has also been about 100 basis points, so that the predicted narrowing of the spread in response to the stress test is of a magnitude that is well within historical norms. That is, while the stress test will likely result in short-run changes in spreads, the effect is hardly distinguishable from the numerous other economic forces that routinely affect the shape of the yield curve.

It has been a pleasure working with you on this highly interesting project. We look forward to another opportunity to assist Freddie Mac in matters involving economic and financial analysis.

Sincerely,

John Y. Campbell
Otto Eckstein Professor of Applied Economics
Harvard University

The Yield Curve and Proposed Stress Tests for Freddie Mac

by

John Y. Campbell
Harvard University

and

Analysis Group/Economics

May 1998

1. Introduction

This report presents our analysis of the yield curve in relation to the "stress test" scenarios specified in the statutory risk-based capital provision that will, when implemented by OFHEO, apply to Freddie Mac and Fannie Mae.[1] The stress tests focus on the 10 year constant maturity Treasury yield (CMT) over a 10 year period, where in each case there is a large shock to the yield within the first year, followed by 9 more years with the yield held fixed at its new level. The scenarios are complex, based on formulas involving:

- 600 basis points plus the average 10-year CMT during the preceding 9 months;
- 160 percent of the average 10-year CMT during the preceding 3 years;
- the average 10-year CMT during the preceding 9 months minus 600 basis points;
- 60 percent of the average 10-year CMT during the preceding 3 years.

We have developed a number of economic models to assess the expected effect on the yield curve of alternative interest rate scenarios set forth in the statute. The models can be used to predict changes in short and medium term rates, given these scenarios, that are consistent with economic theory and consistent with historical data (the scenarios are, of course, well outside of historical experience). We use alternative approaches to modeling the term structure in order to provide cross-checks on the reliability of our results.

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[1] The scenarios are specified in the Federal House Enterprises Safety and Soundness Act of 1992, Sec. 1361 (12 U.S.C. Sec. 4611).

In particular, our analysis quantifies the extent of "overshooting." Overshooting occurs if the short rate moves in the direction of the long rate but with greater magnitude. Equivalently, overshooting occurs if a) the long-short spread changes due to the stress test shock; and b) the direction of the change has opposite sign of the shock. For example, overshooting with a positive shock means that the short rate increases by more than the long rate, so that the spread decreases. "Undershooting" with a positive shock is the case where the spread widens, so that the short rate increases by less than the long rate.

To understand our approach to analyzing the stress test, consider the change in the short rate (ΔYS) associated with a change in the long rate (ΔYL). A natural measure of the magnitude of this relationship is the regression coefficient of ΔYS on ΔYL, defined as

$$b = corr(\Delta YS, \Delta YL)\frac{s\,(\Delta YS)}{s\,(\Delta YL)}\ .$$

That is, β is equal to the correlation between ΔYS and ΔYL multiplied by the ratio of their volatilities. Given a particular ΔYL, a β of unity corresponds to no change in the spread, whereas $\beta>1$ and $\beta<1$ indicate overshooting and undershooting, respectively.

Overshooting is effectively determined by the magnitude of the correlation between ΔYS and ΔYL. This follows because the ratio of the volatilities is generally accepted to be greater than one. If the correlation is sufficiently close to unity then β also has to be greater than one. On the other hand, as the correlation declines then β also declines, and can fall to one or below.

Our modeling approaches can be viewed as alternative methodologies to measure β based on different ways of estimating the correlation. We first use regression methods, both in a contemporaneous (static) framework and a vector-autoregressive (dynamic) framework. We then use a two-factor term structure model. Each approach allows the data to determine the correlation in an internally consistent manner. In particular, no *a priori* constraint is placed on the magnitude of the correlation.

The report is organized as follows. Section 2 discusses the behavior of long and short interest rates over the period 1952–1997, comparing the behavior of levels, changes, and spreads and analyzing the frequency of changes in rates of different magnitudes. Section 3 presents the results of models based on regression analysis of the data, using both single-equation and multi-equation methods. Section 4 explains a two-factor theoretical model of the term structure and presents estimation results based on the Kalman filter. Section 5 summarizes our conclusions. Separate technical appendices discuss the models and estimation procedures in greater detail.

2. Overview of the Yield Curve, 1952-1997

In order to gain familiarity with the historical behavior of the yield curve, this section focuses on the relevant long rate, the 10 year CMT (hereinafter “YL”), and a representative short rate, taken here to be the yield on 3 month Treasury bills (hereinafter “YS”). Exhibit 1 shows these two series on a quarterly basis over the period 1952:1 to 1997:3.[2] While the movements in the series are irregular, both short and long rates had a gradual upward tendency until the 1970s. Following the 1973 OPEC oil shock the short rate spiked briefly, while the long rate remained roughly steady. After the October 1979 change in Federal Reserve policy under Paul Volcker, both rates soared and remained high until a second change in policy in mid-1982. The subsequent years on balance have been a period of declining rates, and since 1993 both short and long rates have remained at levels similar to the early 1970s.

At different times the yield curve may be upward sloping (a “normal” yield curve), downward sloping (“inverted”), or humped in a variety of patterns. Exhibit 2 shows the difference between YL and YS (hereinafter the “LS spread”), which summarizes the general shape of the yield curve. For most of the data the normal case prevailed, where the long rate was higher than the short rate and the LS spread was positive . However, there have been periods, notably at the time of the first OPEC shock and during the Volcker policy, when the yield curve was inverted.

Changes in interest rates have essentially random sign. That is, an increase in the rate from one period to the next is as likely to be followed by a decrease as by a further increase. Exhibit 3 shows the quarterly changes in YL and Exhibit 4 shows the quarterly changes in YS. The randomness in the direction of the change each period is apparent for both series. It is also clear that changes in the T-bill yield on average are larger than changes in the 10 year CMT. The data therefore demonstrate the important fact that short rates are more volatile than long rates.

Exhibit 5 presents sample statistics that summarize the historical behavior of long and short rates over the full sample period. The exhibit also shows the sample statistics obtained by breaking out the “Volcker period,” defined as 1980:1–1982:4, from the rest of the data. This break-out shows that interest rates during the Volcker period were unusual in a number of ways. The average levels were approximately double the levels for the rest of the data and the yield curve on average was nearly inverted, with an average spread for our maturities of only 13 basis points. More important for interest rate modeling, however, is the structure of the *changes* in YL and YS. The volatility of interest rates, as measured by the standard deviation of the rate changes, increased dramatically — by a factor of 3 for YL and by nearly a factor of 6 for YS. It is also relevant to consider the correlation of the changes in YL and changes in YS. This correlation also increased substantially during the Volcker period, from 0.53 to 0.83.

Exhibit 6 depicts the quarterly data for the entire sample. The points plotted as open triangles correspond to the Volcker period and further illustrate the noisiness of the data from that time.

Exhibit 7 provides information on the likelihood of the scenarios envisaged in the stress tests. The exhibit shows the frequency distribution for quarterly changes in YL using the entire sample of data. The sample probability of a quarterly move in YL of 150 basis points or more is approximately 1.6 percent. An annual move of 600 basis points, for example, therefore requires a sequence of moves, with a joint probability that is clearly far below 1.6 percent. Indeed, the magnitude of the largest annual change in YL, using all 4-quarter differences in the complete sample (535 observations), is only 412 basis points.

Exhibits 8(a)–(b) contains an analysis of yield curve inversion. For the full sample, the yield curve was inverted for approximately 11 percent of the observations. We also used the full sample to model the LS spread as a first-order autoregressive (“AR(1)”)

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[2] This sample period therefore avoids the World War II “accord” between the Federal Reserve and the Treasury, under which interest rates were pegged until 1951.

process. Simulating the model over a long horizon produced negative spreads, i.e., inversions, approximately 15 percent of the time. Inversion can also be characterized in terms of duration. Empirically, the average duration of an inversion has been approximately 2.9 quarters. The simulations of the AR(1) model resulted in a slightly shorter average duration of 2.4 quarters.

3. Regression Models of the Term Structure

In this section we use regression analysis to investigate empirically how short rates react to a shock to long rates. The first models involve contemporaneous regressions that measure the extent to which shocks to the long rate are reflected immediately in short rates. We then use vector autoregressions ("VARs") to jointly model the dynamic behavior of long and short rates, taking into account shocks to both long and short rates and the structure of the lags that determine the evolution of the system.

Our analysis of Treasury yields indicates that the levels are non-stationary. On the other hand, changes in yields are stationary. Yield spreads, including the LS spread, are stationary because levels of yields are cointegrated.[3] The implication for our models is that regressions involving yields should be specified using ΔYS and ΔYL, where Δ is the first difference operator. Spreads, however, are not transformed. We assume that changes in yields have zero long-run trends, implying that a) a regression with change in yield as the dependent variable should not include an intercept term and b) spreads should be de-meaned for use in the regressions.

We check the robustness of our regression results using a variety of methods. Given the increase in interest-rate volatility in the Volcker period, we estimate our models using ordinary least squares ("OLS"), weighted least squares ("WLS"), and GARCH(1,1) regression. In addition, we estimate the models using OLS over a reduced sample that excludes the Volcker period.

[3] See Campbell and Shiller (1987) for a detailed discussion of cointegration and interest rates. Other researchers who have reported stationary processes for Treasury yields nonetheless generally find near unit-roots and borderline non-stationarity (see Ait-Sahalia, 1986; Chan, Karolyi, Longstaff, and Sanders, 1992; Jones, 1997). The assumption of non-stationarity in these cases remains a reasonable approximation.

3.1. Contemporaneous Regression Models

The contemporaneous regressions analyze the effect of ΔYL on ΔYS. We examine alternative models using both quarterly and annual differences of the data.. Overlapping differences are used in the annual regressions to maximize the number of observations. The estimated equations are therefore all of the form

$$YS_t - YS_{t-k} = b\,(YL_t - YL_{t-k}) + e_t$$

where k is equal to either 1 or 4, corresponding to quarterly and annual regressions, respectively. Consistent standard errors are calculated for all estimated coefficients to allow for any induced serial correlation and possible heteroskedasticity.

Exhibit 9 summarizes the contemporaneous regression results. Considering first the OLS results over the full sample, the point estimates fall from an effect of 1.19 over one quarter to 1.07 over one year. While suggestive of some overshooting, neither coefficient is statistically different from unity at any conventional significance level. The WLS results, weighting by the square root of YS lagged one period, rise slightly from a coefficient of 1.15 over a quarter to 1.18 over a year. Again, however, the coefficients do not appear to be significantly different from unity. The GARCH(1,1) results show a different pattern, indicating undershooting over a quarter (coefficient of 0.65) but overshooting over a year (coefficient of 1.20). In addition, the GARCH estimates are significantly different from unity, but in different directions at the different horizons. Omitting the Volcker years has a striking effect, in that OLS on the reduced sample shows statistically significant undershooting over a quarter (coefficient of 0.77), that persists but is no longer significant by one year (coefficient of 0.96).

Economic theory predicts a coefficient of 1, i.e., no overshooting, in the long-run. The contemporaneous regression results bracket this value at both one quarter and one year horizons. Moreover, the deviations from unity in these results are generally statistically insignificant, as well as small in magnitude. Our conclusion from this analysis is that shocks to the long rate are passed along essentially one-for-one to short rates.

3.2. VAR Analysis

Vector autoregressions are standard tools in the analysis of multivariate economic time series. The use of VARs was first advocated by Sims (1980). Since then, they have been widely used in macroeconomics and finance (see, for example, Bernanke (1986), Campbell (1991, 1996), Watson (1994) for a recent survey, and Hamilton (1994) for a textbook treatment). The main advantage of this approach is that the dynamic relationships among the variables and their evolution over time can be estimated without having to impose strong prior restrictions. In particular, one can avoid making any a priori assumptions regarding which variables are exogenous and which are endogenous.

The estimated VAR system can be used to analyze the effect of a shock. In this case, we construct impulse response functions to examine the time paths of YS and YL in response to an initial shock to the long yield.

We specify the VAR using ΔYL and the LS spread. This specification exploits the cointegration of YL and YS to achieve efficient estimates.[4] We orthogonalize the system by placing ΔYL first in the ordering so that we can calculate the effect of a shock to ΔYL on the dynamic behavior of LS. The system can be written as

$$\Delta YL_t = b_{11}\Delta YL_{t-1} + b_{12} LS_{t-1} + e_{1t}$$
$$LS_t = b_{21}\Delta YL_{t-1} + b_{22} LS_{t-1} + r\hat{e}_{1t} + e_{2t}\,.$$

The use of one lag for each variable in the estimated systems is justified empirically by two alternative test procedures, the Schwarz Information Criterion ("SBC") and the Hannan-Quinn Information Criterion ("HQIC"). We specify each test, allowing the possible lag lengths to range from zero to four periods. The results of each test indicate that a lag length of one is best supported by the data.

Exhibit 10 shows the estimation results using quarterly data. The model is estimated by OLS, WLS, and GARCH methods. WLS estimates are produced using two alternative weighting schemes. The first scheme uses the square root of YS lagged one period. The second scheme uses the lagged square root of the GARCH variances

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[4] We also performed the analysis using ΔYS in place of LS in the VAR, and find that our results are robust to this change in specification.

estimated by the contemporaneous regression. In addition, the OLS estimation is carried out using the full sample and a reduced sample that excludes the Volcker period.

The own lag in the equation for ΔYL is not significant in any of the results, consistent with the hypothesis that YL is a univariate random walk. The coefficient on lagged LS in the equation for ΔYL is negative in all cases, indicating some predictability in ΔYL. This is consistent with other results in the term structure literature (see Campbell, Lo, and McKinlay, 1997, chap. 10). The OLS, GARCH, and GARCH-weighted WLS results all indicate positive contemporaneous correlation, which implies initial undershooting. The YS-weighted WLS results, however, yield a negative correlation and imply initial overshooting. The coefficient on the own lag in the equation for LS is consistently positive, which indicates a gradual adjustment of the spread back to its long run mean. However, the coefficient of ΔYL in the equation for LS is negative, an this produces overshooting after 1 period in all cases except OLS on the full sample.

We construct impulse-response functions for YL and YS implied by each estimated system. The impulse response functions order the ΔYL equation first, to focus on the effects of shocks to the long rate. Predicted levels of YL are obtained by summing the simulated values of ΔYL over the relevant horizon and adding the cumulative change to the starting value. Predicted levels for YS are then calculated as the predicted level of YL minus the simulated LS spread.

The positive shock under the statute is analyzed as follows. The current (1997:3) level of YL is 6.52 percent. The average of YL over the preceding 9 months, denoted YL_9, is 6.48 percent. The average of YL over the preceding 3 years, denoted YL_{36}, is 6.70 percent. The magnitude of the shock under the statute is therefore 482 basis points, calculated as

$$\mathrm{MIN}(\mathrm{MAX}(6.48 + 6.00,\ 1.6(6.70)),\ 1.75(6.48)) - 6.52 = 11.34 - 6.52.$$

Because the statute specifies that YL increases over the first year to its post-shock level, we shock the equation for ΔYL by 120.5 basis points (482 divided by 4) for each of the first 4 quarters of the simulation period.

Median predicted levels of YL and YS and confidence intervals for YS are obtained by "bootstrapping" the simulation 500 times.[5] The resulting time paths of YL and YS are plotted in Exhibits 11(a)–(e). The median paths indicate the median values for each period generated by the bootstrapped impulse response functions out to the forecast horizon. The confidence intervals show the 97.5 and 2.5 percentiles for each period for the values of YS generated by the bootstrap.

We analyze the negative shock case similarly. The magnitude of the shock is 329 basis points, calculated as

$$6.52 - \mathrm{MAX}(\mathrm{MIN}(6.48 - 6, 0.6(6.70)), 0.5(6.48)) = 6.52 - 3.23.$$

We shock the equation for ΔYL by –82 basis points (329 divided by 4) for each of the first 4 quarters of the simulation period. As before, median paths and confidence intervals are obtained by bootstrapping. The resulting time paths of YL and YS are plotted in Exhibits 12(a)–(e).

The impulse responses generated by the alternative VAR models for each shock are similar. They indicate a modest amount of overshooting that begins to dissipate after one year. For example, using the OLS full-sample model in the positive shock case, the median simulated spread declines from 122 basis points initially to 32 basis points by the fourth quarter, and rises gradually thereafter back to its historical average. There is no inversion of the yield curve using the median forecasts. The OLS full-sample model in the negative shock case yields a median simulated spread that rises to 183 basis points by quarter 4, and then returns gradually to the average. Qualitatively, the positive and negative shock cases are identical, with responses that differ only as a result of the magnitude of the assumed shock.

4. A Homoskedastic Two-Factor Term Structure Model

4.1. The Stress Test in the Context of One-Factor and Two-Factor Models

One-factor models, where the factor is the short term interest rate, are the oldest and most simple complete models of the term structure (Vasicek (1977); Cox, Ingersoll

[5] The confidence intervals are calculated using the bootstrap procedure described in Runkle (1987).

and Ross (1985)). These models have several well-known properties that limit their usefulness in analyzing the stress test. In particular, they are based on the assumption that short and long rates are perfectly correlated. Moreover, since short rates are more volatile than long rates, these models also imply that a shock to the long rate is always accompanied by an even larger shock to the short rate in the same direction.

Use of such one-factor models to model the stress test necessarily results in a prediction of large overshooting. For example, Exhibit 5 showed that for the entire dataset the standard deviation of annual changes in the short rate is 1.88 times the standard deviation of annual changes in the long rate. With a permanent positive shock to the long rate as proposed in the stress test, i.e., approximately 500 basis points, a one-factor model requires the short rate to increase by 942 basis points so that the long-short spread narrows by 442 basis points. Given that the historical average spread between long and short rates is approximately 100 basis points, the result must be a highly inverted yield curve.

The assumption of perfectly correlated changes in long and short rates is counterfactual. For the sample periods that we study, the correlation between changes in long and short rates range from 0.63 (1952.1-1997.3) to only 0.51 (1952.1-1979.4 and 1983.1-1997.3). Thus, the restrictions implied by one-factor models are inappropriate for analyzing the large shocks contemplated under the stress test.

Two-factor models have become increasingly popular in the academic literature as a more general methodology for modeling the term structure (for example, Longstaff and Schwartz (1992), Balduzzi, Das and Foresi (1995), Dai and Singleton (1997). Riskless bonds of different maturities are assumed to be close substitutes with very little idiosyncratic risk. Two-factor models are typically based on a “short run” state variable and a “long run” state variable, with the former driving most of the variation at the short end of the yield curve and the latter driving most of the variation at the longer end of the yield curve. Thus, the factors produce independent variation in long and short rates that can generate an imperfect correlation between changes in long and short rates. Two-factor models can therefore produce a much wider range of outcomes in response to the stress test. These models can produce undershooting or modest overshooting rather than the extreme overshooting and inversion implied by one-factor models.

In this section, we propose a two-factor homoskedastic term structure model. The specification of this model is very similar to Longstaff and Schwartz (1992), although we impose the simpler restriction of constant variances.[6] Unlike Longstaff and Schwartz, however, we specify the model in discrete time and allow correlation between the two factors. The short run, or transitory, factor in our model is interpreted as the driver of the real term structure, and it is proxied by the short term real interest rate. The long run, or persistent, factor is expected inflation. The nominal term structure is therefore driven by both factors, i.e., real interest rates and expected inflation. Most of the variation at the short end of the term structure is driven by the transitory factor, while most of the variation in long rates is driven by the persistent component.

In the two-factor approach, the stress test is best interpreted as a shock to the persistent factor of expected inflation. In the following sections, we develop our term structure model, explain the estimation methodology, and present the results of the estimation and analysis of the stress test.

4.2. Model Specification

The proposed model falls in the class of affine yield models - in other words, nominal bond prices and yields are linear or affine functions of the two factors. The model is specified in discrete time. We begin by specifying a single-factor affine model for the real term structure. The implied model for the nominal term structure has two factors.

The first step is to specify a process for the real log stochastic discount factor or pricing kernel. The stochastic discount factor determines the risk premia or expected returns on all assets--in particular, the expected return on any asset is negatively related to its covariance with the stochastic discount factor. In models with utility maximizing investors, the stochastic discount factor measures the marginal utility of investors. Assets whose returns covary positively with the stochastic discount factor deliver wealth when

[6] This assumption can be relaxed most easily by assuming that the level of one of the factors affects volatility. If both factors are allowed to affect volatility, however, the model is no longer linear.

consumption or wealth is low (the marginal utility of consumption is high). These assets have insurance value since they deliver wealth when it is most valuable to investors. Consequently, investors are willing to pay high prices or accept negative risk premia on these assets. Conversely, assets which covary negatively with the stochastic discount factor are risky and require positive risk premia by investors. Appendix 1 shows how the real stochastic discount factor is used to price real bonds.

The current real bond price can be expressed as the expected product of future real discount factors out to the maturity date of the bond. Thus, the real term structure model can be specified completely by specifying a time series process for the real stochastic discount factor. Nominal bonds can be priced by focusing on the covariance between nominal returns and the log nominal stochastic discount factor. This is accomplished by specifying a process for inflation and by using it in conjunction with the process for the real stochastic discount factor.[7]

The process for the real stochastic discount factor is specified in equation (1). The state variable relevant for forecasting the log real stochastic discount factor, m_{t+1}, is the proxy for the real interest rate, x_t.

(1) $$-m_{t+1} = x_t + v_{m,t+1}$$

The process for inflation is specified in equation (2). The rate of inflation, p_{t+1}, has an expected component, z_t, and an unexpected component, $v_{p,t+1}$. The expected component, as mentioned before, is one of the state variables in the model.

(2) $$p_{t+1} = z_t + v_{p,t+1}$$

We assume that the two state variables, x_t and z_t, follow univariate AR(1) processes with rates of mean reversion $1-f_x$ and $1-f_z$ and long-run means m_x and m_z respectively. The processes for x_t and z_t are specified in equations (3) and (4) below:

(3) $$x_{t+1} = (1-f_x)m_x + f_x x_t + u_{x,t+1}$$

(4) $$z_{t+1} = (1-f_z)m_z + f_z z_t + u_{z,t+1}$$

[7] As Appendix 2 shows (equation A.2.3), the nominal log stochastic discount factor is equal to the log real stochastic discount factor minus the rate of inflation.

We next assume that shocks to the two factors are correlated - this correlation is explicitly expressed in equation (5).

(5) $$u_{z,t+1} = b_{zx} u_{x,t+1} + e_{z,t+1}$$

In equation (6) below, the unforecastable component of the stochastic discount factor is expressed as a function of orthogonal innovations to the state variables and an uncorrelated shock.

(6) $$v_{m,t+1} = b_{mx} u_{x,t+1} + b_{mz} e_{z,t+1} + e_{m,t+1}$$

Finally, in equation (7) below, unexpected inflation is also a function of the same innovations to the state variables as in equation (6) and an uncorrelated shock.

(7) $$v_{p,t+1} = b_{px} u_{x,t+1} + b_{pz} e_{z,t+1} + e_{p,t+1}$$

In the equations above, the pairs of coefficients b_{mx}, b_{px} and b_{mz}, b_{pz} tell us about the risk premia attributable to the two factors. The factor z_t accounts for the inflation risk premium. Consider the case where the sum of b_{mx} and b_{px}, and b_{mz} and b_{pz} respectively, are positive. A positive shock to x_{t+1} and z_{t+1} lowers nominal bond prices and returns[8], while the parameters imply a negative shock to the nominal stochastic discount factor, $m^{\$}_{t+1}$.[9] Thus, bond returns are positively correlated with the stochastic discount factor. The bonds provide hedge value and therefore bond risk premia are negative. Since bond risk premia are, in reality, positive, we expect the sums of b_{mx} and b_{px}, and b_{mz} and b_{pz} to be negative.

The following additional assumptions are made about the error terms in the model:

(8a) $$E_t(u_{x,t+1}) = E_t(e_{z,t+1}) = E_t(e_{m,t+1}) = E_t(e_{p,t+1}) = 0$$

(8b) $$Var_t(e_{z,t+1}) = s_z^2,\ Var_t(e_{m,t+1}) = s_m^2 \text{ and } Var_t(e_{p,t+1}) = s_p^2$$

(8c) $$Cov_t(u_{x,t+1}, e_{z,t+1}) = Cov_t(u_{x,t+1}, e_{m,t+1}) = Cov_t(e_{z,t+1}, e_{m,t+1}) = 0$$

(8d) $$Cov_t(u_{x,t+1}, e_{p,t+1}) = Cov_t(e_{p,t+1}, e_{m,t+1}) = Cov_t(e_{z,t+1}, e_{p,t+1}) = 0$$

8 See bond pricing equation (A.2.5) in Appendix 2.
9 From equation (A.2.3) in Appendix 2 and equations (1), (2), (6) and (7) above.

The assumption of homoskedasticity is implicit in (8b) while the orthogonality of the shocks u_x, e_z, e_m and e_p is seen from (8c) and (8d). In this model, $Var_t(e_{m,t+1}) = s_m^2$ is not identified and consequently, one can arbitrarily set it to zero in the estimation process.

Once the model specification is complete, it is possible to solve for both real and nominal bond prices and yields. Appendix 1 provides the details of deriving the pricing equations for the real term structure model. The nominal bond pricing equations are set out in Appendix 2. One of the important results from Appendix 1 is that the unobserved factor x_t can be proxied by the one period real interest rate -- this can be seen from equation (A.1.4). The bond pricing equations also confirm that real bond prices and yields are affine functions of the real interest rate (or the state variable x_t) and nominal bond yields are affine functions of both the real interest rate (x_t) and expected inflation (z_t). Thus, the shape of the term structure over time is determined by the behavior over time of the unobserved state variables. The restrictions implied by the nominal bond pricing equations are imposed in the estimation process.

4.3. Estimation Methodology and Stress Test Design

4.3.1. The Kalman Filter Approach

We estimate the two-factor model of the U.S. nominal term structure with a Kalman filter. As noted earlier, the two-factor model is specified in terms of two unobserved state variables, whose behavior over time determines the shape of the nominal term structure. While the state variables cannot be observed, we do observe bond yields and the rate of inflation. While the bond pricing equations are exact, the estimation procedure assumes that bond yields are measured with error. The Kalman filter is a standard methodology for inferring the time series behavior of the state variables, conditional on the observed sample.[10] In our estimation process, we employ the conditional joint density of four observed yields (the 3-month rate, the 1-year rate, the 5-year rate and the 10-year rate) and the rate of inflation. The Kalman filter permits recursive computation of the likelihood function, so that maximum likelihood is the natural

[10] See Harvey (1989, 1993) and Gong and Remolona (1996a, 1996b,1996c).

estimation method to use. In addition, we impose the bond pricing equations from Appendix 2 (Equation (A.2.6)).

One of the advantages of the Kalman filter procedure is that it attempts to fit the model to the data at each point in time rather than simply reproduce the average cross-sectional shape of the term structure. This is particularly useful for the pricing of individual instruments. In addition, the methodology readily lends itself to an analysis of the experiment in the stress test.

In order to implement the Kalman filter, it is necessary to explicitly specify the evolution through time of the state variables (the “transition” equations) and to express the time series behavior of the observed variables in terms of the state variables (the “measurement” equations). In this application, the four yields and the rate of inflation as affine functions of the factors serve as the measurement equations and the factors' stochastic processes serve as the transition equations. The nominal bond pricing equations determine the parameters of the measurement equations. The measurement errors in the bond pricing equations are determined by the data. Details of the specification of the measurement and transition equations are provided in Appendix 3.

Another way to use the Kalman filter is to use it to back out the time series behavior of the two factors for the actual sample. In this model, this implies being able to infer the time series behavior of expected inflation and the real interest rate. In addition, one can infer the paths implied by the theoretical model for nominal yields of all maturities.

4.3.2. Implementation of the Stress Test

The Kalman filter provides a natural framework for implementing the stress test. For illustrative purposes, consider the positive shock of 482 basis points to the long rate as specified in the stress test. This shock occurs during the first year of the stress test and we assume that the long rate goes up by 120.5 basis points each quarter during this year. Thereafter, that is, for the next nine years, it remains constant. This can be interpreted within the context of the model as a path resulting from a series of shocks to the long rate. We consider a hypothetical sample in which the only measured variable is the long rate and it follows the path specified in the stress test.[11] One can then ask what is the most likely path for the underlying state variables and the implied path for the short rate, given the model parameters estimated from the historical data. The Kalman filter can be used to infer the paths for the state variables, conditional on the observed full sample rather than predicting and updating as each data point becomes available.[12] The long and short rates are assumed to start off from their "current" rates. As in Section 3, these are the rates at the beginning of the third quarter of 1997.

4.4. Results from Estimation and Stress Test

4.4.1. Estimation Results

Results from estimating the model using maximum likelihood are presented in Exhibit 13. We present results for both the full sample period of 1952.1-1997.3 and the sample excluding the Volcker period of 1980.1 to 1982.4.

The parameter estimates for f_x and f_z for both sample periods indicate that the expected inflation process is highly persistent, while the process for the short term real interest rate has a much higher rate of mean reversion. In particular, for the full sample (sample excluding the Volcker period), the expected inflation process z_t, reverts to its fixed mean at the rate of 0.15% (0.24%) per quarter while the second factor, x_t, reverts at the rate of 11.27% (13.11%) per quarter. This implies a half-life of 112.1 years (71.7 years) for the expected inflation process and a half-life of only 1.45 years (1.23 years) for the real interest rate process. These parameters are also highly statistically significant.

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[11] Thus, while the state transition equations for this problem are identical to those in the estimation process for the actual sample, the measurement equation now only has a single observed variable. This model, with the ten year yield as the single measured variable is simpler to implement because the errors in the transition and measurement equations are no longer correlated. In Appendix 3, we show that in the estimation of the two-factor model, the errors in the transition and measurement equations are correlated, and this correlation is attributable to including inflation as one of the measured variables.

[12] This is implemented by applying the smoothing algorithm of the Kalman filter after the recursions in the prediction and updating equations in the Kalman filter have been performed. For details on the smoothing algorithm and the prediction and updating recursions, see Harvey (1993), Chapter 4, pp. 85-87. The smoothing algorithm is also used to back out the time series behavior of the two factors for the actual sample. In other words, we condition on the full sample of four observed yields and the rate of inflation, rather than predict and update as each observation becomes available.

The estimates for the standard deviations of the two factors show that the transitory factor is also more volatile (0.23% (0.18%) versus 0.12% per quarter).

The estimate for the parameter b_{zx}, the covariance between x_t and z_t, is significantly different for the two sample periods. It is negative (-0.22) and significantly different from zero for the sample excluding the Volcker period and positive and insignificant for the full sample. This result has important implications for the response of the short rate in the stress test. In particular, we will see that the difference in the estimate for b_{zx} for the two samples produces different paths for the short rate in response to the shock to the long rate proposed in the stress test.

Both b_{mx} and b_{mz} are negative for the two samples. They are statistically significant for the sample excluding the Volcker period. b_{px} and b_{pz} are significant and positive for both samples. The model attributes positive risk premia to both factors and a larger risk premium to the less persistent factor. A positive shock to x_{t+1} and z_{t+1} lowers nominal bond prices and returns, while the sum of b_{mx} and b_{px}, b_{mz} and b_{pz} is negative, implying a positive shock to the stochastic discount factor, $m_{t+1}^{\$}$. Thus, bond returns are negatively correlated with the stochastic discount factor and have positive risk premia.

4.4.2. Goodness of Fit

Exhibits 14(a)–(b) and 15(a)–(b) compare the theoretical versus actual sample paths of the 3-month yield and the 10-year yield for the two sample periods. The theoretical paths are inferred from the paths for the state variables and the coefficients in the bond pricing equations. These exhibits indicate that the model does remarkably well in replicating the time series behavior of yields. Exhibit 16 reports numerical measures of the model's fit for these and other maturities: 6-month, 1-year, 2-year and 5-year yields. Note that the 6-month and 2-year yields are not employed in the estimation process as measured variables. The model is able to fit the long bond yield very well because of the smoothness of the yield curve at longer maturities. In fact, the maximum likelihood procedure makes the variance of the measurement error for the 10-year yield zero, so that the correlation between the theoretical and sample paths is 1 for both the level and the change in the long yield. On the other hand, the shorter end of the yield curve exhibits richer movements that are harder to replicate using any simple term structure model. Even for the 3-month yield, however, the correlation between theoretical and sample yields is very high at 0.99. The lowest correlation is that between changes in actual and theoretical 3-month yields (0.90 for the full sample and 0.88 for the sample excluding the Volcker period). All other correlations are greater than 0.96.

In addition to reproducing the historical path for the nominal short term rate, the term structure model traces the behavior of the short term real interest rate and expected inflation for the two sample periods (Exhibits 17 and 18). Both the nominal rate and expected inflation were exceptionally high during the 1982-1985 period. The short term real rate was negative during 1992-1994 and was in the 0%-4% range for the remainder of the full sample period.

The cross sectional behavior of the term structure can be examined by studying the unconditional moments of the data. Exhibits 19 and 20 compare the unconditional moments for excess returns and yield spreads implied by the theoretical model with the sample for the full sample period and subsample respectively. The model captures the curvature of the term structure very well, although it does tend to underestimate its average slope. The term structure is upward sloping and the discrepancy between the average yield spread implied by the model and the sample is 17 (20) basis points on average across all maturities for the full sample (sample excluding the Volcker period).

Mean excess returns for the sample are an increasing function of maturity up to 5 years, after which they start to fall. Except for the 6-month maturity, the model overestimates mean excess returns, which, moreover, rise monotonically with maturity. For the sample periods that we consider, both average yield spreads and average excess returns are affected by the fact that interest rates rose on average during the sample. Such behavior cannot persist in the long-run, but it may drive average excess returns down and average yield spreads up in a particular finite sample. Given the unusual rise in interest rates, it may be appropriate to rely on the estimates produced by the theoretical model.

4.4.3. Results of Stress Test Implementation

Exhibits 21(a)–(b) show the paths of the nominal rates and the spread from the proposed permanent positive 482 basis point shock and negative 329 basis point shock for model fitted to the entire dataset. Exhibits 22(a)–(b) plot the corresponding sample paths for expected inflation and the real short term rate. Exhibits 23(a)–(b) and 24(a)–(b) show the corresponding results for the model that excludes the Volcker period.

Consider the positive shock to the long rate. From the point of view of the stress test, the permanent increase in the long rate has to be "justified" by the behavior of the long-run or permanent factor driving the term structure. Both Exhibits 22(a) and 24(a) confirm the relationship between the shock to the long rate and expected inflation: expected inflation jumps with the increase in the long rate and stays at a permanently higher level thereafter. For the full sample, the real short rate also rises initially, before decreasing to its new long-run value. The initial increase reflects the positive covariance between x_t and z_t (parameter b_{zx}) for the full sample. On the other hand, for the sample excluding the Volcker period, the real short rate shows a small decrease initially, reflecting the negative covariance between x_t and z_t.

Exhibit 21(a) shows that for the full sample, the nominal short-term rate overshoots and produces a temporary inversion from the third quarter through the ninth quarter. The initial spread is 122 basis points. At the peak of the inversion at the end of the fourth quarter the spread is –81 basis points, after which it begins to climb to a long-run value of 68 basis points. Thus, in this model there is a permanent narrowing of the spread as a result of the shock. For the sample excluding the Volcker period there is no inversion. In fact, the short rate undershoots till the end of the first year, after which the spread begins to narrow to its long-run value of about 65 basis points.

The overshooting result for the full sample and undershooting for the sample excluding the Volcker period (for at least the end of the first year) can be understood in terms of the correlations between changes in short rates and long rates produced by the theoretical model (Exhibit 16). For the full sample, the correlation produced by the term structure model (0.77) is higher than that for the subsample (0.64). Moreover, they are both higher than the sample correlations (0.63 and 0.53 respectively). While our two-factor model does produce less than perfect correlations between movements in short and long rates, so that overshooting is not guaranteed as in a single-factor model, the number of factors is nevertheless insufficient to bring down the correlations to that observed in the sample. We also note that the positive correlation between x_t and z_t for the full sample amplifies the greater volatility of the short rate relative to the long rate. On the other hand, the negative correlation between the state variables for the subsample dampens the greater volatility of the short rate so that it does not produce an inversion in the yield curve.

For the full sample, the negative shock of 329 basis points produces initial overshooting but permanent undershooting. The spread widens for the first four quarters and starts narrowing subsequently, to 99 basis points, at the end of the adjustment period. For the subsample, however, the negative shock produces both immediate and permanent undershooting.

The long-run narrowing of the spread in response to a positive shock can be explained in terms of the expectations hypothesis imposed by the model. Even though the long rate is moving to a permanently higher level when there is a positive shock as proposed in the stress test, market participants keep expecting the long rate to fall since, although persistent, the process for it is not a random walk. This implies capital gains from holding long-term bonds. In equilibrium, market participants must be indifferent between short and long bonds and consequently, short rates must rise.

5. Conclusion

This report analyzes the implications of the stress test for the shape of the yield curve using three alternative econometric approaches. The first approach estimates contemporaneous regressions of the change in the 3 month Treasury yield on the change in the 10-year CMT yield, using data at both the quarterly and annual level. The second approach uses quarterly vector autoregressions and associated impulse response functions to estimate changes in 3 month and 10-year yields given the stress test shocks. The third approach uses a two-factor term structure model and applies the stress test shock to the 10 year yield.

Exhibits 25(a)–(b) summarize the results of the regression models at different horizons. Both the contemporaneous models and the VAR models are estimated using OLS, WLS, and GARCH(1,1) procedures and are estimated both with and without data from the Volcker period. The positive stress test shock, calibrated to market conditions as of 1997:3, is 482 basis points. The negative shock is –329 basis points. The initial spread is 122 basis points.

The contemporaneous regressions predict either overshooting or undershooting over a horizon of one quarter, depending on the estimation method and sample period. For the positive shock case, the results range from overshooting of 23 basis points to undershooting of 42 basis points. Over a horizon of one year, the models estimated using the full sample predict overshooting ranging from 34 to 96 basis points for the positive shock case. With the Volcker period omitted, the model predicts undershooting of 19 basis points in response to the same shock. The contemporaneous models do not predict inversion.

The VAR results also show a mixture of overshooting and undershooting over a horizon of one quarter. For the positive shock case, the results range from overshooting of 32 basis points to undershooting of 22 basis points. Over a horizon of one year, each of the VAR models predicts overshooting. Using the positive shock case as a benchmark, the overshooting ranges from 33 to 124 basis points, depending on the equation specification. Each VAR also predicts a gradual return of the spread to the historical average. By year 4 the maximum overshooting in these results falls to 31 basis points. One WLS specification predicts a transitory negative spread, but the inversion is only 2 basis points at the one year horizon. The other VAR models do not predict inversion.

Exhibit 26 presents the predictions from the term structure model. Using the entire sample, the results for the positive shock predict overshooting of 203 basis points, sufficient to cause an inversion of 81 basis points, at the one year horizon. The overshooting diminishes to 83 basis points by year 4, so that the spread is again positive. The full-sample negative shock case also results in overshooting over the entire simulation horizon but by year 4 the effect is only 6 basis points. Omitting the Volcker period, the results for the positive shock are undershooting of 4 basis points at the one year horizon, followed by overshooting of 41 basis points by year 4. The corresponding negative shock case is rather persistent undershooting of approximately 20 to 30 basis points out to year 4.

The term structure model also allows us to estimate the effects of the stress test scenarios on the short-term real interest rate and the expected inflation rate. In all cases the movements of the nominal short-term interest rate are dominated by the movements of the expected inflation rate. The movements of the real interest rate are smaller and less persistent. In the model estimated over the full sample the real interest rate and expected inflation move in the same direction, rising in response to a positive shock and falling in response to a negative shock. In the model estimated over a sample that excludes the Volcker period, the real interest rate briefly moves opposite to expected inflation, falling in response to a positive shock and rising in response to a negative shock. These results are summarized in Exhibit 26.

Our findings regarding the likely magnitude of overshooting in response to the stress test do not depend meaningfully on the initial level of the 10 year CMT. The data indicate that the influence of this effect is at most a few basis points in the LS spread. On the other hand, the amount of overshooting is proportional to the size of the stress test shock. For example, a 600 basis point shock induces a change in the LS spread that is twice as big compared to a 300 basis point shock.

The three methodologies produce estimated spread changes, consistent with economic theory and historical data, with magnitudes that seldom exceed 100 basis points, or about one standard deviation of the spread. In particular, only two of our analyses produce yield curve inversions, with magnitudes of 81 basis points in one case and 2 basis points in the other. Our analysis therefore suggests that the large stress test shocks have rather modest implications for the shape of the yield curve.

Appendix 1

Pricing Equations for Real Bonds

In order to derive the bond pricing equations, one starts from the no-arbitrage restriction common to intertemporal asset pricing models. For an n-period zero coupon real bond, this condition can be written as:

(A.1.1) $$P_{nt} = E_t[P_{n-1,t+1} M_{t+1}]$$

where, M_{t+1} is the real stochastic discount factor or pricing kernel. This condition expresses the price of the bond as the expected discounted value of the bond's next period price. No-arbitrage is obtained by applying the same stochastic discount factor to all bonds. Solving equation (A1.1) forward, one obtains:

(A.1.1)' $$P_{nt} = E_t[M_{t+1} M_{t+2} \ldots\ldots M_{t+n}]$$

Equations (A.1.1) and (A.1.1)' show that one can model P_{nt} by modeling the stochastic process for M_{t+1}.

In order to specify a model in the affine yield class, it is necessary to assume that M_{t+1} is conditionally lognormal and that bond prices and the stochastic discount factor are conditionally joint lognormal. One can then take logs of (A.1.1) to obtain:

(A.1.2) $$p_{nt} = E_t[m_{t+1} + p_{n-1,t+1}] + (1/2)Var_t[m_{t+1} + p_{n-1,t+1}]$$

This equation forms the basis for deriving the bond pricing equations. For example, the price of a one-period real bond is obtained by noting that when $n = 1$, $p_{n-1,t+1} = p_{0,t+1} = 0$ [13] so that equation (A.1.2) implies:

(A.1.3) $$y_{1,t} = -p_{1,t} = -E_t[m_{t+1}] - (1/2)Var_t[m_{t+1}]$$

One can use equation (A.1.3) above in conjunction with equations (1) and (6) in the model to solve for the one period real bond yield. This is given by:

(A.1.4) $$\begin{aligned} y_{1,t} = -p_{1,t} &= -E_t[m_{t+1}] - (1/2)Var_t[m_{t+1}] \\ &= x_t - (1/2)(b_{mx}^2 \sigma_x^2 + b_{mz}^2 \sigma_z^2 + \sigma_m^2) \end{aligned}$$

[13] This is obtained by equating the bond's price at maturity to its par value, normalized to unity ($P_{0,t} = 1$).

The price of an n-period real bond can be obtained by using the solution for the one period yield to guess the affine price function:

(A.1.5) $$-p_{n,t} = A_n + B_n x_t$$

The coefficients A_n and B_n will depend on the stochastic process for x_t. In particular, it will imply restrictions across coefficients for bond prices of different maturities, since there are fewer factors than maturities. The coefficients A_n and B_n can be obtained by solving (A.1.2) using equation (1) in the model and verifying that (A.1.5) above holds. The following restrictions hold for this model:

(A.1.6)(a) $$B_n = 1 + f_x B_{n-1} = \frac{1 - f_x^n}{1 - f_x}$$

(A.1.6)(b) $$A_n - A_{n-1} = (1 - f_x) m_x B_{n-1} - (1/2)[(b_{mx} + B_{n-1})^2 s_x^2 + b_{mz}^2 s_z^2 + s_m^2)$$

Appendix 2

Pricing Equations for Nominal Bonds

Let Q_t be the nominal price index at time t. Applying the asset pricing condition (A.1.1) to the real return on an n-period bond,

(A.2.1) $$\frac{P_{nt}^{\$}}{Q_t} = E_t[\frac{P_{n-1,t+1}^{\$}}{Q_{t+1}} M_{t+1}]$$

Multiplying through by Q_t , and defining $p_{t+1} \equiv \frac{Q_{t+1}}{Q_t}$, $M_{t+1}^{\$} \equiv \frac{M_{t+1}}{p_{t+1}}$, (A.2.1) can be written as:

(A.2.2) $$P_{nt}^{\$} = E_t[P_{n-1,t+1}^{\$} M_{t+1}^{\$}]$$

where, $M_{t+1}^{\$}$ can be interpreted as a nominal stochastic discount factor that prices nominal returns. This equation is exactly analogous to equation (A.1.1). The log nominal stochastic discount factor can now be specified as:

(A.2.3) $$m_{t+1}^{\$} = m_{t+1} - p_{t+1}$$

Proceeding as in Appendix 1, one obtains the one-period nominal yield as:

(A.2.4) $$\begin{aligned} y_{1,t}^{\$} &= -p_{1,t}^{\$} = -E_t[m_{t+1}^{\$}] - (1/2)Var_t[m_{t+1}^{\$}] \\ &= x_t + z_t - (1/2)[(b_{mx} - b_{px})^2 s_x^2 + (b_{mz} - b_{pz})^2 s_z^2 + (s_m^2 + s_p^2)] \end{aligned}$$

and the n-period bond price as

(A.2.5) $$-p_{n,t}^{\$} = A_n^{\$} + B_{1,n}^{\$} x_t + B_{2,n}^{\$} z_t$$

where

(A.2.6)(a) $$B_{1,n}^{\$} = 1 + f_x B_{1,n-1}^{\$} = \frac{1 - f_x^n}{1 - f_x}$$

(A.2.6)(b) $$B_{2,n}^{\$} = 1 + f_z B_{2,n-1}^{\$} = \frac{1 - f_z^n}{1 - f_z}$$

and

(A.2.6)(c)

$$\begin{aligned} A_n^{\$} - A_{n-1}^{\$} = {} & (1 - f_x) m_x B_{1,n-1}^{\$} + (1 - f_z) m_z B_{2,n-1}^{\$} - (1/2)(b_{mx} - b_{px} + B_{1,n-1}^{\$} + b_{zx} B_{2,n-1}^{\$})^2 s_x^2 \\ & - (1/2)(b_{mz} - b_{pz} + B_{2,n-1}^{\$})^2 s_z^2 - (1/2)(s_m^2 + s_p^2) \end{aligned}$$

and

$$A_0^{\$} = B_{1,0}^{\$} = B_{2,0}^{\$} = 0 \, .$$

Appendix 3

Measurement and Transition Equations in Kalman Filter Estimation

The state transition equations are specified as follows:

(A.3.1) $$\begin{bmatrix} x_{t+1} \\ z_{t+1} \end{bmatrix} = \begin{bmatrix} (1-f_x)m_x \\ (1-f_z)m_z \end{bmatrix} + \begin{bmatrix} f_x & 0 \\ 0 & f_z \end{bmatrix} \begin{bmatrix} x_t \\ z_t \end{bmatrix} + R \begin{bmatrix} \tilde{u}_{x,t+1} \\ \tilde{e}_{z,t+1} \end{bmatrix},$$

where

$$R = \begin{bmatrix} s_x & 0 \\ b_{zx} s_x & s_z \end{bmatrix} \text{ and}$$

$$\begin{bmatrix} u_{x,t+1} \\ u_{z,t+1} \end{bmatrix} = \begin{bmatrix} u_{x,t+1} \\ b_{zx} u_{x,t+1} + e_{z,t+1} \end{bmatrix} = \begin{bmatrix} s_x & 0 \\ b_{zx} s_x & s_z \end{bmatrix} \begin{bmatrix} \tilde{u}_{x,t+1} \\ \tilde{e}_{z,t+1} \end{bmatrix} = R\tilde{u}$$

In order to estimate the parameters using maximum likelihood, one can now assume:

$$\tilde{u} \sim NIID(0, I_2)$$

For brevity of notation, the transition equations (A.3.1) can be written as:

(A.3.1)' $$a_{t+1} = c + T a_t + R\tilde{u}_{t+1}$$

The measurement equations can be written as:

(A.3.2) $$\begin{bmatrix} p_{t+1} \\ y_{t+1} \end{bmatrix} = \begin{bmatrix} a_p \\ a_y \end{bmatrix} + \begin{bmatrix} 0 & b_p \\ b_{y1} & b_{y2} \end{bmatrix} \begin{bmatrix} x_{t+1} \\ z_{t+1} \end{bmatrix} + \begin{bmatrix} s_{11} & s_{12} & s_{13} & 0_4' \\ 0_4 & 0_4 & 0_4 & diag(s_y) \end{bmatrix} \begin{bmatrix} \tilde{u}_{x,t+1} \\ \tilde{e}_{z,t+1} \\ \tilde{e}_{p,t+1} \\ \tilde{x}_{y,t+1} \end{bmatrix}$$

where,

$$a_p = \frac{-(1-f_z)}{f_z} m_z$$

$$b_p = \frac{1}{f_z}$$

$$s_{11} = (b_{px} - (1/f_z) b_{zx}) s_x$$

$$s_{12} = (b_{pz} - (1/f_z)) s_z$$

$$s_{13} = s_p$$

$a_y = (1/n)A_n^{\$}$ is a 4x1 vector from the bond pricing equations for the four yields, n is the maturity of the bond, and similarly for b_{y1} and b_{y2} below,

$b_{y1} = (1/n)B_{1,n}^{\$}$,

$b_{y2} = (1/n)B_{2,n}^{\$}$,

y_{t+1} is the 4x1 vector of four yields,

s_y is the vector of standard deviations for the four yields and

$diag(s_y)$ is a 4x4 matrix with its diagonal elements equal to the standard deviations of the four yields.

Equation (A.3.2) can be written more compactly as follows:

(A.3.2)' $$y_{t+1} = d + Za_{t+1} + Sx_{t+1}$$

where,

$x_{t+1} \sim NIID(0, I_{4+3})$.

Equations (A.3.1) and (A.3.2) show that including the rate of inflation as one of the measured variables produces correlation between the errors in the measurement and transition equations. Consequently, one must apply the Kalman filter prediction and updating equations for correlated measurement and transition equation errors (an application of Harvey (1989), p112-113). The likelihood function can be generated by using the prediction errors from the prediction and updating equations and is set out in Harvey (1993), p91.

The smoothing algorithm used to produce smoothed estimates of the state variables and implement the stress test is set out in detail in Harvey (1993), p87. We note that in the implementation of the stress test, the transition equations remain the same as in the estimation process but that the measurement equation has only one observed variable, the path assumed by the long rate in the stress test specification. Consequently, the error terms in the measurement and transition equations will not be correlated and the prediction and updating equations are more standard (Harvey (1993), p. 85-86).

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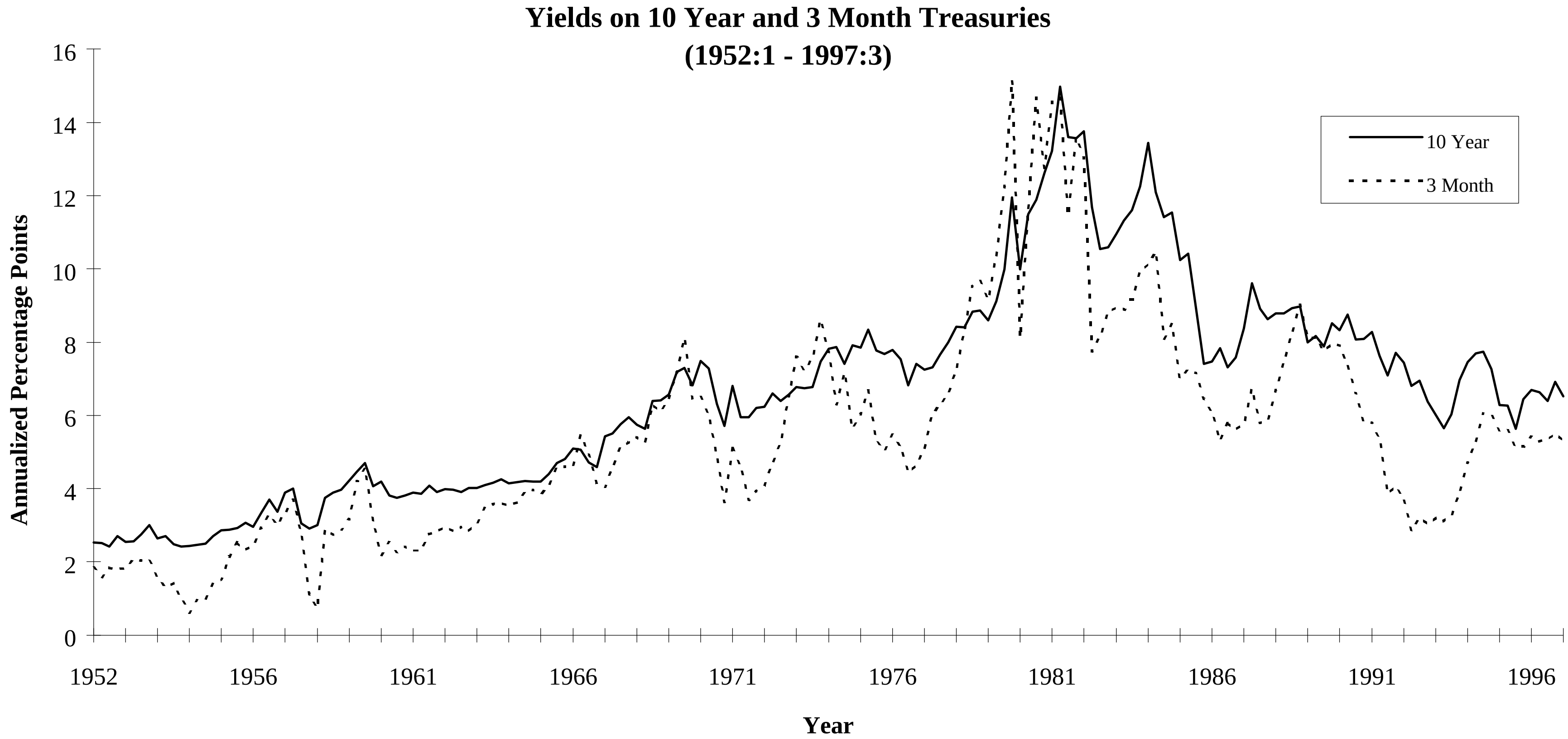
Exhibit 1



Yields on 10 Year and 3 Month Treasuries
(1952:1 - 1997:3)
Annualized Percentage Points
Year
10 Year
3 Month
0
2
4
6
8
10
12
14
16
1952
1956
1961
1966
1971
1976
1981
1986
1991
1996

Exhibit 2
Spread Between 10 Year and 3 Month Treasury Yields
(1952:1 - 1997:3)

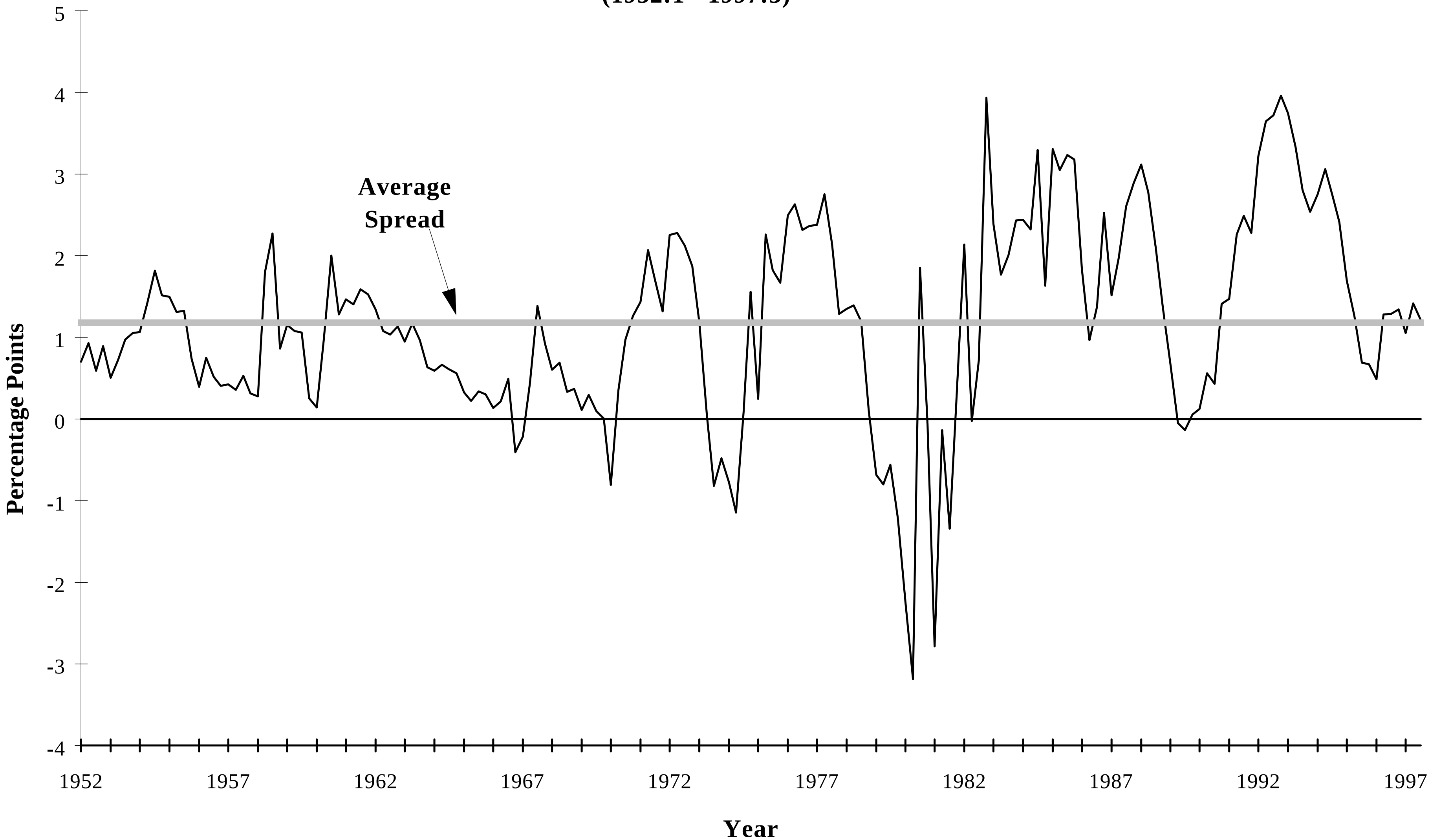


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Exhibit 3
Quarterly Change in 10 Year Treasury Yield
(1952:2 - 1997:3)

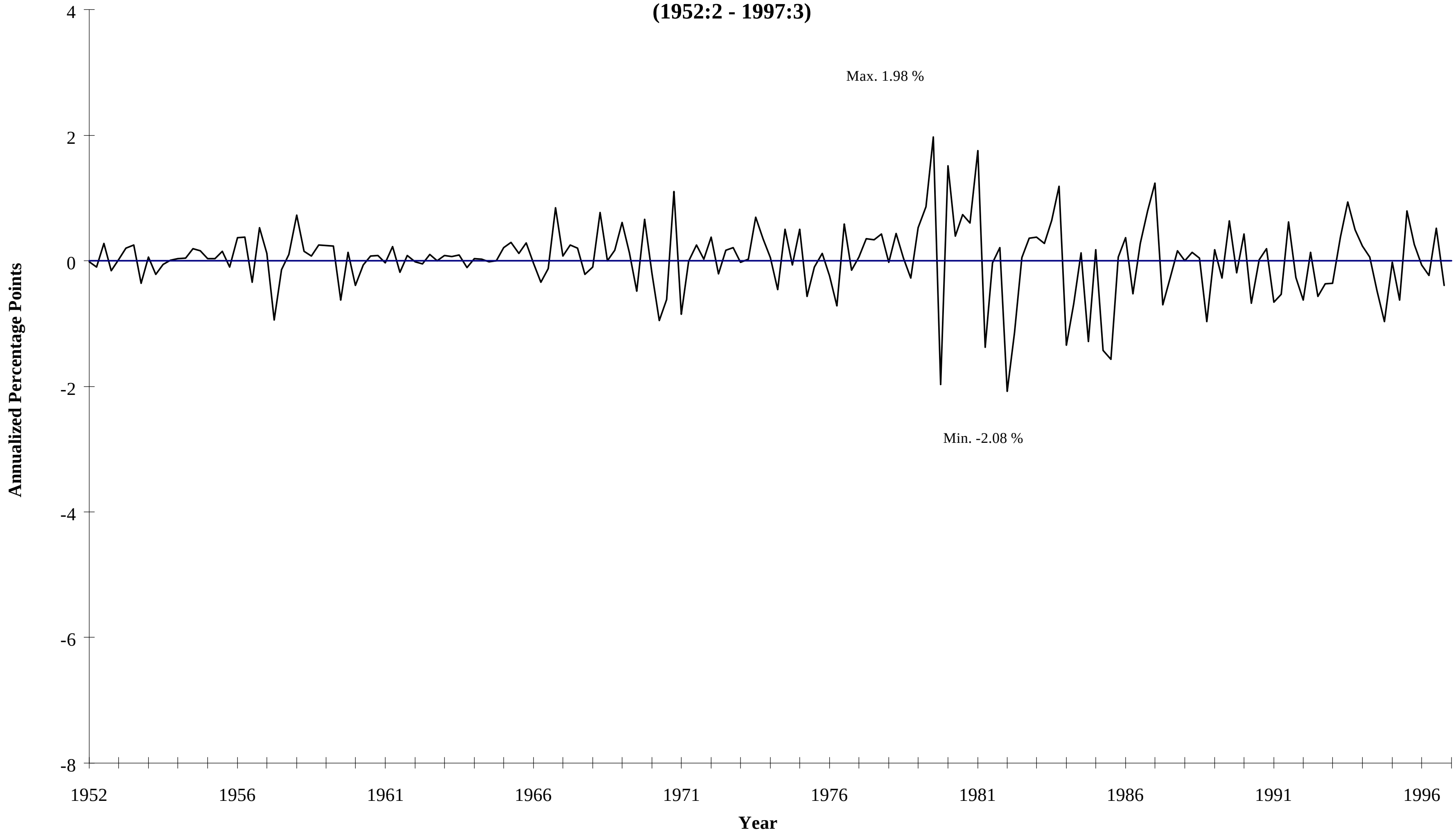

Exhibit 4
Quarterly Change in 3 Month Treasury Yield
(1952:2 - 1997:3)

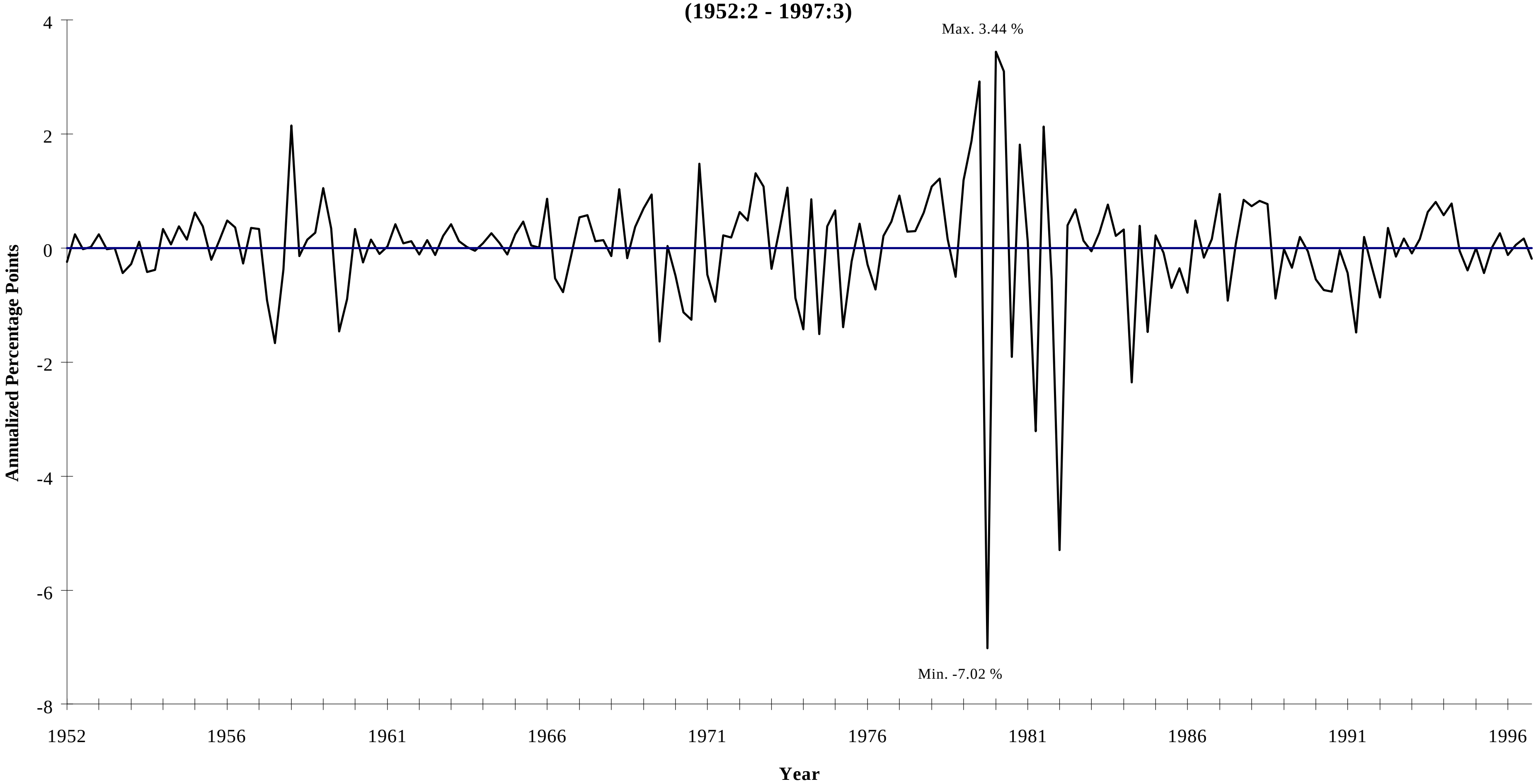

Exhibit 5

Sample Statistics for 10 year CMT and 3 month T-Bill (quarterly data)

		Levels			*Changes*	
Period		10 year CMT yield	3 mo. yield	Spread	10 year CMT yield	3 mo. yield
1952:1–1997:3	Average	6.46	5.33	1.13	0.021	0.019
	Standard deviation	2.62	2.77	1.13	0.523	0.983
	Correlation between change in 10 year and change in 3 mo.				0.63	
1952:1–1979:4 & 1983:1–1997:3	Average	6.06	4.86	1.20	0.015	0.032
	Standard deviation	2.25	2.17	1.01	0.43	0.63
	Correlation between change in 10 year and change in 3 mo.				0.53	
1980:1–1982:4	Average	11.93	11.80	0.13	0.14	–0.37
	Standard deviation	1.24	2.32	1.89	1.28	3.22
	Correlation between change in 10 year and change in 3 mo.				0.83	

Exhibit 6
Change in 3 Month Yield Vs. Change in 10 Year Yield
(1952:2 to 1997:3)

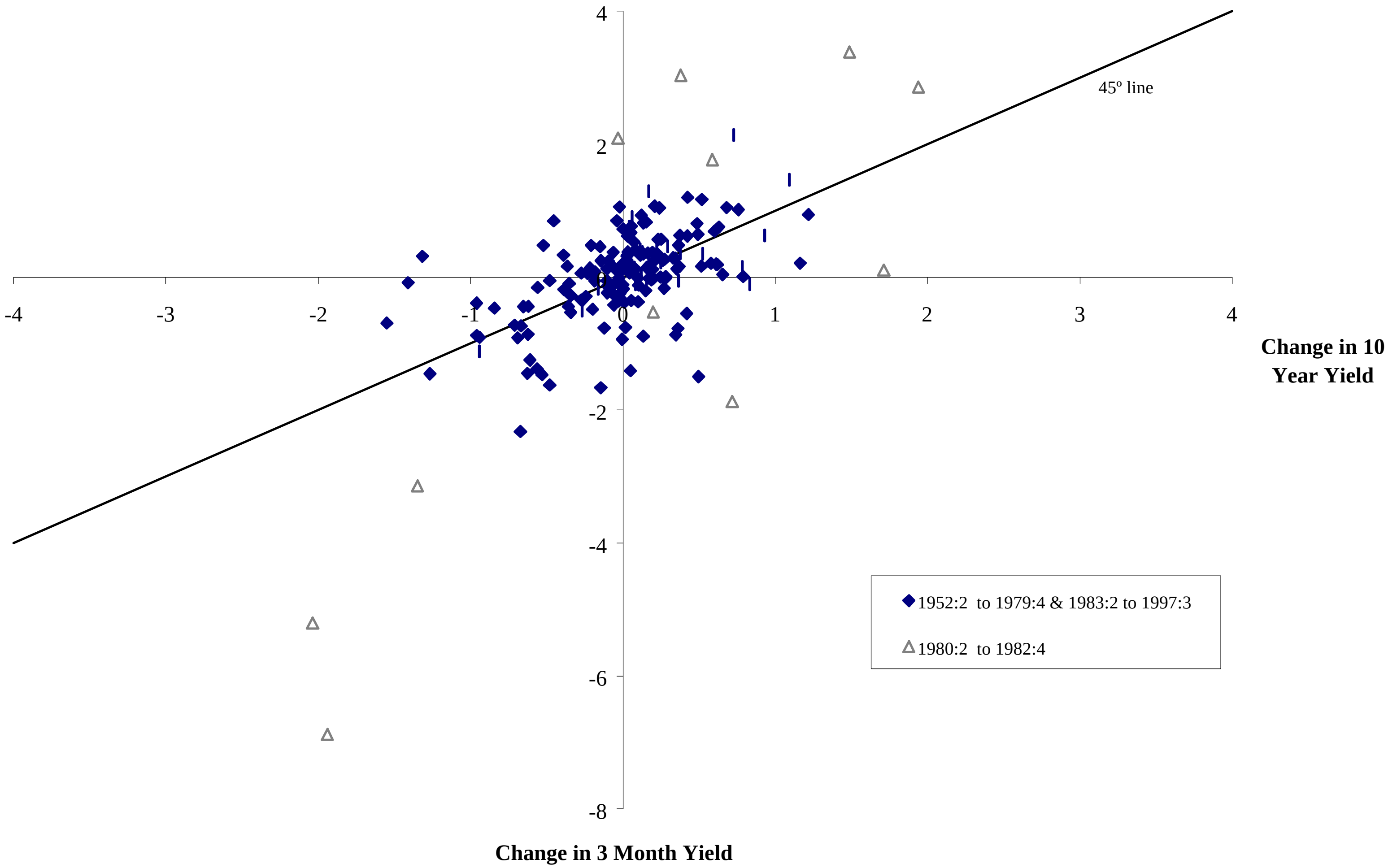

Exhibit 7
Distribution of Change in 10 Year Yield
(quarterly, 1952:2 - 1997:3)

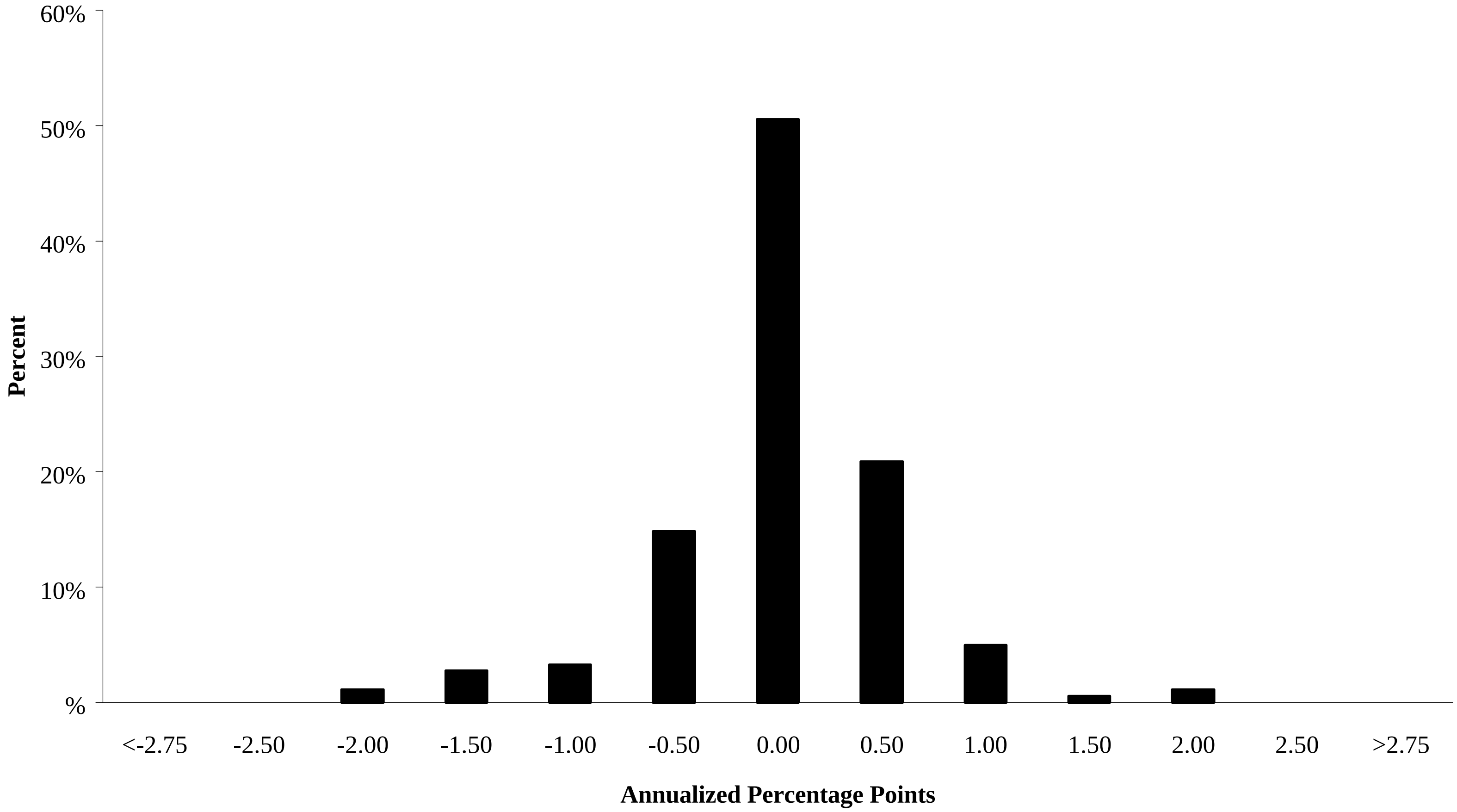

Exhibit 8(a)

Distribution of Long-Short Spread
Sample: 1952:1-1997:3

Parameters from Fitting Univariate AR(1) to Spread

Parameter	Estimate	Standard Error	t-stat
Constant	0.0026	0.0013	2.11
Lagged Spread	0.7673	0.0814	9.43
R^2	0.5890		

Unconditional Probability of a Negative Spread

Empirical	10.9%
AR(1) Process	15.5%

Percentiles of Spread Distribution

Percentile	Empirical	AR(1) process
1%	-0.0248	-0.0143
2.5%	-0.0112	-0.0101
5%	-0.0074	-0.0069
10%	-0.0007	-0.0028
20%	0.0028	0.0021
30%	0.0051	0.0057
40%	0.0084	0.0087
50%	0.0112	0.0116
60%	0.0131	0.0144
70%	0.0161	0.0174
80%	0.0213	0.0210
90%	0.0261	0.0258
95%	0.0298	0.0298
97.5%	0.0320	0.0329
99%	0.0358	0.0367

NOTES:
(1) Monthly Zero Coupon Yields are from McCulloch & Kwon up to end of February 1991.
For subsequent years, yields are from the Federal Reserve Bank of New York.
(2) Frequency of data is quarterly.

Exhibit 8(b)

Distribution of Duration of Inversion in Yield Curve
Sample: 1952:1-1997:3

Probability of Duration of Inversion

Number of Quarters	Empirical	AR(1) Process
1	10.9%	15.4%
2	7.1%	8.8%
3	4.4%	5.5%
4	2.8%	3.4%
5	1.1%	2.2%
6	0.6%	1.5%
7	0.0%	0.9%
8	0.0%	0.6%
9	0.0%	0.4%
10	0.0%	0.3%
11	0.0%	0.2%
12	0.0%	0.1%
13	0.0%	0.1%
14	0.0%	0.1%
15	0.0%	0.0%

Average Duration of Inversion

Empirical	2.8571
AR(1) Process	2.3568

NOTES:
(1) Monthly Zero Coupon Yields are from McCulloch & Kwon up to end of February 1991.
For subsequent years, yields are from the Federal Reserve Bank of New York.
(2) Frequency of data is quarterly.

Exhibit 9

Contemporaneous Regression Results

Model: $\Delta YS_t = b\Delta YL_t + e_t$

Quarterly data

Sample Period	*Estimation Method*	*Estimated Coefficient on* ΔYL_t	*Standard Error*	R^2
1952:2 to 1997:3	OLS	1.19	0.22	0.40
	WLS*	1.15	0.20	
	GARCH	0.65	0.08	
1952:2 to 1979:4 & 1983:2 to 1997:3	OLS	0.77	0.11	0.28

*Weighted by square root of lagged 3-month yield.

Note: OLS and WLS standard errors calculated using White heteroskedasticity-consistent standard error.

GARCH model estimated by imposing stationarity constraint on the variance process.

Annual data (overlapping 4-quarter periods)

Sample Period	*Estimation Method*	*Estimated Coefficient on* ΔYL_t	*Standard Error*	R^2
1953:1 to 1997:3	OLS	1.07	0.13	0.48
	WLS**	1.18	0.10	
	GARCH	1.20	0.08	
1953:1 to 1979:4 & 1984:1 to 1997:3	OLS	0.96	0.15	0.39

**Weighted by square root of lagged 3-month short rate.

Note: OLS and WLS standard errors calculated using Newey-West serial correlation and heteroskedasticity-consistent standard error.

GARCH model estimated by imposing stationarity constraint on the variance process.

Exhibit 10

VAR Estimation Results
(quarterly data)

Ordinary Least Squares Estimation

VAR System: $\Delta YL_t = \beta_{11}\,\Delta YL_{t-1} + \beta_{12}\,LS_{t-1} + e_1$
$LS_t = \beta_{21}\,\Delta YL_{t-1} + \beta_{22}\,LS_{t-1} + e_2$

	ΔYL		LS	
	$\hat{b}_{11}$ *(std. error)*	$\hat{b}_{12}$ *(std. error)*	$\hat{b}_{21}$ *(std. error)*	$\hat{b}_{22}$ *(std. error)*
Sample Period				
1953:1 to 1997:3	–0.091	–0.086	0.006	0.768
	(0.076)	(0.035)	(0.107)	(0.050)
	$R^2 = 0.03$		$R^2 = 0.59$	
1953:1 to 1979:4 & 1984:1 to 1997:3	–0.001	–0.062	–0.333	0.865
	(0.078)	(0.034)	(0.091)	(0.039)
	$R^2 = 0.02$		$R^2 = 0.75$	

Heteroskedasticity-Adjusted Estimation

VAR System: $\Delta YL_t = \beta_{11}\,\Delta YL_{t-1} + \beta_{12}\,LS_{t-1} + e_1$
$LS_t = \beta_{21}\,\Delta YL_{t-1} + \beta_{22}\,LS_{t-1} + r\hat{e}_1 + u_2$

Sample Period: 1953:1 to 1997:3

	ΔYL		LS		
	$\hat{b}_{11}$ *(std. error)*	$\hat{b}_{12}$ *(std. error)*	$\hat{b}_{21}$ *(std. error)*	$\hat{b}_{22}$ *(std. error)*	$\hat{r}$ *(std. error)*
Estimation Method					
WLS*	–0.023	–0.034	–0.200	0.781	–0.194
	(0.076)	(0.033)	(0.102)	(0.044)	(0.100)
WLS**	0.003	–0.066	–0.299	0.893	0.104
	(0.077)	(0.033)	(0.086)	(0.036)	(0.083)
GARCH***	–0.078	–0.063	–0.295	0.815	0.132
	0.081	0.025	0.084	0.041	0.122

*Both equations weighted by square root of lagged 3-month yield.
**Both equations weighted by square root of estimated GARCH variance from contemporaneous regression model.
** GARCH model estimated by imposing stationarity constraint on the variance process.

Exhibit 11(a)

VAR Impulse Response of S to a 482bp Positive Shock in L
(OLS, 1952:3-1997:3)

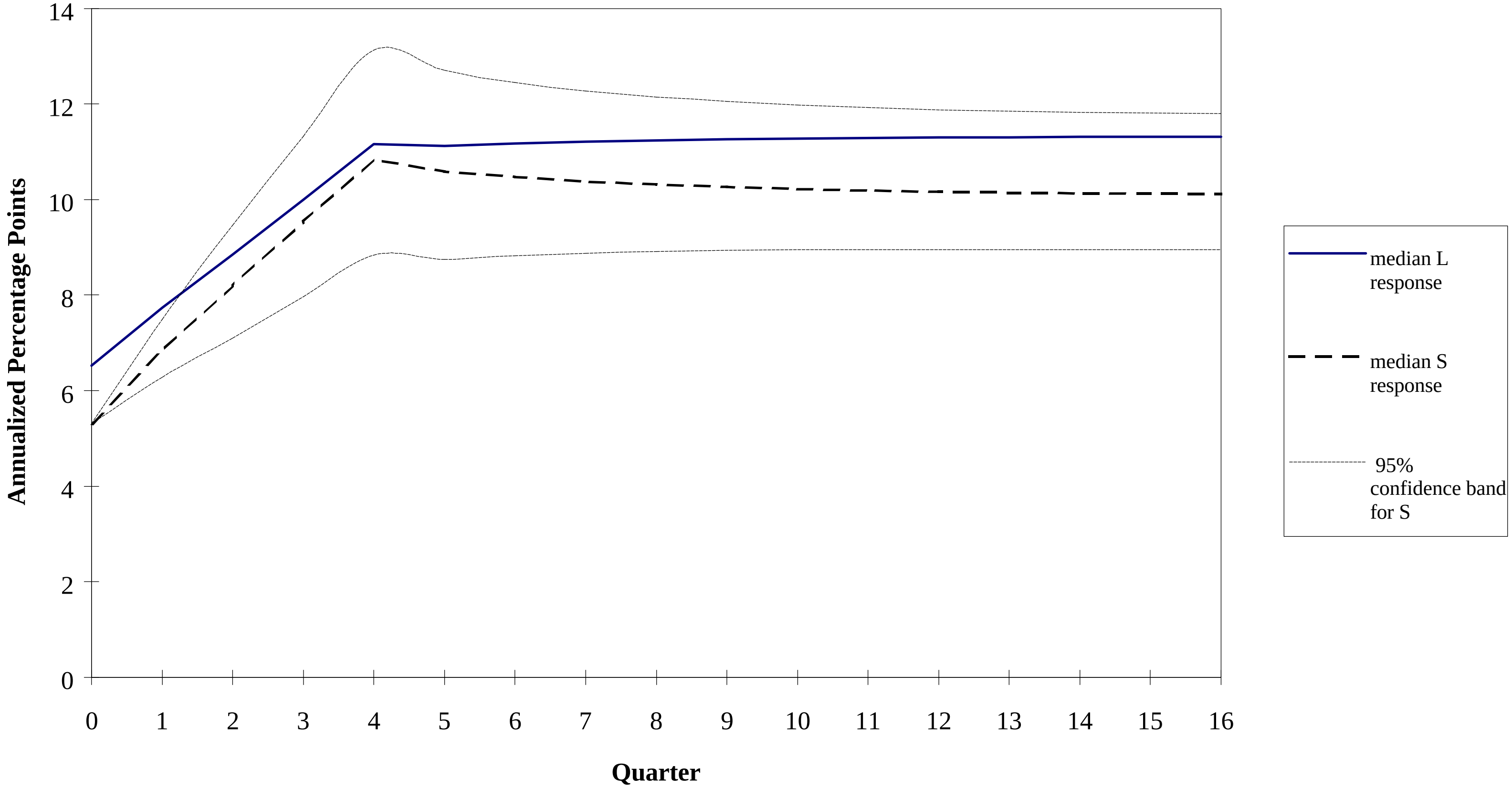

Exhibit 11(b)

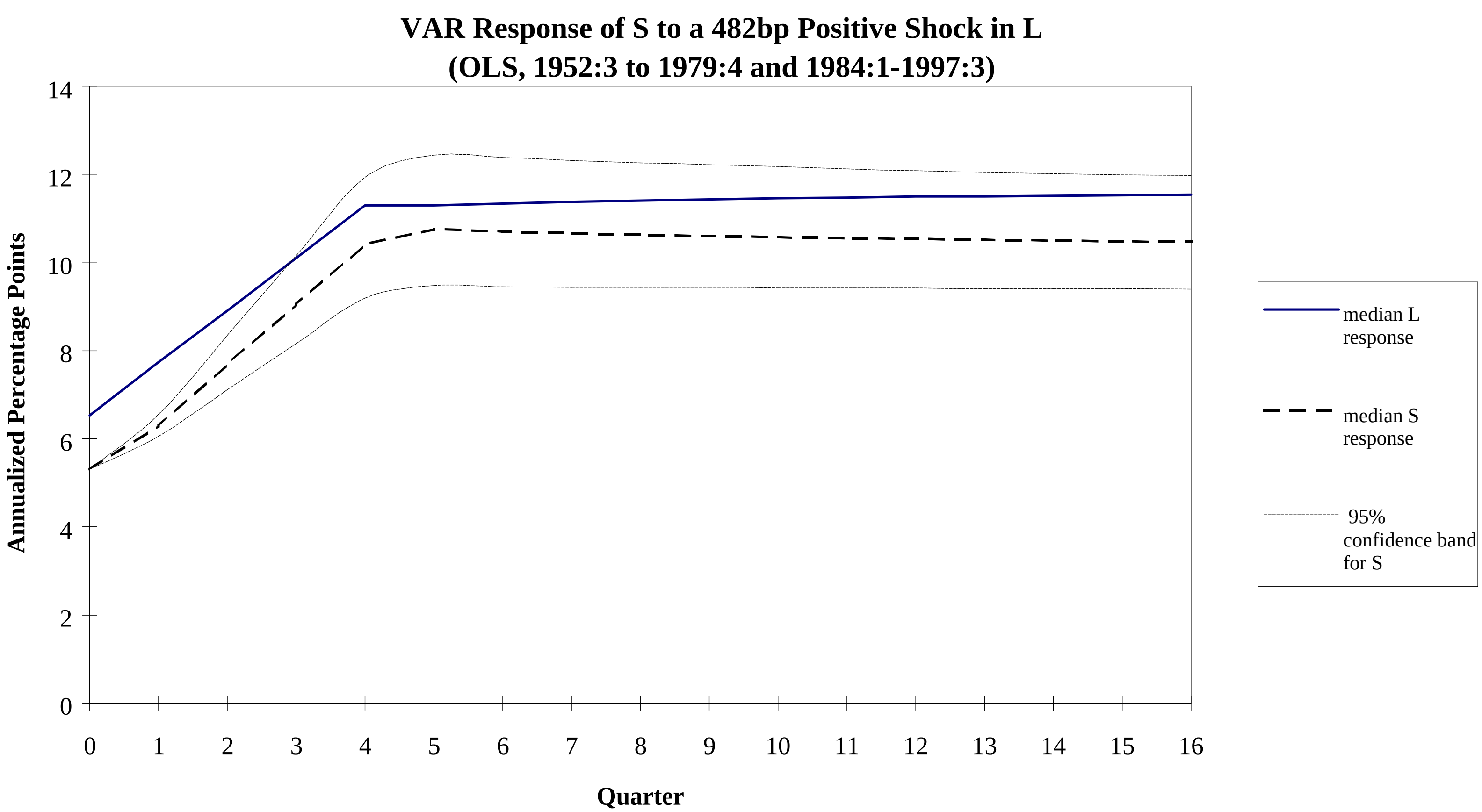
VAR Response of S to a 482bp Positive Shock in L
(OLS, 1952:3 to 1979:4 and 1984:1-1997:3)
Annualized Percentage Points
0
2
4
6
8
10
12
14
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Quarter
median L response
median S response
95% confidence band for S

Exhibit 11(c)

VAR Impulse Response of S to a 482bp Positive Shock in L
(WLS, weighted by square root of lagged S, 1952:3 to 1997:3)

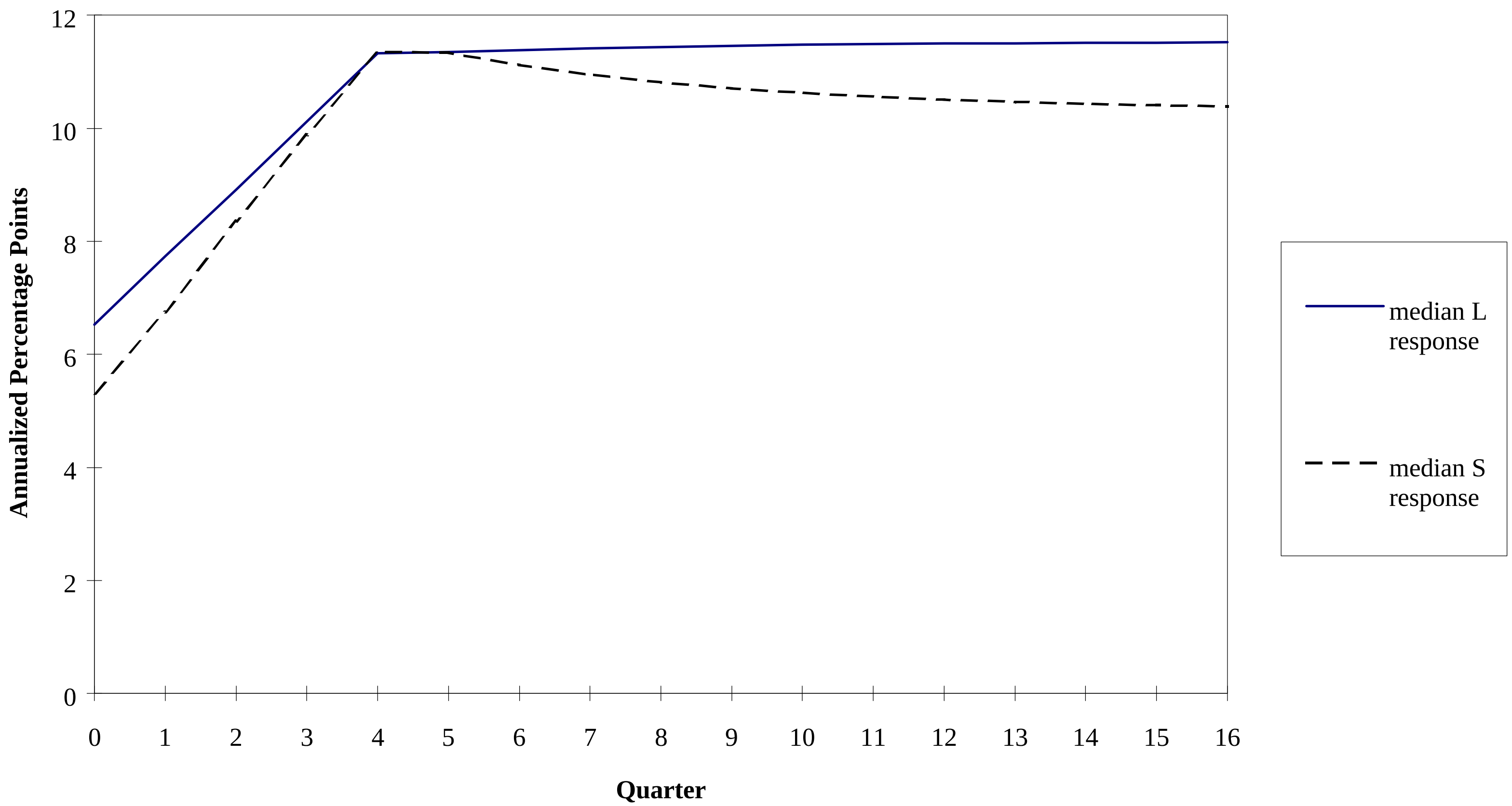

Exhibit 11(d)

VAR Impulse Response of S to a 482bp Positive Shock in L (WLS, weighted by square root of lagged estimated GARCH variances in the regression of DS on DL, 1952:3-1997:3)

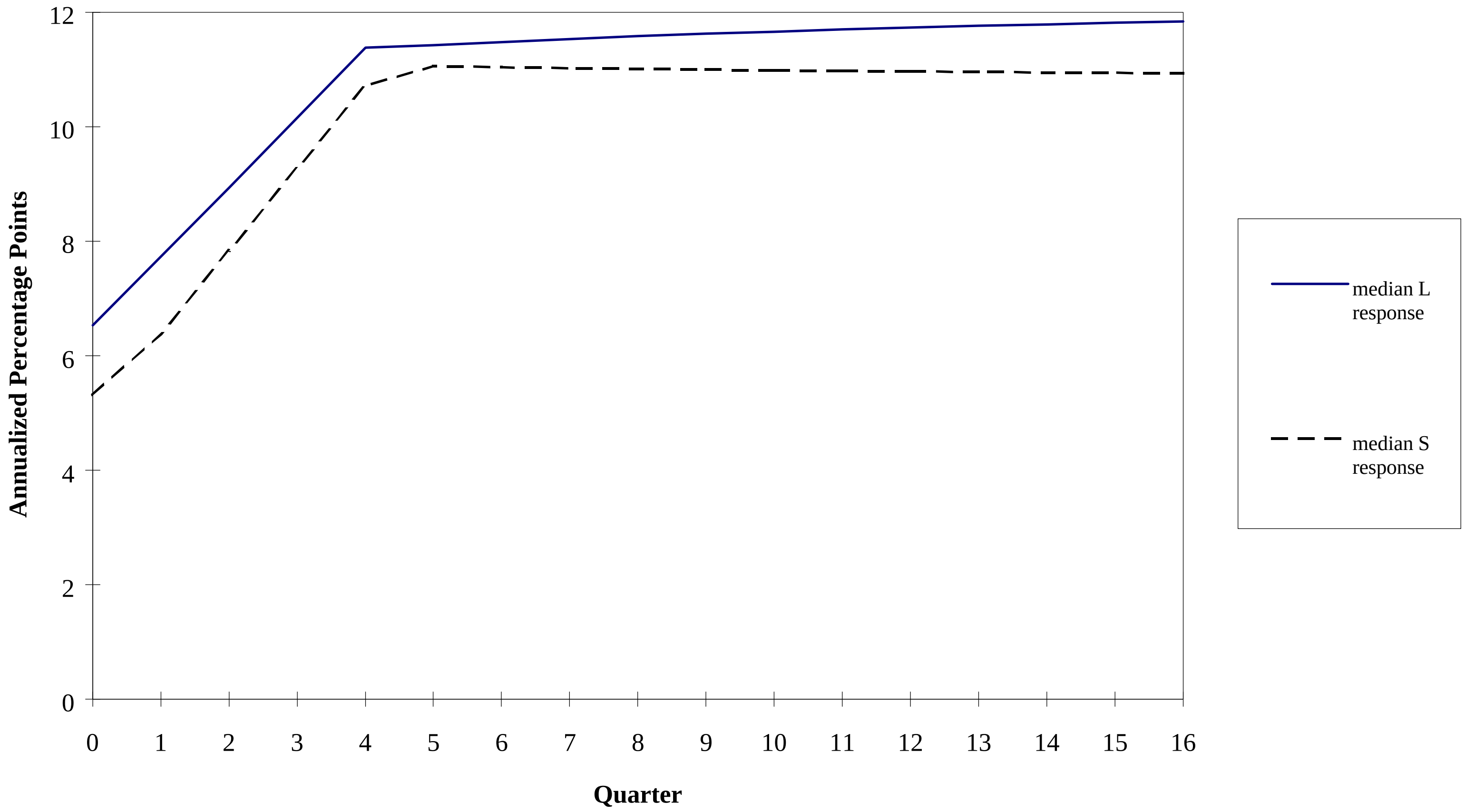

Exhibit 11(e)

VAR Impulse Response of S to a 482bp Positive Shock in L (GARCH(1,1), 1952:3-1997:3)

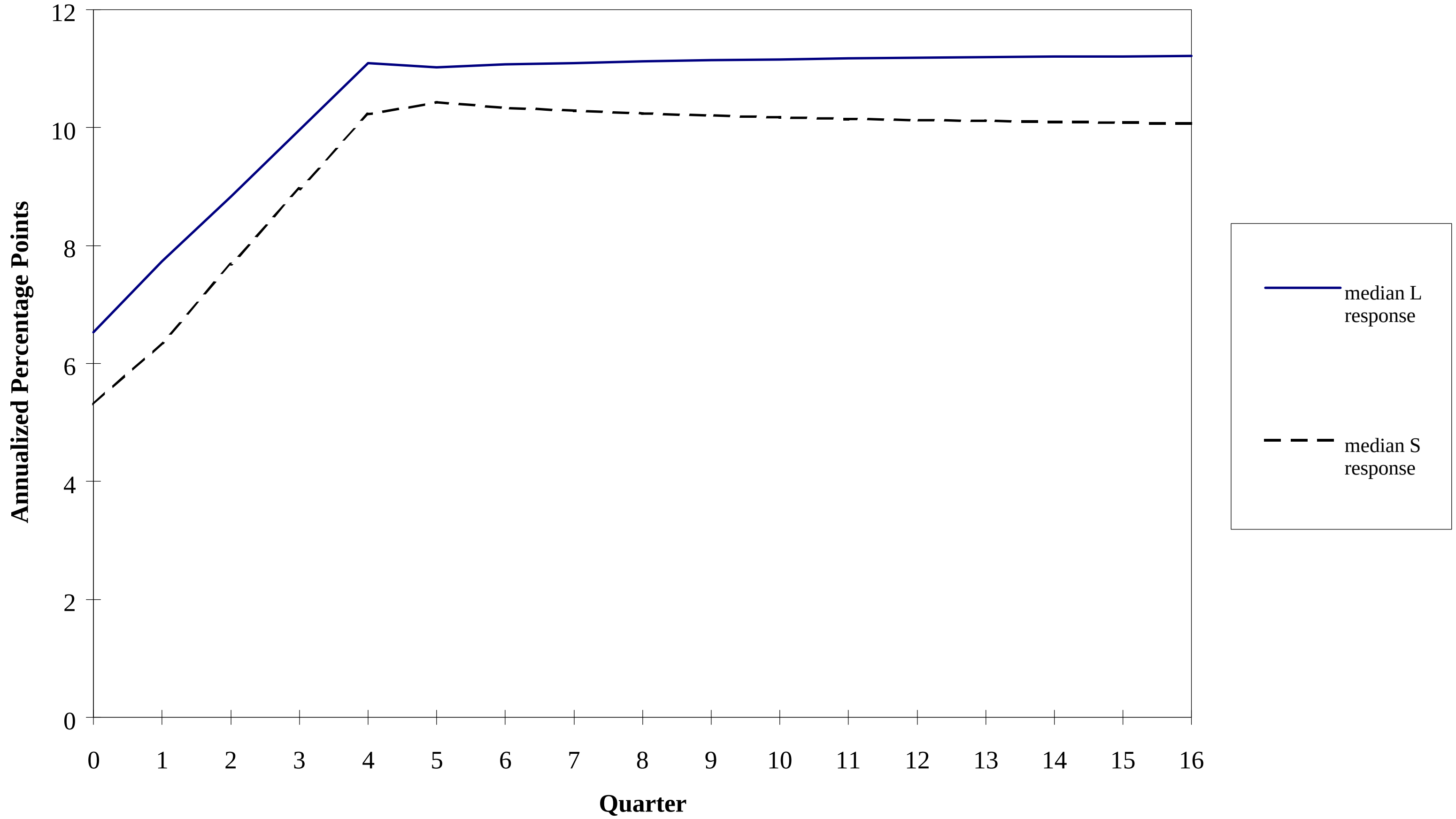

Exhibit 12(a)

VAR Impulse Response of S to a 329bp Negative Shock in L
(OLS, 1952:3 to 1997:3)

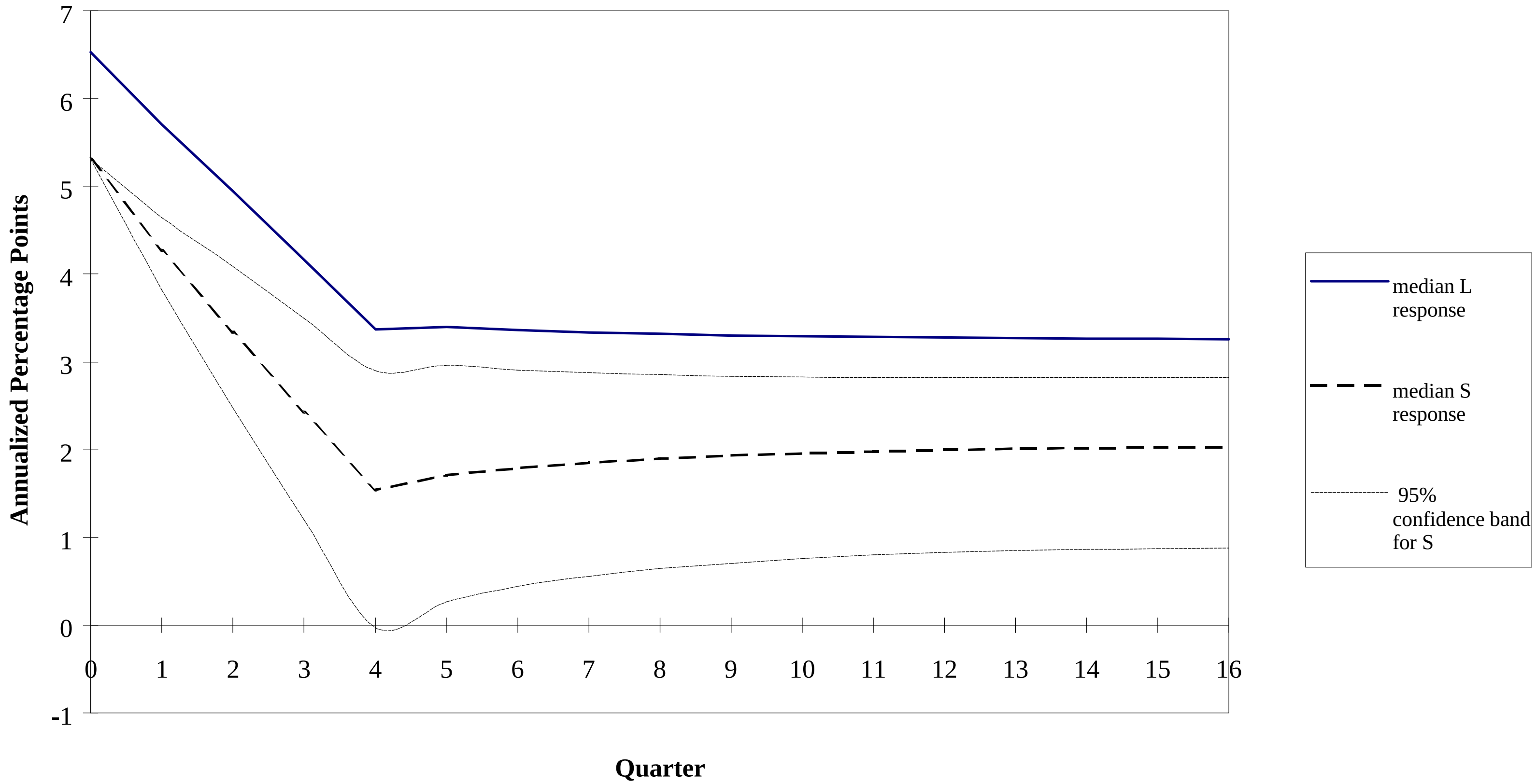

Exhibit 12(b)

VAR Impulse Response of S to a 329bp Negative Shock in L
(OLS, 1953:1-1979:4 and 1984:1-1997:3)

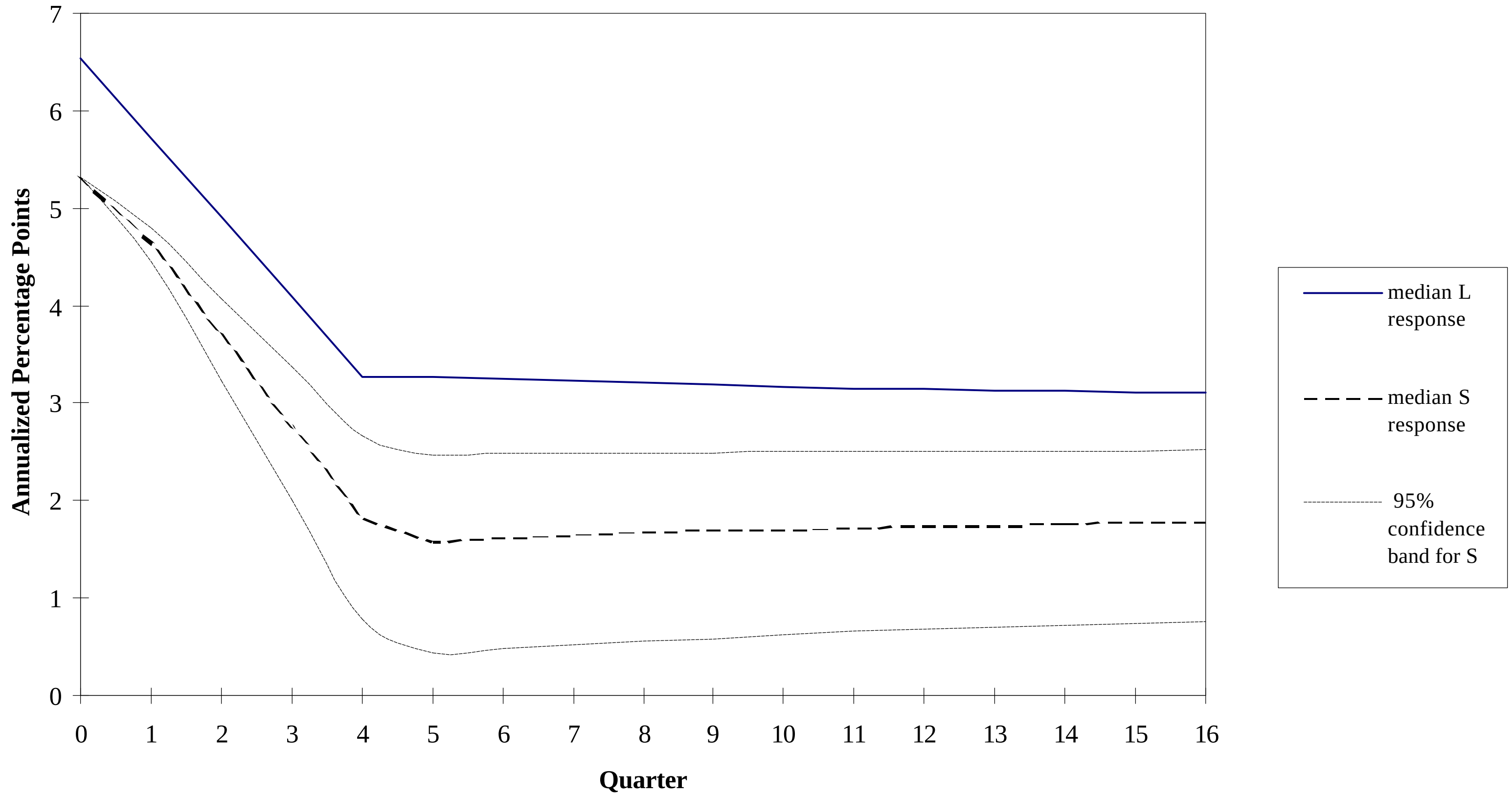

Exhibit 12(c)

VAR Impulse Response of S to a 329bp Negative Shock in L
(WLS, weighted by square root of lagged S, 1952:3-1997:3)

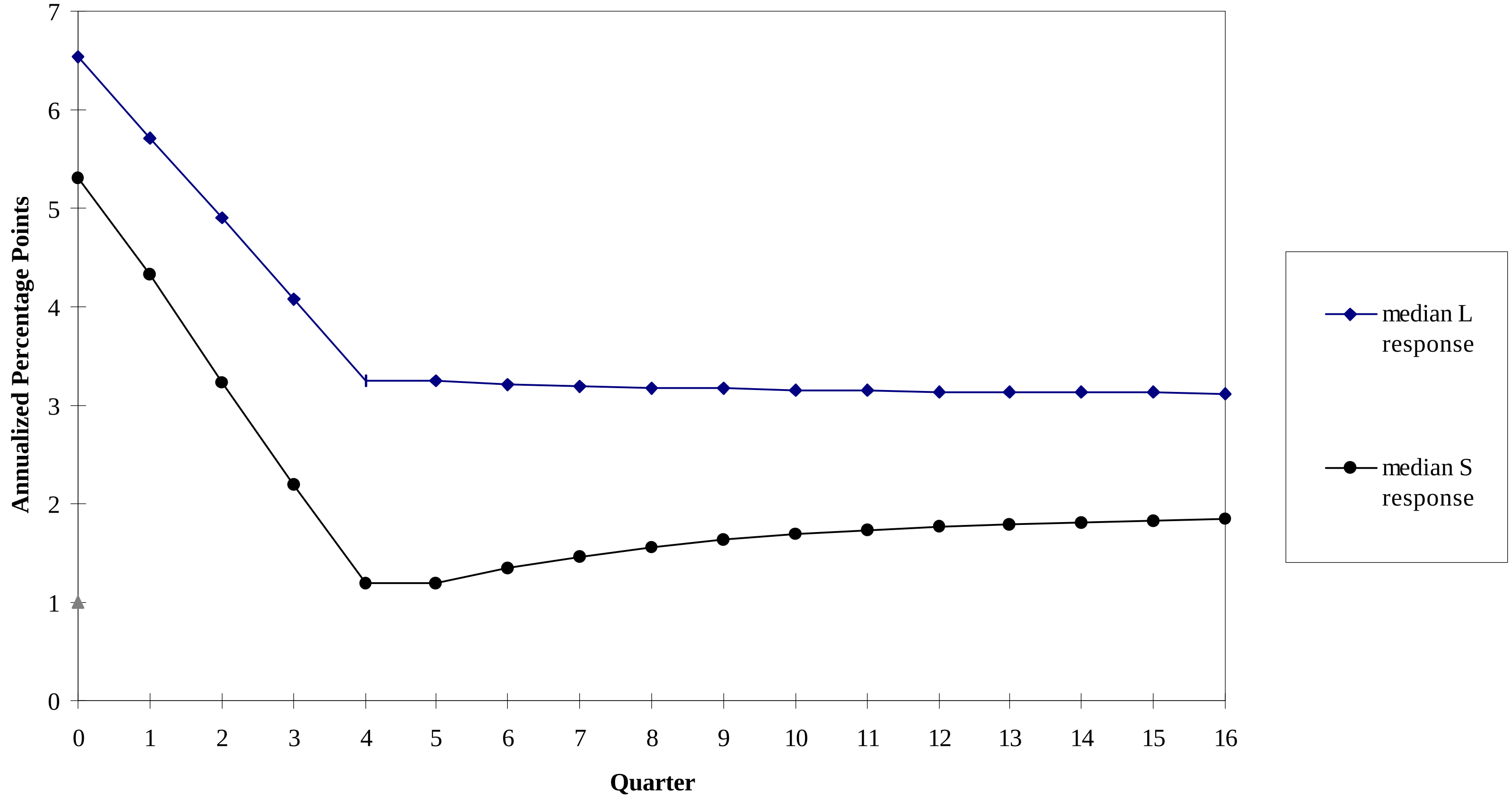

Exhibit 12(d)

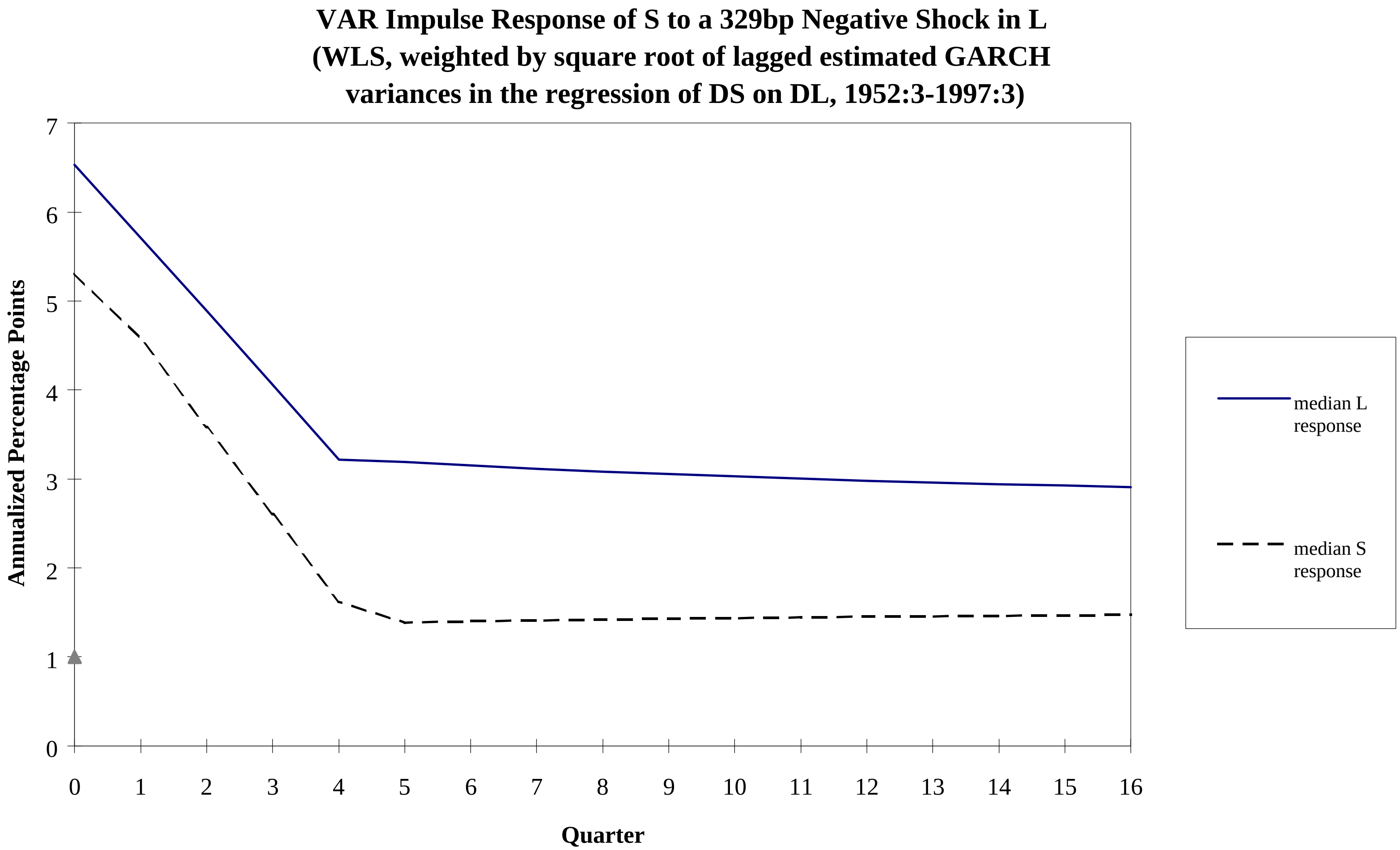
VAR Impulse Response of S to a 329bp Negative Shock in L
(WLS, weighted by square root of lagged estimated GARCH
variances in the regression of DS on DL, 1952:3-1997:3)
Annualized Percentage Points
0
1
2
3
4
5
6
7
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Quarter
median L response
median S response

Exhibit 12(e)

VAR Impulse Response of S to a 329bp Negative Shock in L
(GARCH(1,1), 1952:3 to 1997:3)

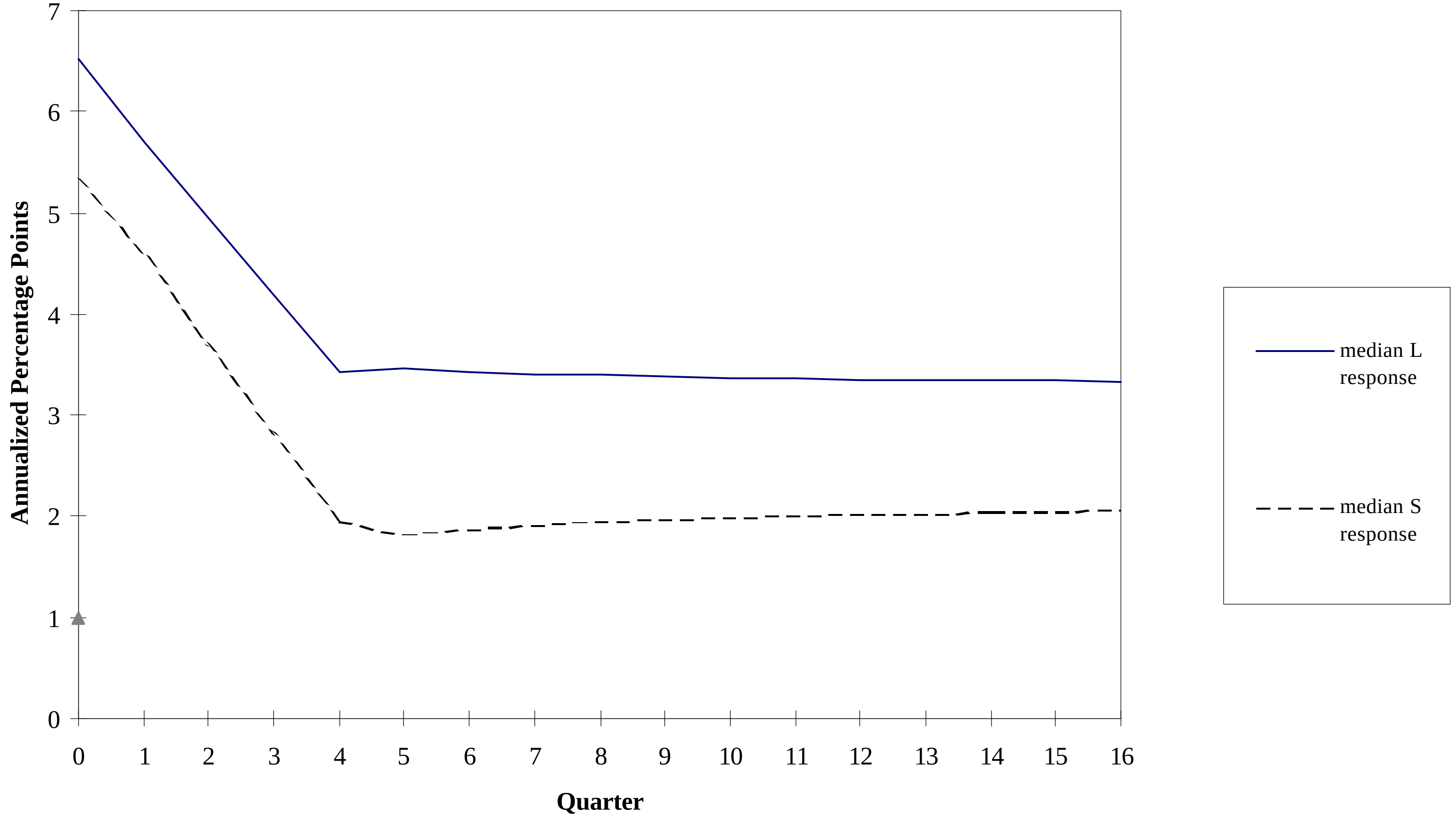

Exhibit 13

Results from Maximum Likelihood Estimation
Measured Variables: (3 mo.,1yr,5yr,10yr Yields)

	Sample: 1952.1-1997.3		Sample: 1952.1-1979.4 and 1983.1-1997.3	
Parameter	Estimate	Standard Error	Estimate	Standard Error
μ_x	1.528	0.913	2.263	1.367
μ_z	-0.030	0.183	0.126	0.224
ϕ_x	0.869	0.007	0.887	0.008
ϕ_z	0.998	0.001	0.998	0.001
σ_x	0.224	0.016	0.182	0.013
σ_z	0.123	0.007	0.116	0.007
β_{zx}	0.047	0.044	-0.220	0.058
β_{mx}	-64.371	32.746	-99.622	40.959
β_{mz}	-21.948	12.024	-76.954	24.173
σ_m	0.000		0.000	
$\beta_{\pi x}$	1.026	0.288	-2.489	0.895
$\beta_{\pi z}$	2.071	0.471	3.046	1.340
σ_π	0.783	0.041	2.031	0.111
σ_y				
3-month	0.116	0.007	0.095	0.008
1-year	0.012	0.024	0.028	0.011
5-year	0.034	0.002	0.031	0.002
10-year	0.000	0.009	0.000	0.007
Mean Log Likelihood	25.765		25.282	

NOTES:
(1) Means and standard deviations are in units of percent per quarter.
(2) Monthly Zero Coupon Yields are from McCulloch & Kwon up to end of February 1991.
For subsequent years, yields are from the Federal Reserve Bank of New York.
(3) Quarterly sampling is used for parameter estimates.

Exhibit 14(a)
Theoretical and Sample Paths for 3-Month Nominal Yield
Sample: 1952:1-1997:3

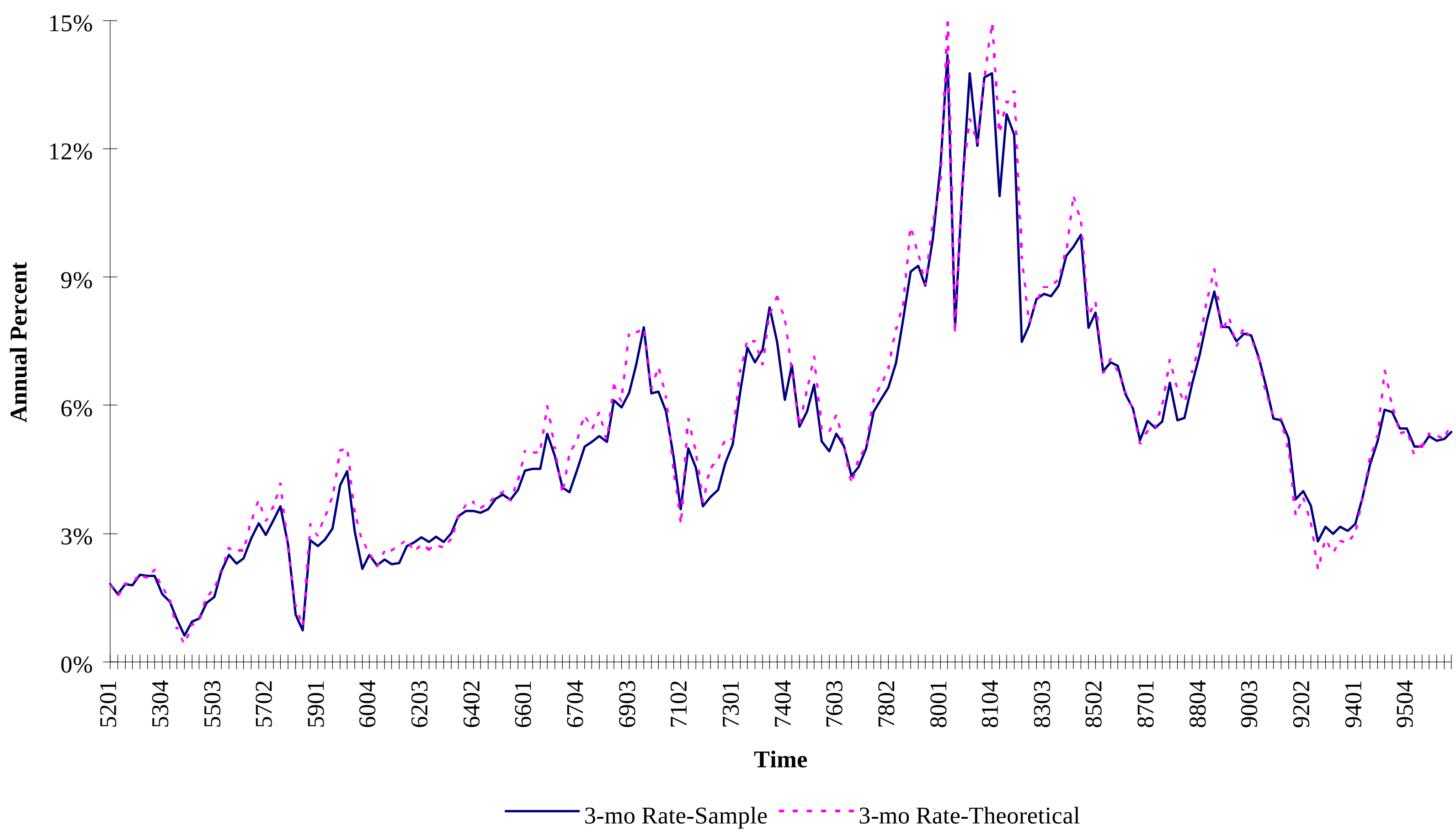

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Exhibit 14(b)
Theoretical and Sample Paths for 10-Year Nominal Yield
Sample: 1952:1-1997:3

Exhibit 15(a)
Theoretical and Sample Paths for 3-Month Nominal Yield
Sample: 1952:1-1979:4 and 1983:1-1997:3

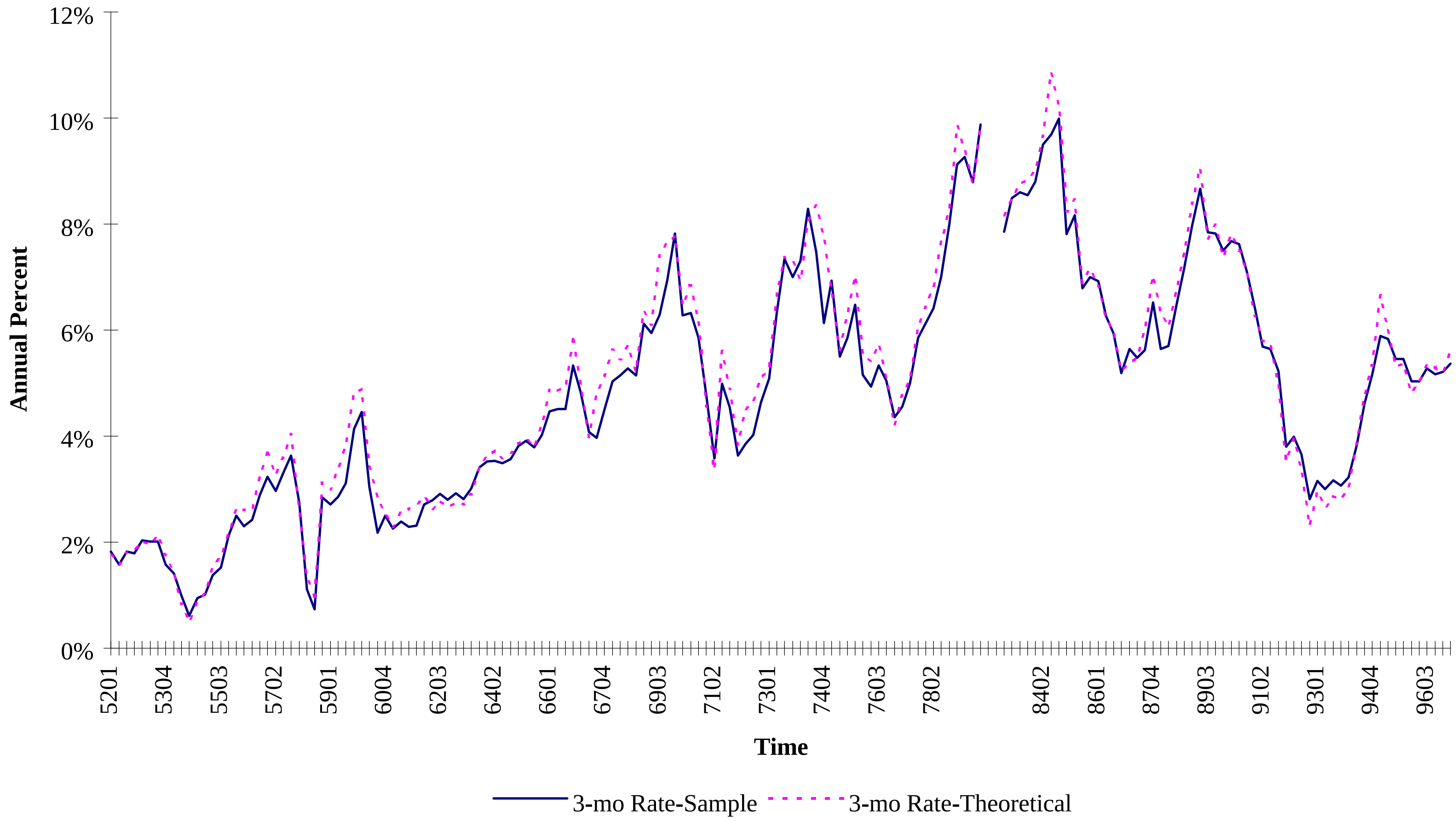

Exhibit 15(b)
Theoretical and Sample Paths for 10-Year Nominal Yield
Sample: 1952:1-1979:4 and 1983:1-1997:3

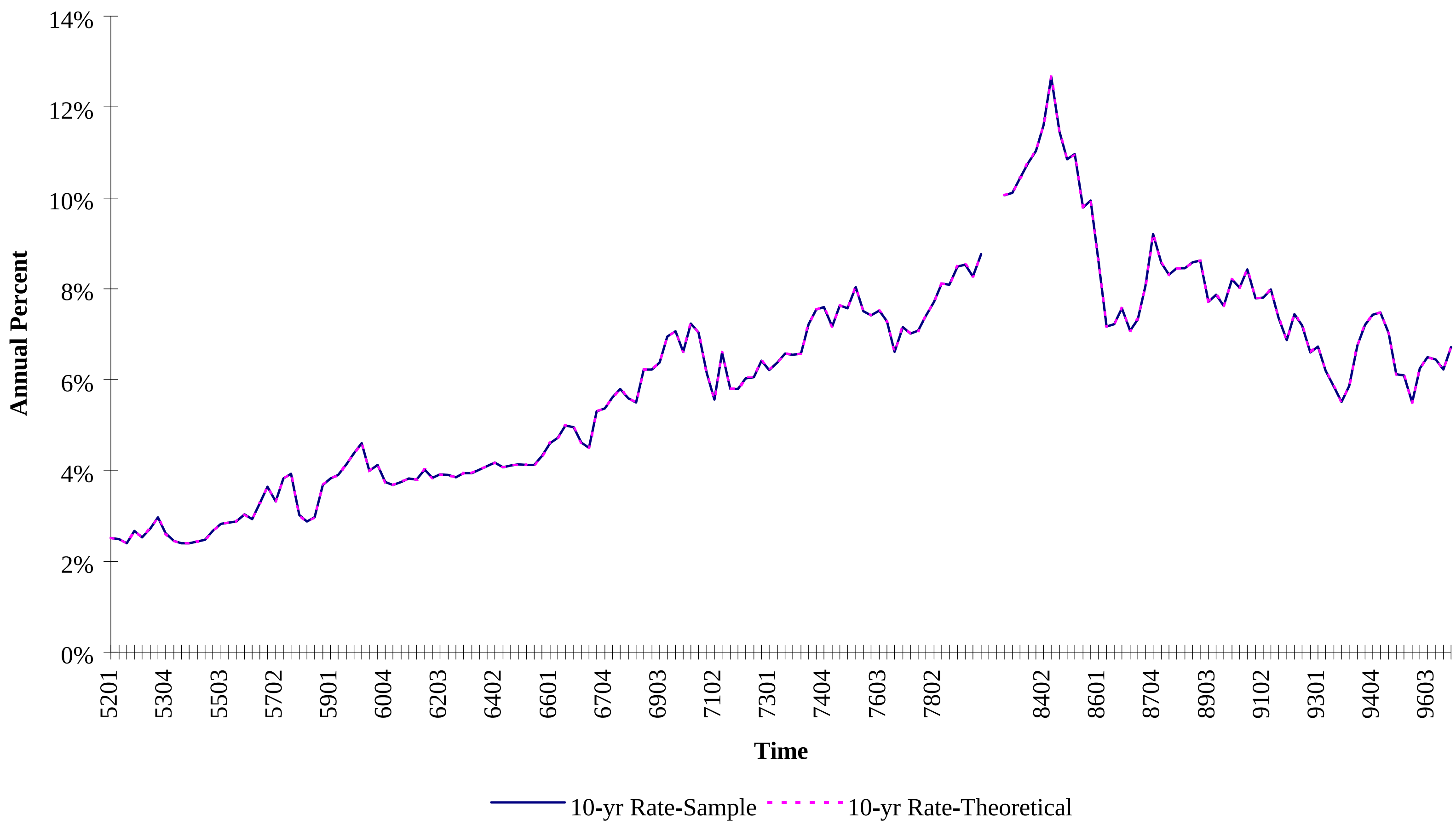

Exhibit 16

Measures of Goodness of Fit

Correlation Between Theoretical and Sample Yields

	1952.1-1997.3		1952.1-1979.4 and 1983.1-1997.3	
Maturity	Level of Yields	Changes in Yields	Level of Yields	Changes in Yields
3-Month	0.9905	0.9041	0.9910	0.8843
6-Month	0.9974	0.9701	0.9977	0.9622
1-Year	1.0000	0.9999	0.9997	0.9958
2-Year	0.9988	0.9892	0.9985	0.9851
5-Year	0.9987	0.9852	0.9986	0.9802
10-Year	1.0000	1.0000	1.0000	1.0000

Correlation Between Changes in 3-Month and 10-Year Yields

1952.1-1997.3	
Theoretical	0.7667
Sample	0.6315

1952.1-1979.4 and 1983.1-1997.3	
Theoretical	0.6407
Sample	0.5318

NOTES:
(1) Monthly Zero Coupon Yields are from McCulloch & Kwon up to end of February 1991.
For subsequent years, yields are from the Federal Reserve Bank of New York.
(2) Quarterly sampling is used for parameter estimates.

Exhibit 17
Paths for Expected Inflation and Real Short Rate
Sample: 1952:1-1997:3

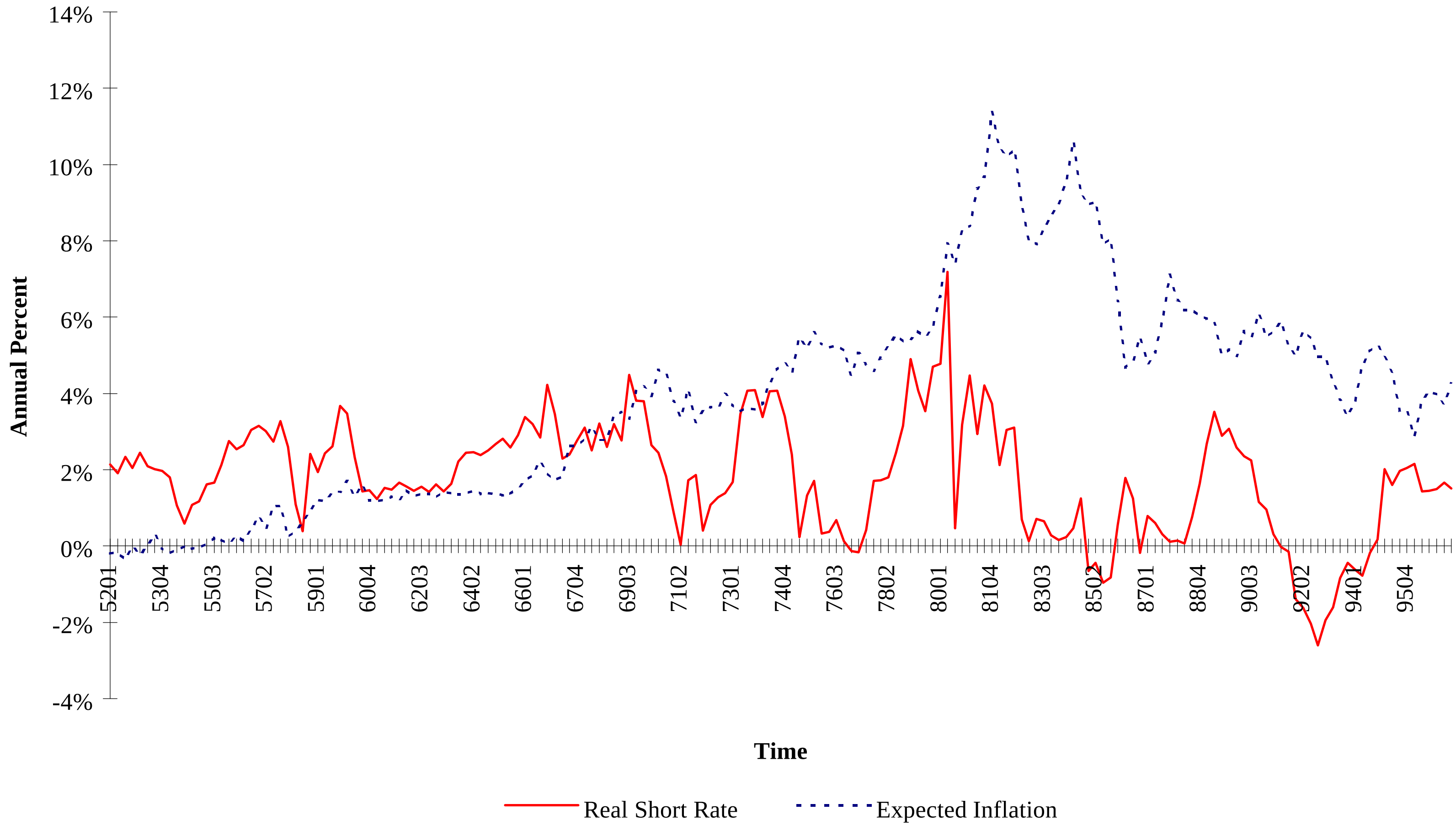

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Exhibit 18
Paths for Expected Inflation and Real Short Rate
Sample: 1952:1-1979:4 and 1983:1-1997:3

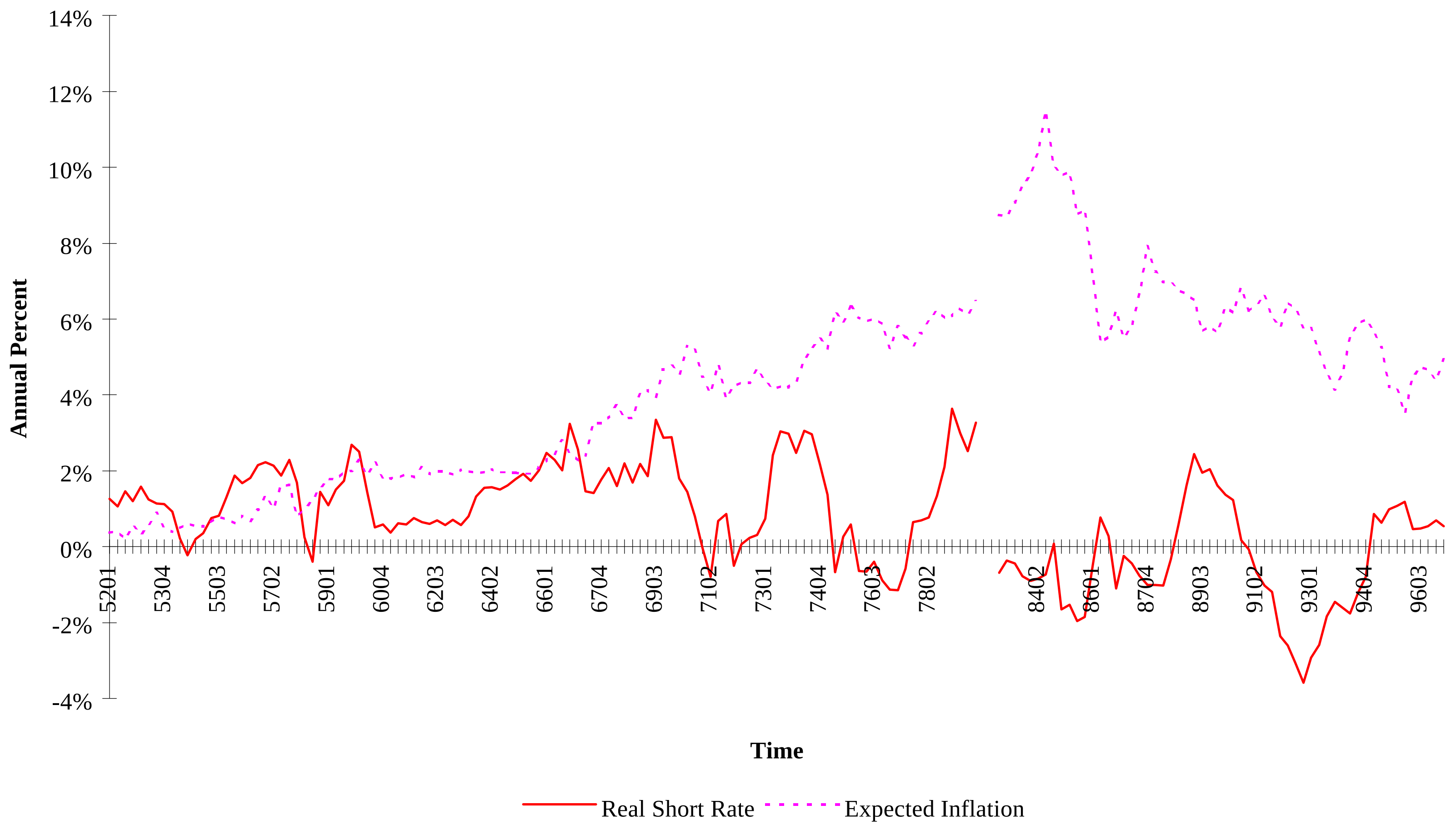

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Exhibit 19

Comparison of Theoretical and Sample Moments
Sample: 1952:1-1997:3

Measured Variables in Estimation: (3 mo.,1yr,5yr,10yr Yields)

Excess Returns

	Mean		Standard Deviation	
Maturity	Theoretical	Sample	Theoretical	Sample
3-Month	0.000	0.000	0.000	0.000
6-Month	0.151	0.204	0.529	0.530
1-Year	0.396	0.356	1.441	1.463
2-Year	0.730	0.466	2.856	2.974
5-Year	1.149	0.478	5.828	6.159
10-Year	1.259	0.215	10.208	10.326

Yield Spread

	Mean		Standard Deviation	
Maturity	Theoretical	Sample	Theoretical	Sample
3-Month	0.000	0.000	0.000	0.000
6-Month	0.075	0.224	0.059	0.107
1-Year	0.207	0.421	0.163	0.202
2-Year	0.412	0.629	0.324	0.304
5-Year	0.766	0.929	0.585	0.465
10-Year	1.002	1.122	0.747	0.564

Change in Yield

	Mean		Standard Deviation	
Maturity	Theoretical	Sample	Theoretical	Sample
3-Month	0.000	0.020	0.000	0.493
6-Month	0.000	0.020	0.533	0.500
1-Year	0.000	0.022	0.483	0.470
2-Year	0.000	0.023	0.411	0.416
5-Year	0.000	0.024	0.308	0.320
10-Year	0.000	0.023	0.262	0.262

NOTES:
(1) All results are in % per year.
(2) Monthly Zero Coupon Yields are from McCulloch & Kwon up to end of February 1991.
For subsequent years, yields are from the Federal Reserve Bank of New York.
(3) Quarterly sampling is used for parameter estimates.
(4) Excess returns are defined as rnt+1-y1t, the yield spread is defined as ynt-y1t
and the change in yield is defined as yn,t+1-ynt, where, n is the bond's maturity.

Exhibit 20

Comparison of Theoretical and Sample Moments
Sample: 1952:1-1979:4 and 1983:1-1997:3

Measured Variables in Estimation: (3 mo.,1yr,5yr,10yr Yields)

Excess Returns

	Mean		Standard Deviation	
Maturity	Theoretical	Sample	Theoretical	Sample
3-Month	0.000	0.000	0.000	0.000
6-Month	0.142	0.193	0.366	0.344
1-Year	0.382	0.355	1.008	1.048
2-Year	0.725	0.477	2.049	2.240
5-Year	1.188	0.505	4.522	4.974
10-Year	1.296	0.234	8.617	8.720

Yield Spread

	Mean		Standard Deviation	
Maturity	Theoretical	Sample	Theoretical	Sample
3-Month	0.000	0.000	0.000	0.000
6-Month	0.071	0.214	0.044	0.089
1-Year	0.198	0.425	0.123	0.164
2-Year	0.403	0.650	0.249	0.255
5-Year	0.776	0.987	0.470	0.407
10-Year	1.028	1.205	0.621	0.505

Change in Yield

	Mean		Standard Deviation	
Maturity	Theoretical	Sample	Theoretical	Sample
3-Month	0.000	0.021	0.000	0.323
6-Month	0.000	0.022	0.368	0.333
1-Year	0.000	0.023	0.338	0.339
2-Year	0.000	0.025	0.295	0.314
5-Year	0.000	0.025	0.239	0.258
10-Year	0.000	0.025	0.222	0.221

NOTES:
(1) All results are in % per year.
(2) Monthly Zero Coupon Yields are from McCulloch & Kwon up to end of February 1991.
For subsequent years, yields are from the Federal Reserve Bank of New York.
(3) Quarterly sampling is used for parameter estimates.
(4) Excess returns are defined as rnt+1-y1t, the yield spread is defined as ynt-y1t
and the change in yield is defined as yn,t+1-ynt, where, n is the bond's maturity.

Exhibit 21(a)
Paths of Nominal Interest Rates and Spread Following Positive Shock to Long Rate
Sample: 1952:1-1997:3

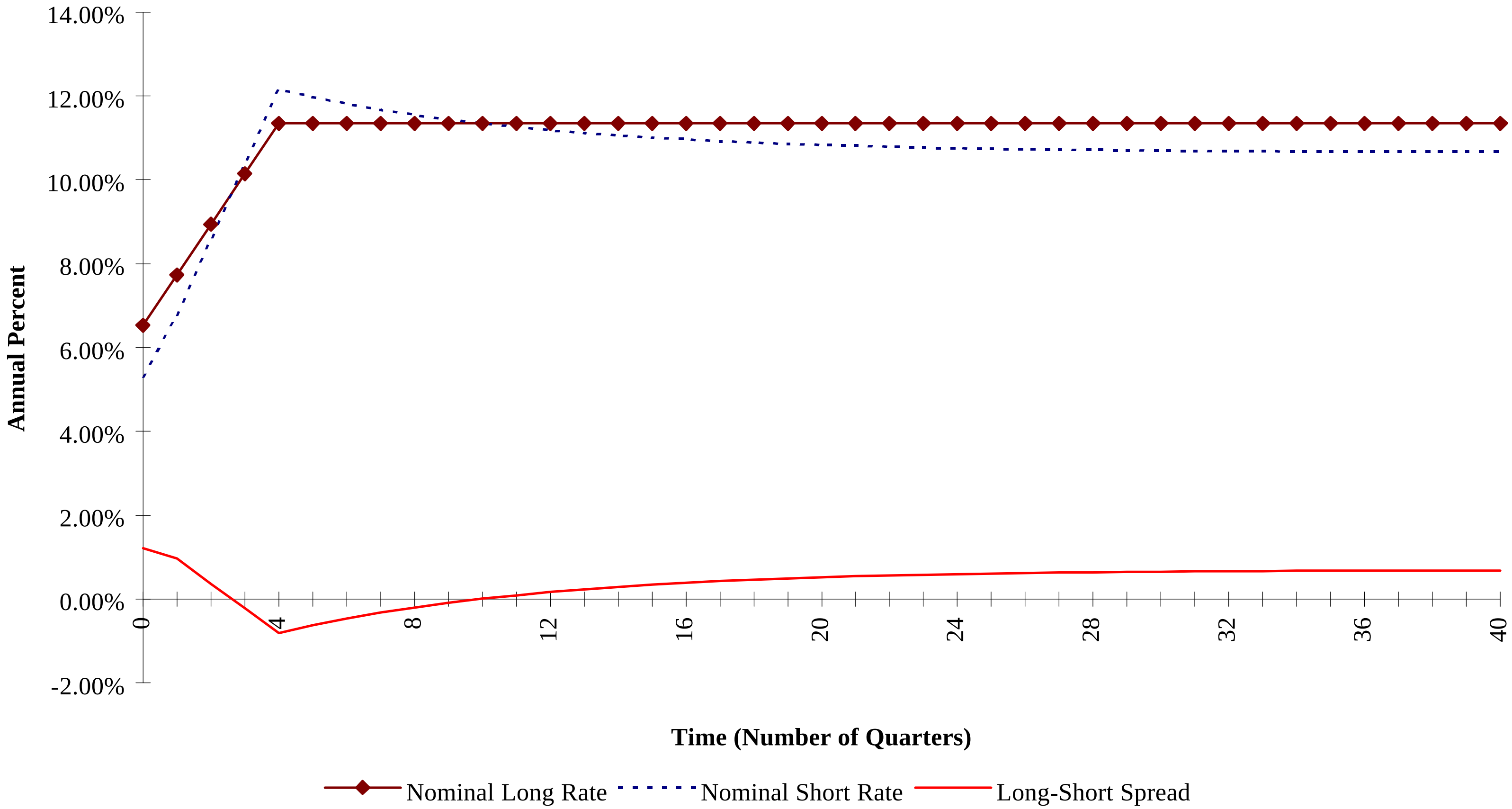

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Exhibit 21(b)
Paths of Nominal Interest Rates and Spread Following Negative Shock to Long Rate
Sample: 1952:1-1997:3

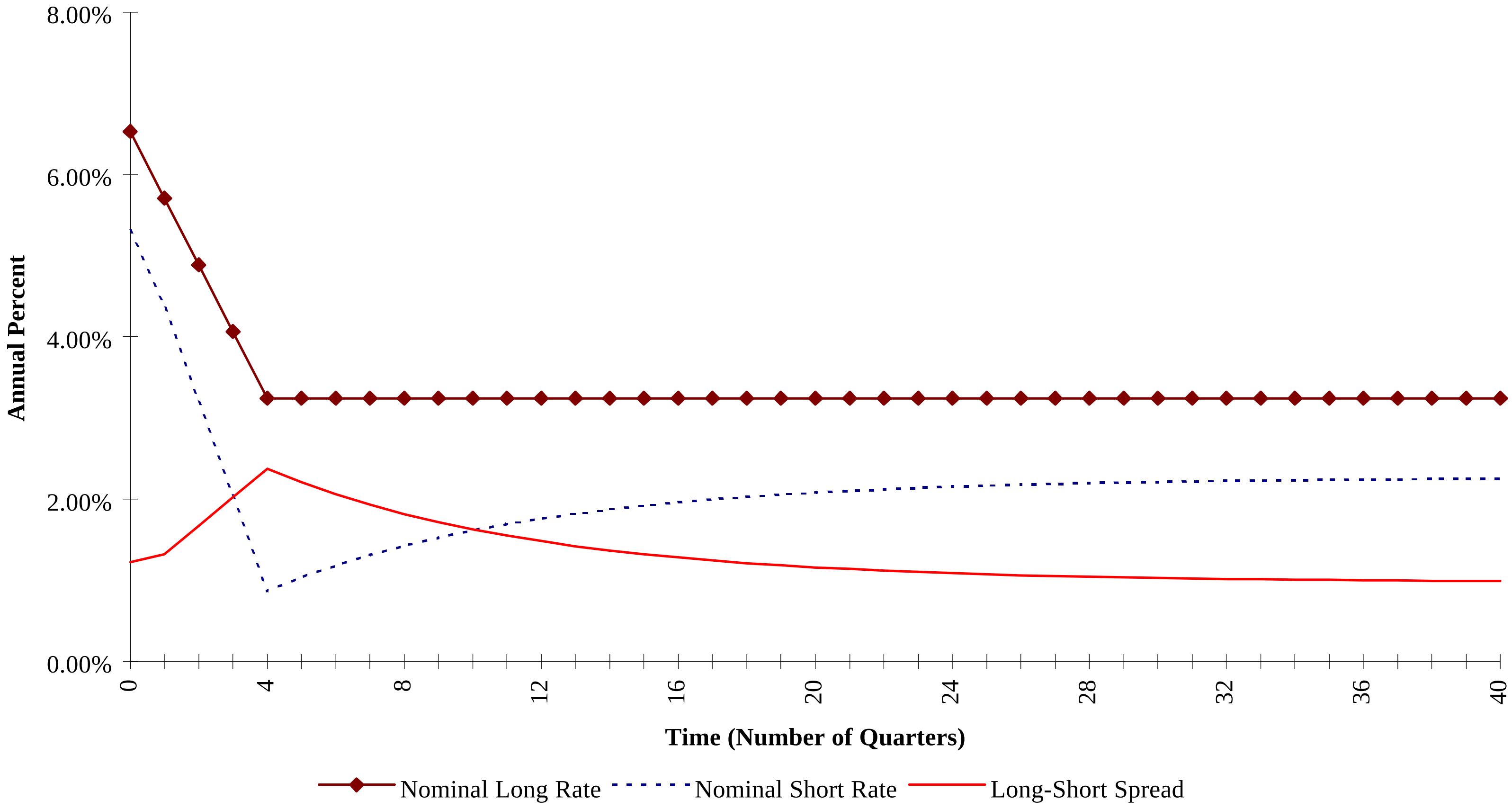

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Exhibit 22(a)
Paths of Real Interest Rate and Expected Inflation Following Positive Shock to Long Rate
Sample: 1952:1-1997:3

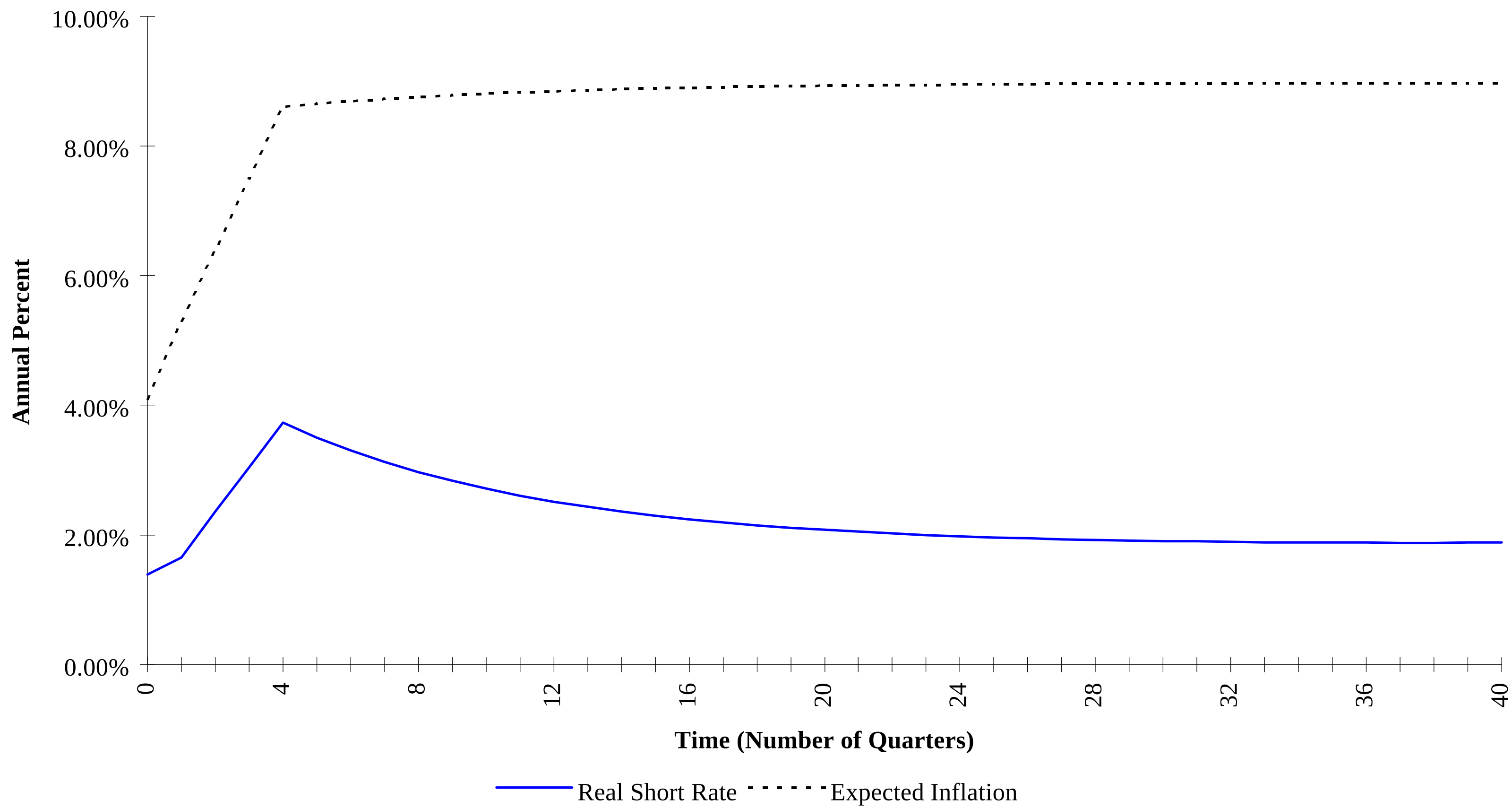

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Exhibit 22(b)
Paths of Real Interest Rate and Expected Inflation Following Negative Shock to Long Rate
Sample: 1952:1-1997:3

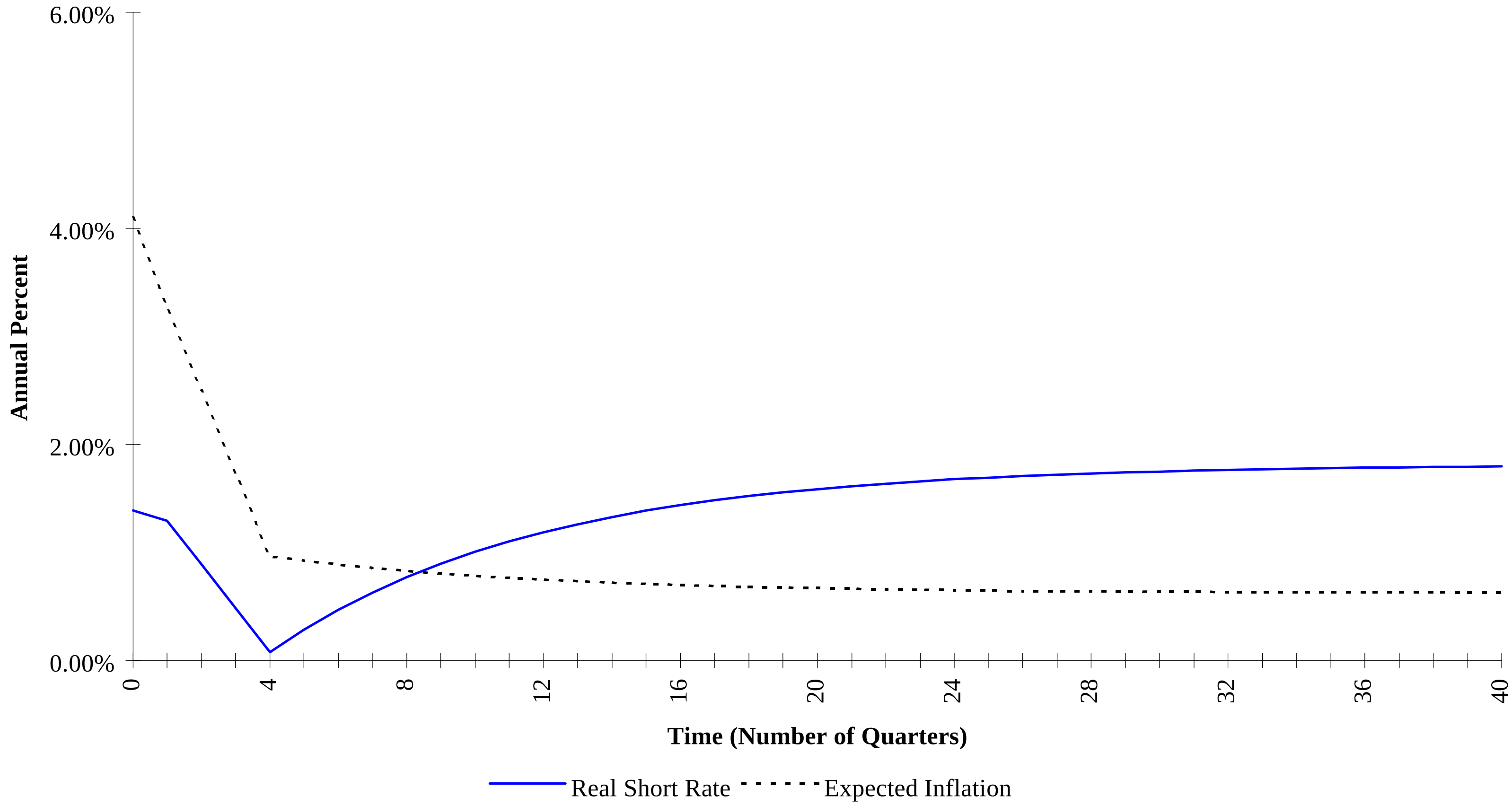

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Exhibit 23(a)
Paths of Nominal Interest Rates and Spread Following Positive Shock to Long Rate
Sample: 1952:1-1979:4 and 1983.1-1997:3

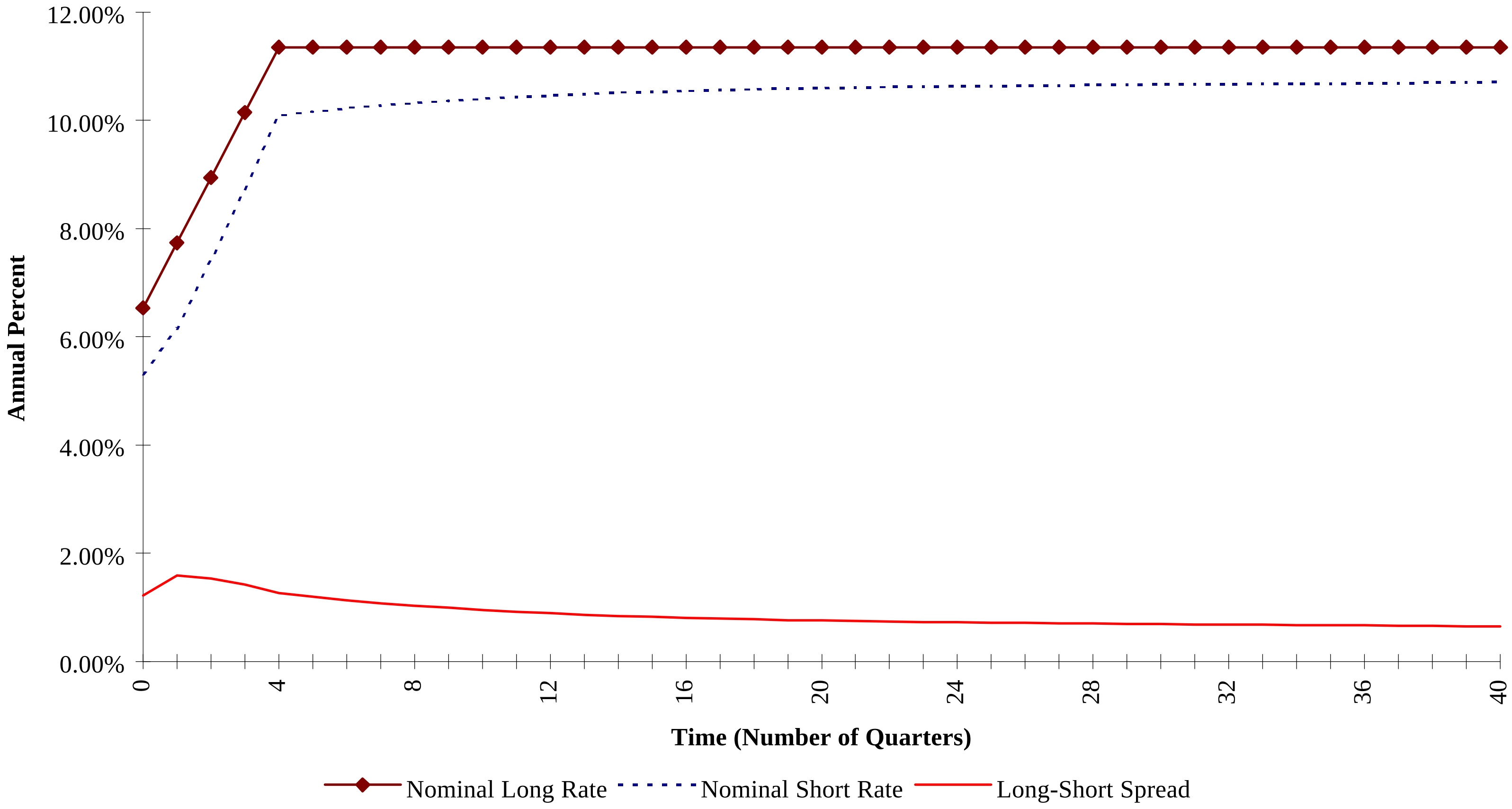

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Exhibit 23(b)
Paths of Nominal Interest Rates and Spread Following Negative Shock to Long Rate
Sample: 1952:1-1979:4 and 1983.1-1997:3

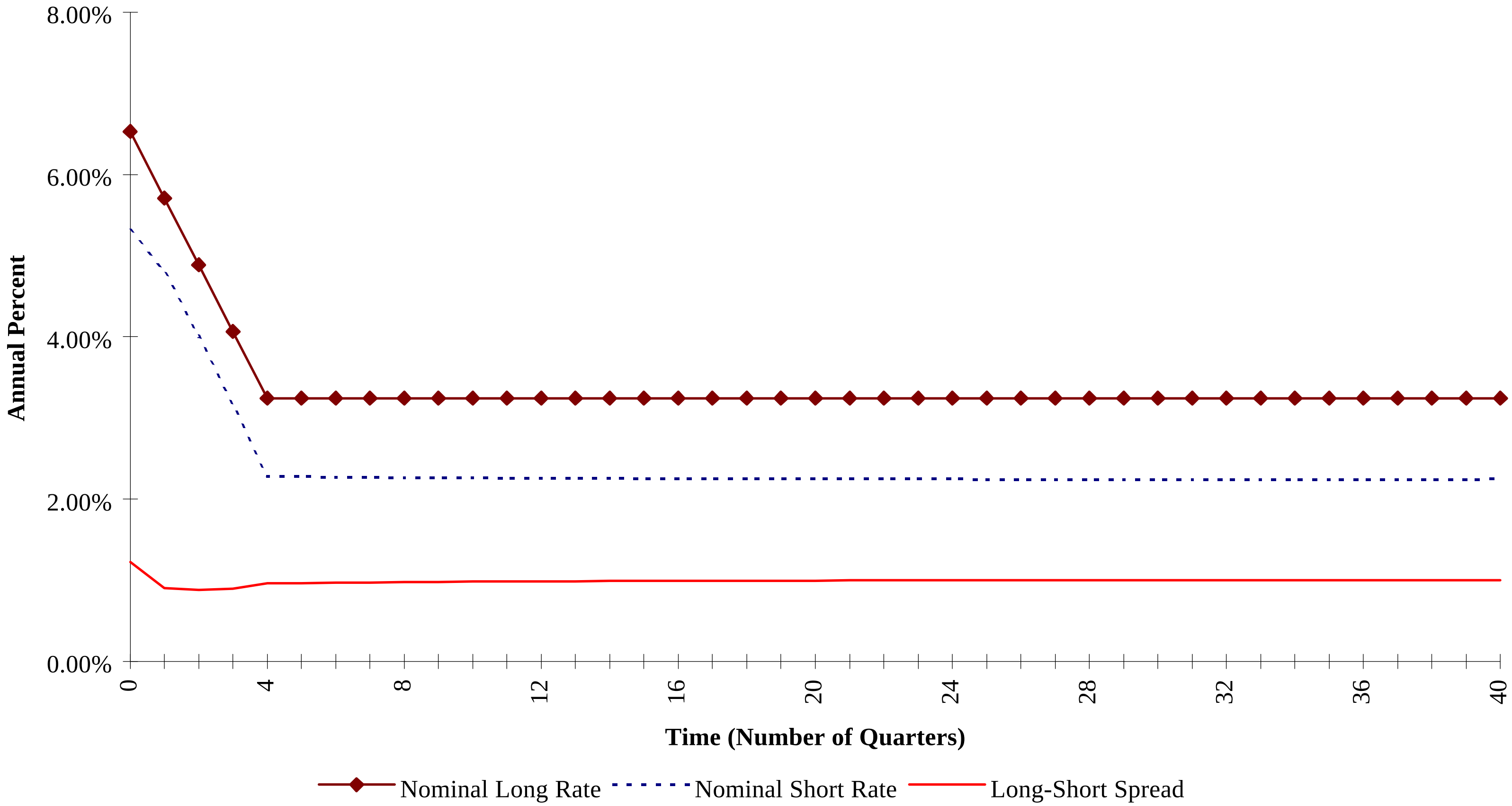


Exhibit 24(a)

Paths of Real Interest Rate and Expected Inflation Following Positive Shock to Long Rate

Sample: 1952:1-1979:4 and 1983.1-1997:3

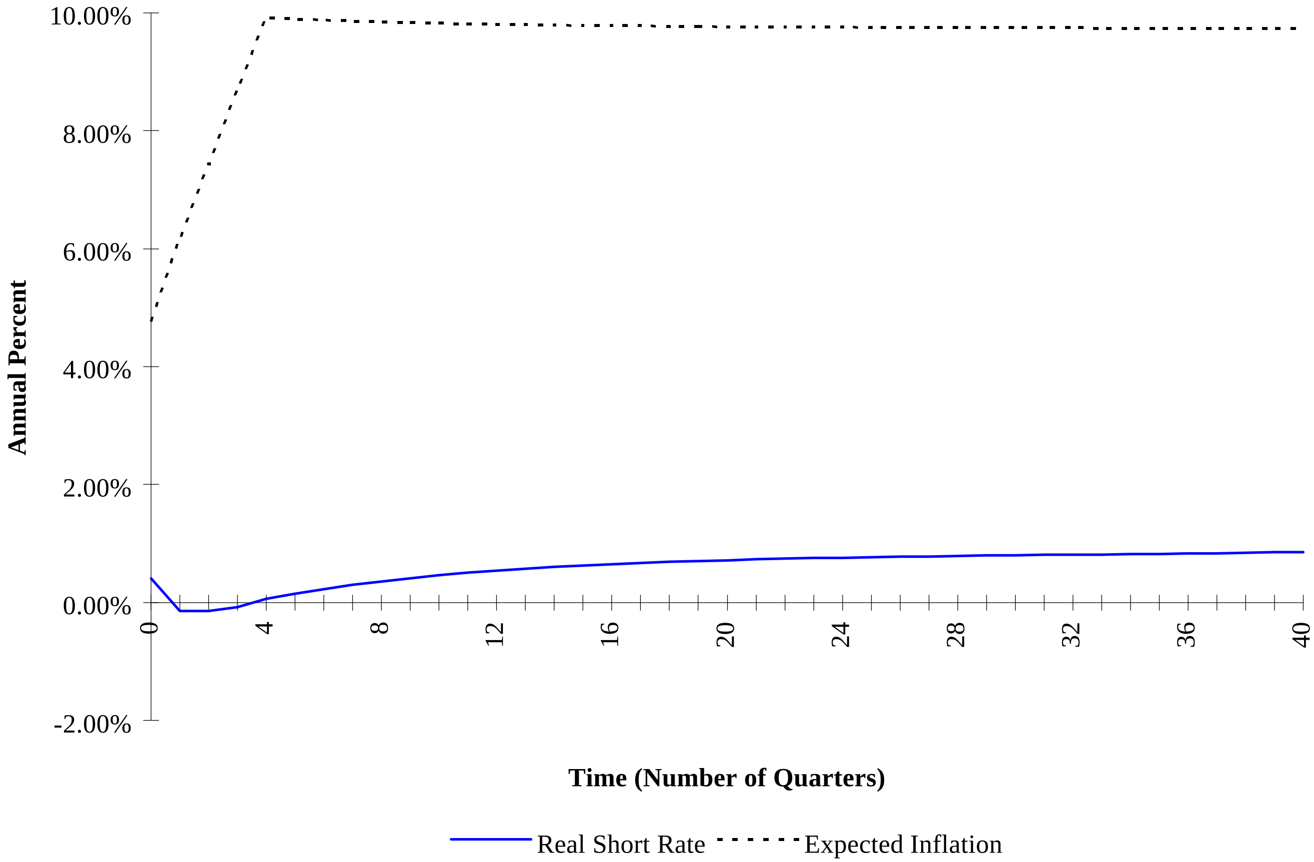
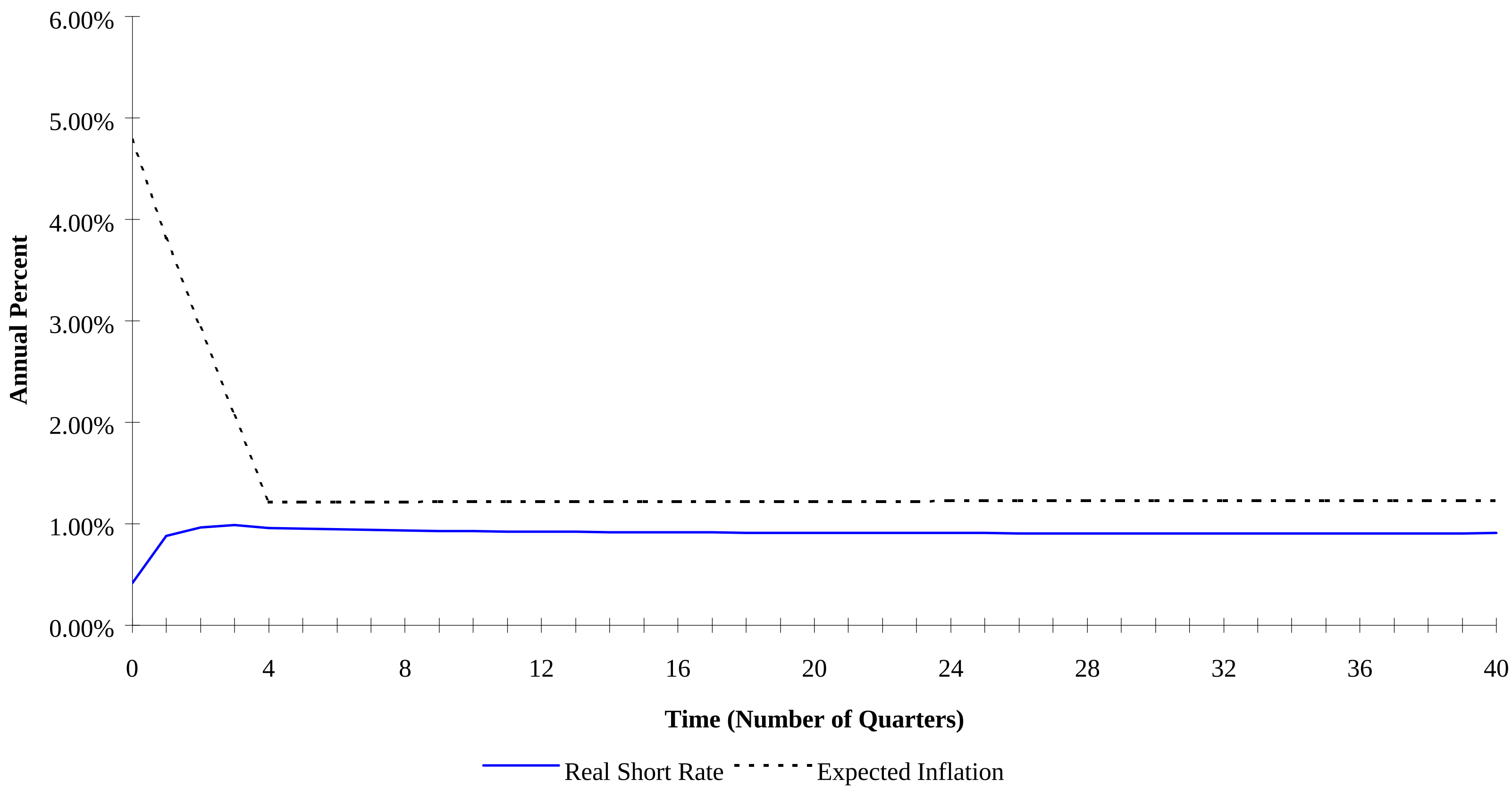


Exhibit 24(b)
Paths of Real Short Rate and Expected Inflation Following Negative Shock to Long Rate
Sample: 1952:1-1979:4 and 1983.1-1997:3



ANALYSIS GROUP/ECONOMICS

Exhibit 25(a)

Regression Analyses of Response of
Yield Spread to a Positive Shock of 482 basis points

Initial Long Rate	6.53%
Initial Short Rate	5.31%
Initial Spread	1.22%

		1 Quarter	1 Year	4 Years
Contemporaneous Regression Models	Long Rate	7.74%	11.35%	
(a) Full Sample OLS	Short Rate	6.75%	10.47%	
	Spread	0.99%	0.88%	
(b) 1952:2 to 1979:4, 1983:2 to 1997:3 OLS	Short Rate	6.24%	9.94%	
	Spread	1.50%	1.41%	
(c) WLS (weighted by the square root of the lagged short rate)	Short Rate	6.70%	11.00%	
	Spread	1.04%	0.35%	
(d) GARCH(1,1)	Short Rate	6.10%	11.09%	
	Spread	1.64%	0.26%	
VAR Models				
(a) Full Sample OLS	Long Rate	7.74%	11.16%	11.32%
	Short Rate	6.84%	10.84%	10.12%
	Spread	0.90%	0.32%	1.20%
(b) 1952:2 to 1979:4, 1983:2 to 1997:3 OLS	Long Rate	7.74%	11.30%	11.54%
	Short Rate	6.30%	10.41%	10.47%
	Spread	1.44%	0.89%	1.07%
(c) WLS (weighted by the square root of the lagged short rate)	Long Rate	7.74%	11.33%	11.52%
	Short Rate	6.75%	11.35%	10.39%
	Spread	0.99%	-0.02%	1.13%
(d) WLS (weighted by GARCH standard error)	Long Rate	7.74%	11.38%	11.84%
	Short Rate	6.39%	10.71%	10.93%
	Spread	1.35%	0.67%	0.91%
(e) GARCH(1,1)	Long Rate	7.74%	11.09%	11.21%
	Short Rate	6.36%	10.22%	10.07%
	Spread	1.38%	0.87%	1.14%

Exhibit 25(b)

Regression Analyses of Response of Yield Spread to a Negative Shock of 329 basis points

Initial Long Rate	6.53%
Initial Short Rate	5.31%
Initial Spread	1.22%

		1 Quarter	1 Year	4 Years
Contemporaneous Regression Models	Long Rate	5.71%	3.24%	
(a) Full Sample OLS	Short Rate	4.33%	1.79%	
	Spread	1.38%	1.45%	
(b) 1952:2 to 1979:4, 1983:2 to 1997:3 OLS	Short Rate	4.68%	2.15%	
	Spread	1.03%	1.09%	
(c) WLS (weighted by the square root of the lagged short rate)	Short Rate	4.37%	1.43%	
	Spread	1.34%	1.81%	
(d) GARCH(1,1)	Short Rate	4.78%	1.36%	
	Spread	0.93%	1.88%	
VAR Models				
(a) Full Sample OLS	Long Rate	5.71%	3.37%	3.26%
	Short Rate	4.27%	1.54%	2.03%
	Spread	1.44%	1.83%	1.23%
(b) 1952:2 to 1979:4, 1983:2 to 1997:3 OLS	Long Rate	5.71%	3.27%	3.11%
	Short Rate	4.63%	1.83%	1.79%
	Spread	1.08%	1.44%	1.32%
(c) WLS (weighted by the square root of the lagged short rate)	Long Rate	5.71%	3.25%	3.12%
	Short Rate	4.33%	1.19%	1.84%
	Spread	1.38%	2.06%	1.28%
(d) WLS (weighted by GARCH standard error)	Long Rate	5.71%	3.22%	2.91%
	Short Rate	4.57%	1.62%	1.47%
	Spread	1.14%	1.60%	1.44%
(e) GARCH(1,1)	Long Rate	5.71%	3.42%	3.34%
	Short Rate	4.60%	1.96%	2.06%
	Spread	1.11%	1.46%	1.28%

Exhibit 26

Term Structure Model Analyses of
Response of Interest Rates, Spread, and Expected Inflation

Response to Positive Shock of 482 basis points

	1952:1-1997:3			1952:1-1979:4 and 1983:1-1997:3		
	1 Quarter	1 Year	4 Years	1 Quarter	1 Year	4 Years
Long Rate	7.74%	11.35%	11.35%	7.74%	11.35%	11.35%
Short Rate	6.76%	12.16%	10.96%	6.15%	10.09%	10.54%
Spread	0.97%	-0.81%	0.39%	1.59%	1.26%	0.81%
Real Short Rate	1.65%	3.73%	2.24%	-0.14%	0.06%	0.65%
Expected Inflation	5.29%	8.61%	8.90%	6.17%	9.92%	9.78%

Response to Negative Shock of 329 basis points

	1952:1-1997:3			1952:1-1979:4 and 1983:1-1997:3		
	1 Quarter	1 Year	4 Years	1 Quarter	1 Year	4 Years
Long Rate	5.71%	3.24%	3.24%	5.71%	3.24%	3.24%
Short Rate	4.39%	0.87%	1.96%	4.81%	2.28%	2.25%
Spread	1.32%	2.37%	1.28%	0.90%	0.96%	0.99%
Real Short Rate	1.29%	0.08%	1.44%	0.88%	0.96%	0.91%
Expected Inflation	3.27%	0.96%	0.70%	3.81%	1.21%	1.22%

NOTES:

The initial long rate is 6.53%, the nominal short rate is 5.31% and the implied long-short spread is 1.22%.

The initial real short rate is 1.39% and expected inflation is 4.10%.

The real short rate is interpreted as the hypothetical rate on a fully inflation-protected bill. The nominal short rate in the model is equal to the real rate plus expected inflation plus a small inflation risk premium.

APPENDIX 4

"Consistent Macroeconomic Conditions for a Risk-Based Capital Stress Test"

Michael R. Darby

1997

June 6, 1997

Consistent Macroeconomic Conditions for a Risk-Based Capital Stress Test

Michael R. Darby
Warren C. Cordner Professor of Money and Financial Markets, UCLA

ABSTRACT--This paper describes changes in the macroeconomic environment consistent with a 600 basis point increase in 10-year T-bond yields maintained for 10 years. Since these yields are themselves endogenous variables, alternative exogenous sources of such a large increase are considered and it is concluded that a preannounced, credible shift toward a more inflationary monetary-policy regime is the only plausible source. The increase in the inflation rate corresponding to the assumed yield change would be 75 to 100 percent as large, or 450 to 600 basis points. The preannounced, credible shift in monetary policy minimizes the mitigating effects of lower unemployment early in the stress test.

Stress tests have become a standard tool for assessing adequacy of capital for financial institutions (Global Derivatives Study Group [G-30] 1993 and Darby 1997). Appropriate stress tests provide a superior approach to capital requirements based on schedules of fixed percentages of liabilities (and sometimes assets) because they allow for realistic co-movements among correlated prices in response to realizations of alternative, states of the world instead of inducing financial institutions to game scheduled capital requirements where risk is underpriced by the schedule or shrinking the regulated firms where risk is overpriced.

Certain scenarios for stress-test simulations can be adequately derived from straightforward estimates of the variance-covariance matrix for the relevant markets. More often, stress tests are used to assess changes associated with extraordinary changes in the state of the world, such as when price gapping occurs in assessment of risks of a dynamically managed derivatives portfolio. In these cases estimates can be biased by the "peso problem" associated with policy regime changes and macroeconomic theory is useful for design of the stress test.

The Federal Housing Enterprises Financial Safety and Soundness Act of 1992 (FHEFSSA) requires (Sec. 1361 [12 U.S.C. §4611]) that the Director of the Office of Federal Housing Enterprise Oversight (OFHEO) establish a risk-based capital test to determine the amount of total capital for a regulated enterprise which is sufficient to maintain positive capital throughout a 10-year "stress period" during which the 10-year constant maturity Treasury (CMT) yield increases in the first year and remains thereafter at 600 basis points above the average yield during the nine months preceding the stress period. The Director is instructed by the Act to adjust the losses "to reflect a correspondingly higher rate of general price inflation." Thus, the statute contemplates an economically sophisticated stress-test scenario in which interest and inflation rates move together in accordance with economic theory.[1]

This paper develops the scenario appropriate to that stress test and, thereby, a methodology for other analyses of regime shifts. Since both the bond yield and

[1] In fact, the FHEFSSA has additional provisions which (a) increase the size of the interest shock to 60 percent of the average 10-year CMT yield during the preceding 3 years if that amount is larger than 600 basis points, but (b) limit the shock in either case to no more than 75 percent of the average 10-year CMT yield during the preceding 9 months. As a result the actual stress test applied might be for somewhat larger or smaller interest rate shocks than 600 basis points. Since the difference is not likely to be large, we shall stick to the simpler specification for the current exposition. Finally, the OFHEO Director is required to adjust for correspondingly higher inflation only where the shock is more than 50 percent of the average 10-year CMT yield during the prior 9 months; thus only in extraordinary cases of high and fast rising interest rates does the Director have an option not to adjust for inflation and exercise of that option would be nonsensical given the assumption that the interest rate increase is maintained for ten years.

inflation rate are themselves endogenous variables, the first section discusses the exogenous sources of such a large increase in the bond yield and concludes it should be associated with a credible, preannounced shift toward a more inflationary monetary-policy regime. The next section discusses the inflation rate increase corresponding to the assumed yield change. The third section considers short- and long-run Phillips curve effects on the unemployment rate and their implications for both interpreting the legislated stress test and designing more sophisticated alternatives. The final section concludes the analysis with a canonical statement of the macroeconomic environment which is consistent -- based on U.S. experience -- with the assumed change in 10-year T-bond yields.

I. Defining the Policy Regime Shift for the Stress Test

A 600 basis point increase in interest rates persisting for 10 years certainly qualifies as an unusual event, but one which can be well characterized. The persistence of the increase rules out the possibility that this increase is due to a major tightening of monetary policy, since such a tightening would only temporarily raise rates before lowering them in the long run (Darby 1975). The large size of the increase rules out moves in the real interest rate due to productivity shocks. Despite the globalization of financial markets, U.S. real interest rates do appear to differ from those abroad by a variable risk premium or discount, but this difference is of too small an order of magnitude for its movements to account for a persistent 600 point increase in interest rates. That is, there is no realistic prospect that real interest rate movements are contemplated in the scenario: The only realistic scenario implying a persistent 600 basis point increase in interest rates is a substantial increase in the Federal Reserve System's money growth and/or inflation rate target(s) at the beginning of the stress period.

The main question is to determine the amount of the increase in inflation associated with a 600 basis point increase in the 10-year constant maturity Treasury yield. The typical response to increased money growth is for inflation to rise gradually but still more rapidly than inflationary expectations during an extended adjustment to the changed regime with the unemployment rate initially lowered.[2] However, this scenario would not provide as much stress to the regulated institutions and is inconsistent with the maintained assumption that the rate of interest rises 600 basis points in the first year of the stress period. A more appropriate and conservative stress test would adopt the assumption that the change in inflation target is credibly announced at the time the change is made so that the effects on the real economy are minimized and the effects on actual and expected inflation are accelerated.[3] Therefore, a credible, preannounced change in monetary regime at the beginning of the stress period is adopted as the "worst case" exogenous source of the prescribed increase in interest rates.

II. Determining the Corresponding Increase in Inflation

[2] For a fuller analysis of the standard macrodynamics, see Darby (1976, 1979) and Darby and Melvin (1986).

[3] Alternatively, one might assume that the change in inflation target occurred some years before the stress period which begins only as inflationary expectations and interest rates rapidly adjust. However, that alternative still involves a catch-up period with the increase in the inflation rate overshooting both its steady-state change and the change in interest rates. Preference for avoiding complicated dynamics and choosing the more stressful of the plausible alternatives both argue for the simpler assumption of a credible, preannounced change in monetary regime.

The assumed credible, preannounced change in monetary regime implies that we can examine the changes in inflation and interest rates in terms of their steady-state relationship. Thus we turn to the basic tax-adjusted Fisher equation developed in Darby (1975) and Feldstein (1976). This equation states that the interest rate **i** equals the sum of the (before-tax) real interest rate **r** and the expected inflation rate p divided by **(1-*T*)** where ***T*** is the net tax rate on the transfer of income tax liability with the inflation premium:

(1) $$\mathbf{i = r + \pi/(1-}\boldsymbol{T}\mathbf{)}$$

We can use (1) to find the change in the expected inflation rate Δp corresponding to a given change in the level of interest rates Δ**i**:

(2) $$\Delta p = (1 - T)\Delta \mathbf{i}$$

The change in the actual inflation rate is identical to the change in the expected inflation rate in the steady state; so the value of the net tax rate ***T*** is the crucial parameter in determining the "correspondingly higher rate of general price inflation" required for implementing the stress test.[4]

Early attempts to estimate **1/(1-*T*)**, the coefficient of π in equation (1), typically resulted in values insignificantly different from and not infrequently less than 1. These results could be interpreted to imply that ***T*** = 0, that the simple Fisher equation (**i** = **r** + π)

[4] FHEFSSA refers to an unspecified "rate of general price inflation" which could equally well refer to the implicit price deflator for gross domestic product or the consumer price index. Biases in the latter have received much attention lately, and some of them are also present in the GDP deflator. Nonetheless, there is no presumption that the biases in either measure would change with a shift to a more inflationary regime so the predicted change in inflation rates can be applied to either concept.

is applicable, and that the inflation rate should change one for one with the change in interest rates. However, these estimated coefficients (and thus the implied value of τ) suffered from downward errors-in-the-variables bias because only estimated values were available for expected inflation. Recent work by Crowder and Hoffman (1996) shows that using the fully efficient Johansen (1988) estimator for cointegrated series results in an estimated value of 1.34 for $\mathbf{1/(1-\tau)}$ implying that $\tau = 0.25$.[5] While pride of paternity for the so-called Darby effect leads me to favor the latter estimates, perhaps for the current purposes it is safest to say that the literature supports a range of estimates for τ from 0 to 0.25 and the stress test should consider alternative inflation rates corresponding to that range.

In conclusion, the "correspondingly higher rate of general price inflation" required for implementing the stress test lies between 75 and 100 percent of the assumed increase in the 10-year CMT yield, or a 450 to 650 basis point increase for the 600 basis point test.

III. Changes in Unemployment Rate

The OFHEO Director is not explicitly required by law to consider in the stress test any corresponding changes in the unemployment rate. This omission is consistent with and supports the conclusion that the macroeconomic shock underlying the stress test is a credible, preannounced change in the Federal Reserve System's

[5] Crowder and Hoffman (1996) also provide an up-to-date review of the empirical literature.

inflation target so that macroeconomic theory would predict *de minimis* deviations of actual and expected inflation and hence actual and normal unemployment rates. If instead, we were to consider an unannounced change in inflation or monetary growth targets, then it would be necessary to more fully specify the adjustment of inflationary expectations underlying the short-run Phillips curve and to come to a conclusion as to whether the long-run Phillips curve is precisely vertical or characterized by a small positive or negative slope.

Allowing for temporary reductions in unemployment corresponding to an easier monetary policy would have the effect of decreasing mortgage defaults during the early years of the stress test with an uncertain effect in later years. Suppose for example that the gap between actual and expected inflation is eliminated at the end of the second year. Then the arguments in Darby, Haltiwanger, and Plant (1985) imply that the reduction in unemployment thereafter will be attenuated geometrically over time. Other expectation adjustment assumptions and/or models of unemployment dynamics (e.g., Davis, Haltiwanger, and Schuh 1996) would result in alternative cycles in the unemployment rate. Besides these uncertainties, there is also the controversy over whether the long-run Phillips curve is strictly vertical or has a slight negative or positive slope. On balance, allowing for unannounced and/or not credible increases in inflation targets and the corresponding unemployment rate changes would reduce the stringency of the stress test.

Consideration of unemployment dynamics suggests that the interest-rate-risk stress test mandated in FHEFSSA as interpreted here may be unnecessarily complicated for the regulated institutions. It remains an issue for future analysis to develop alternative macroeconomic scenarios which may be more likely to occur than the credible, preannounced inflation target increase implicit in FHEFSSA. The trend in financial regulation is toward requiring large financial institutions to develop their own risk analysis and control systems and to audit the actual performance of those systems. Were a more sophisticated regulatory framework adopted in the future, it would be clearly appropriate for the regulated institutions to allow for the predictable reductions in defaults associated with a transition to a more inflationary, higher interest-rate environment.

IV. Conclusions

This paper has considered the macroeconomic conditions underlying the 600-basis-point interest rate increase imposed by FHEFSSA. The most appropriate exogenous source of such a large change in interest rates is a credible, preannounced step increase at the beginning of the period in the Federal Reserve System's inflation target by an amount equal to the product of one minus the tax rate implicit in the tax adjusted Fisher equation and 600 basis points: that is by 450 to 600 basis points. Under this assumption the corresponding increase in the actual rate of general price inflation would be the same 450 to 600 basis points.

Alternative specifications of the underlying shock are either incredible as sources of such a large increase in interest rates sustained for ten years or else would result in lower capital needs for the regulated institutions due to induced temporary reductions in the unemployment rate.

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APPENDIX 5

"House Prices Under Alternative Interest Rate Paths"

Macroeconomic Advisors, LLC

1999

House Prices under Alternative Interest Rate Paths

by

Macroeconomic Advisers, LLC

January 18, 1999

Summary

Six years ago Congress passed and President Bush signed into Law The Federal Housing Enterprises Financial Safety and Soundness Act of 1992 (FHEFSSA, or the Act). Under Section 1361 [12 U.S.C. 4611]) of the Act, the Director of the Office of Federal Housing Enterprise Oversight (OFHEO) must determine the amount of capital sufficient for a regulated enterprise to endure ten years with interest rates as much as 600 basis points higher or lower than immediately before the "stress period." To help it prepare for this regulatory capital requirement, in May of 1997 Freddie Mac contracted Macroeconomic Advisers, LLC to build a model of the housing market that relates house prices not only to factors specific to the housing market but also to general macroeconomic conditions, including the rate of interest.

This paper briefly summarizes that model, describes the plausibility of the prescribed interest rate scenarios, and presents the most probable behavior of house prices in the "up-rate" scenario described in the Act. Nothing even approaching the sustained increase in interest rates contemplated in FHEFSSA has occurred in the United States since World War II. Furthermore, macroeconomic conditions under which such an increase might occur are extremely unlikely to occur. However, the most plausible scenario involving a sharp rise in the interest rate is one in which there is an accompanying change in the general rate of inflation that leaves the real interest rate relatively unchanged. In this case, nominal house prices increase, not only above current levels but also relative to a baseline scenario that assumes a constant 2.5% rate of appreciation in house prices.

Overview of the Housing Model

Macroeconomic Advisers, LLC has built a model of the housing sector that is intended to help Freddie Mac understand the stresses on its portfolio of mortgages that could arise under scenarios described in FHEFSSA involving extreme, persistent changes in interest rates. The model is quite general, and so also is useful for assessing the effect on housing values of, say, a major tax reform or even the impact of cyclical variations in interest rates and disposable income. Salient features of the model are described below.[1]

In the model, the demand for housing is an increasing function of real income and an inverse function of the real rental-equivalent cost of housing services. Housing services are produced with the current supplies of land and structures. In the short run these supplies are fixed. In the long run, however, the supplies of land and structures can vary positively with their own real price, and substitution between land and structures is possible in the production of housing services. The distinction between land and structures is potentially important. Their costs can respond differently to changes in income, taxes and interest rates, and their price elasticity of supply might differ, too. Therefore, it is important to identify the part of housing values that is explained by the price of land separately from the part that is explained by the price of structures.

House prices are an average of the prices of land and structures. These are computed by equating the derived demands for each with their supplies. The derived demands depend upon seven factors. First is the real price of structures and land. Second is the expected real price appreciation of structures and land. Third is the general rate of price inflation. Fourth are the depreciation and maintenance costs of structures and land. Fifth is the nominal after-tax opportunity cost of investing in housing. This is decomposed into a risk-free rate of return, approximated with the after-tax nominal yield on 10-year Treasury bonds, and a risk premium specific to housing. Sixth is the property tax rate. And seventh are tax deductions allowed for mortgage interest and property taxes.

[1] A detailed analytical exposition of the model is presented in Macroeconomic Advisers, LLC, "A Model of Housing Prices" (September 1998).

Over time, these supplies adjust toward their equilibrium values. As they do, both housing values and the supply of housing services adjust as well. The time-paths of prices can be calculated assuming that expectations of future prices are either myopic or forward-looking. Under myopic expectations, near-term movements of housing values caused by a shift in demand can be far larger than under forward-looking expectations. This is because under myopic expectations, participants in the housing market either fail to recognize the temporary nature of a change in demand or, if the change is permanent, fail to anticipate the eventual adjustment of supplies that offset the initial change in price.

How housing values vary in response to a drastic increase in the interest rate depends importantly on the long-run responses of the supplies of land and structures, how quickly those supplies adjust towards the new equilibrium, and the extent to which the adjustments are anticipated. Another important consideration is whether the increase in the interest rate is "nominal" or "real" in nature. If the rise in rates is real — that is, there is no corresponding increase in the expected rate of general price inflation — the initial impact on housing values is negative and can be large. If the rise in rates is purely inflationary — i.e., the bond yield and expected inflation rise together — then the initial impact on housing values is positive and can exceed the increase in inflation.

The housing model is coded into an Excel 97 workbook and so requires no specialized econometric or analytical software. This makes it simple to recalculate values of housing prices under different paths of interest rates and inflation and then display the results either in tables or in graphs that can be viewed directly on screen or printed to paper. It is also easy to modify the structure of the model if desired, or to perform sensitivity analyses. Therefore, while Macroeconomic Advisers, LLC initially have calibrated the model with what we believe are sensible values for all parameters within the system,[2] it is

[2] Baseline (i.e. 1997) values of the key variables and parameters in the model are as follows. The yield on Treasury bonds with a constant maturity of 10 years is 6.4%. The spread between the bond yield and the FHA insured 30-year fixed mortgage rate is 120 basis points. The general price level, measured as the chain-type price index for GDP, is 1.125. The nominal price of housing, measured by the Freddie Mac repeat sale index, is 1.49. The general inflation rate is 2.5%. The depreciation rate of structures is 1.54%, while land is assumed not to depreciate. The property tax rate is 1.42%. The weight of structures in the production of housing services is 72%. The marginal tax rate is 23%. The income elasticity of housing demand is 1.1, while the elasticity of the demand for housing services with respect to its own rental price is

straightforward to change quickly the assumed values of key elasticities before recalculating any scenario of interest.

Describing the Up-Rate Scenario

The up-rate scenario specified in the Act involves an immediate, extreme, and permanent (for ten years) rise in the yield on 10-year Treasury bonds. The constant-maturity yield on 10-year Treasury bonds increases to the greater of 600 basis points above the average yield during the preceding 9 months or 60% above the average yield during the preceding three years. In no case, however, should the increase be to a yield greater than 75% above the average yield during the preceding 9 months. For example, in December of 1997, the constant-maturity yield on 10-year Treasury bonds was 5.81%. The average during the last nine months of 1997 (April through December) was 6.3%. The average during the last three years (1995 through 1997) was 6.5%. If the stress test begins in January of 1998, a 600 basis point rise in the Treasury bond yield above the average of the last nine months is to 12.3%. A 60% rise above the average of the last three years is to 10.3%. A 75% rise above the average of the last nine months is to 11.0%. The guidelines for the stress test require the yield to rise to the higher of the first two levels provided it doesn't exceed the third. Therefore, during the stress test, the appropriate level of the Treasury bond yield beginning in 1998 is 11.0%. This is an increase of 460 basis points above the 1997 value of 6.4%, which serves as the baseline value in all of our experiments. In addition, if application of these guidelines results in an increase in yield to more than 50% above the average during the preceding 9 months, then FHEFSSA specifies that the stress test shall allow for a correspondingly higher rate of general price inflation. The magnitude of the inflation adjustment is left unspecified. There is more on this below.[3]

-0.47. The elasticity of substitution between land and structures is assumed to unitary. The supply of structures is assumed to be nearly perfectly elastic, while the supply of land is assumed to be nearly inelastic. The supplies of both land and structures adjust towards new equilibrium at 30% per year.

[3] FHEHSSA also describes a down-rate scenario in which there is an immediate and extreme decline in all nominal interest rates for a period of ten years. The constant maturity yield on 10-year Treasury bonds declines to the lesser of 600 basis points below the average yield during the preceding nine months or 60% below the average yield during the preceding 3 years. In no case, however, should the decrease be to a yield less 50% of the average yield during the preceding 9 months. For example, if the stress test begins in

What Could Cause a Sustained Increase in Interest Rates

In the United States, combinations of rapid real economic growth, bursts of inflation, expansionary fiscal policy, and restrictive monetary policy have, on occasion, coalesced in ways that produced sharp cyclical increases in interest rates. These have never been sustained for more than a few years and so do not correspond well to the scenarios described in FHEFSSA. Indeed, the kind of sustained increase in rates contemplated in the Act is a matter of theoretical conjecture rather than of historical experience.

A standard macroeconomic growth model identifies three potential sources of a sustained rise in the interest rate. First is faster productivity growth. Second is an increase in the structural budget deficit relative to potential GDP. Third is an anticipated, sustained increase in monetary growth that precipitates a corresponding increase in expected inflation.[4] Either an acceleration of productivity or a sustained fiscal expansion would cause an increase primarily in the real interest rate, but whether or not they are associated with a higher nominal interest rate rises depends on the response of our monetary authorities. An anticipated monetary expansion with higher inflation would cause primarily an increase in nominal interest rates without an increase in the real rate.[5]

Could real interest rates be pushed up permanently by the magnitudes contemplated in the stress test, either by an acceleration of productivity growth or a sustained fiscal

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January of 1998, a 600 basis point decline in the Treasury bond yield below the average of the last nine months is to 0.3%. A 60% decline below the average of the last three years is to 2.6%. A 50% decline below the average of the last nine months is to 3.2%. The guidelines for the stress test requires the yield to fall to the lower of the first two levels provided it isn't below the third. Therefore, during the stress test, the level of the Treasury bond yield beginning in 1998 is 3.2%. This is a decline of 320 basis points below the 1997 value of 6.4%. Guidelines for the down-rate scenario make no mention of an inflation adjustment.

[4] Recent financial turmoil in Asia also raises the question of whether a combination of large current account deficits, unsustainable fiscal and monetary policies might cause investors to lose confidence in the dollar and force the Federal Reserve to drive up domestic interest rates to defend the currency. Since ultimately it is inflation that undermines a currency, in the end this scenario must be the same as the monetary expansion (the third scenario above). Another scenario, in which the domestic banking system fails, is not necessarily associated with higher interest rates. For example, consider Japan where bank lending has practically ceased but the long-tem interest is the lowest recorded anywhere in the world since 1610.

[5] Real interest rates are not entirely independent of expected inflation because parts of the US income tax code are based on nominal values rather than real. In particular, depreciation deductions are based on the historical cost rather than replacements cost of capital, nominal inventory profits are taxed rather than real, nominal capital gains are taxed rather than real, firms can deduct nominal interest expenses, and households

expansion? It is unlikely. One tool maintained by Macroeconomic Advisers, LLC is a sophisticated and detailed computable dynamic general equilibrium (GE) model of the US economy. Simulations with the GE model reveal that for every extra percentage point of growth in labor productivity the equilibrium real interest rate rises by roughly the same amount — a familiar result in growth theory. Suppose that, as prescribed in the up-rate scenario, the real interest rate rose 460 basis points and remained at that higher level permanently because of stronger growth in labor productivity. This would require an increase in "trend" productivity growth from around 1.25% (the average of the last fifteen years) to around 6%. Six percent growth in productivity is twice the rate enjoyed even during the "golden era" of the 1960s, and is seldom exceeded even when the economy is in the early stages of a powerful cyclical recovery. A sustained increase in productivity growth this large is next to impossible.

Our GE model also suggests that for every one percentage point rise in the federal primary deficit (that is, federal outlays other than interest payments less federal receipts) as a share of potential GDP, the equilibrium real interest rate rises by about 100 basis points. Suppose that, as prescribed in the up-rate scenario, the real interest rate rose 460 basis points and remained there because of a sustained fiscal expansion. This would require a permanent in increase in the structural federal deficit as a percentage of potential GDP from roughly zero now to just shy of 5%. As a historical benchmark, CBO estimates that the post-war decade with the highest average federal deficits was 1983 through 1992, when the structural deficit averaged 3.7% of potential GDP. Hence, an up-rate scenario in which the real interest rate is driven up by 460 basis points for a decade would be unprecedented. At the same time, in its May, 1996, *Report on the Economic and Budget Outlook*, CBO did present projections suggesting that attempting to maintain current entitlement programs as the population ages could push the long-term interest rate up steadily after 2010 from 6% to 11% by 2030 as the deficit approaches 37% of GDP. However, that projected rise in rates is very gradual not, as required in the stress tests, immediate. In our model of the housing sector, this makes a big difference because in such a circumstance the supply of housing can gradually shrink to prevent a

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are taxed on nominal interest income.

large, immediate drop in real housing values. In short, while an eventual large increase in the real interest rate emanating from a sustained expansion of entitlements cannot be ruled out, it is not the scenario that FHEFSSA requires Freddie Mac to analyze.[6]

The sustained and rapid nature of the interest rate change in the FHEHSSA scenario argues for the third source of an interest increase: a monetary expansion and the corresponding rise of expected inflation that would push up nominal yields. To see the importance of inflation in determining large movements in nominal interest rates, consider figure 1. It shows since the early 1970s the 10-year government bond yield along with predicted values from a regression that uses as explanatory variables only current and past values of the "core" inflation rate (i.e., inflation net of the impact of changes in the prices of food and energy). Simple as it is, this regression picks up about 2/3 of the variation in long-term interest rates and makes clear that during the post-war period in the United States, fluctuations in inflation are the single most important cause of changes in the nominal interest rate. Obviously, a sustained inflation could produce a sustained increase in nominal interest rates. Furthermore, the rise in yields could occur quickly if the monetary authorities announced in advance their intention to inflate. It should also go without saying that this would be a colossal mistake in the implementation of monetary policy, and the Fed knows better than to make it.

The Up-Rate Scenario in Historical Perspective

The discussion above suggests that an up-rate episode like that described in FHEFSSA is very unlikely to occur. Post-war experience in the United States re-enforces that view. To see this, consider figure 2, the construction of which requires additional discussion. First, we gathered quarterly data on the yield on 10-year constant maturity Treasury bonds back to the early 1950s. Next, for each quarter we computed the increase in

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[6] CBO's analysis is not a forecast, only a simulation of what might happen if policies are not adopted to reduce the burden of entitlements. The simulation also shows that without corrective policies, real GDP per capita in the US could begin declining as early as 2010. We expect building political pressure for legislation to prevent such a decline in living standards, and this would mitigate or perhaps even eliminate the upward pressure on interest rates. This, of course, is what recently has been accomplished in response to the fiscal spree of the 1980s.

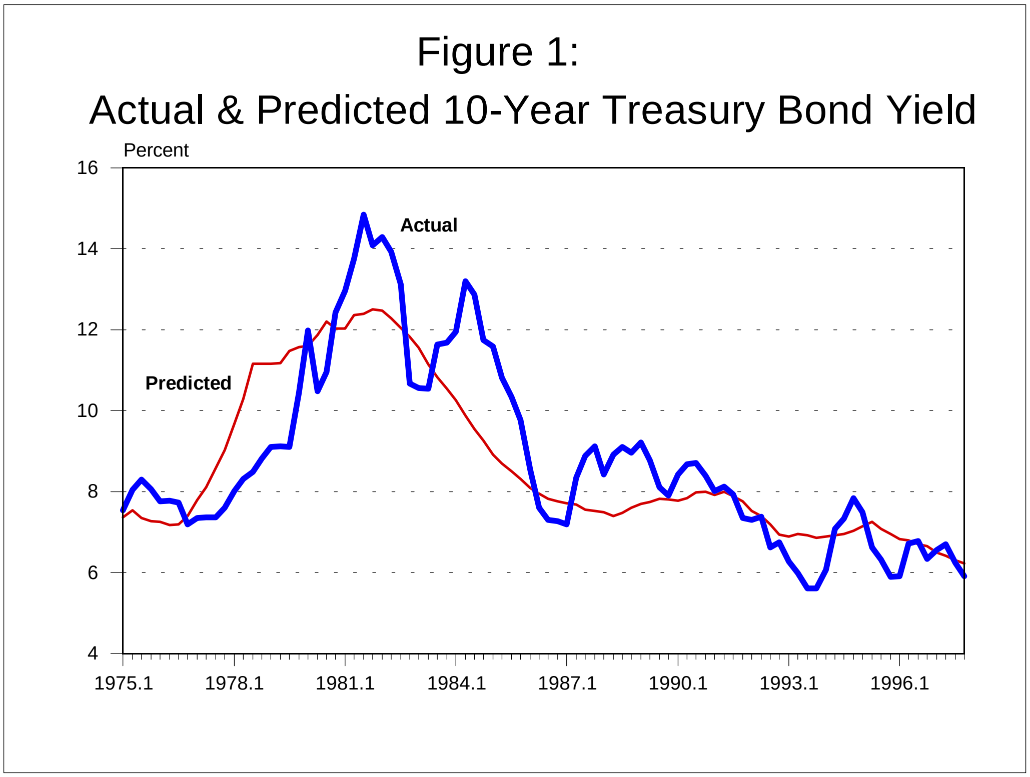


Figure 1:
Actual & Predicted 10-Year Treasury Bond Yield
Percent
16
14
12
10
8
6
4
Actual
Predicted
1975.1
1978.1
1981.1
1984.1
1987.1
1990.1
1993.1
1996.1

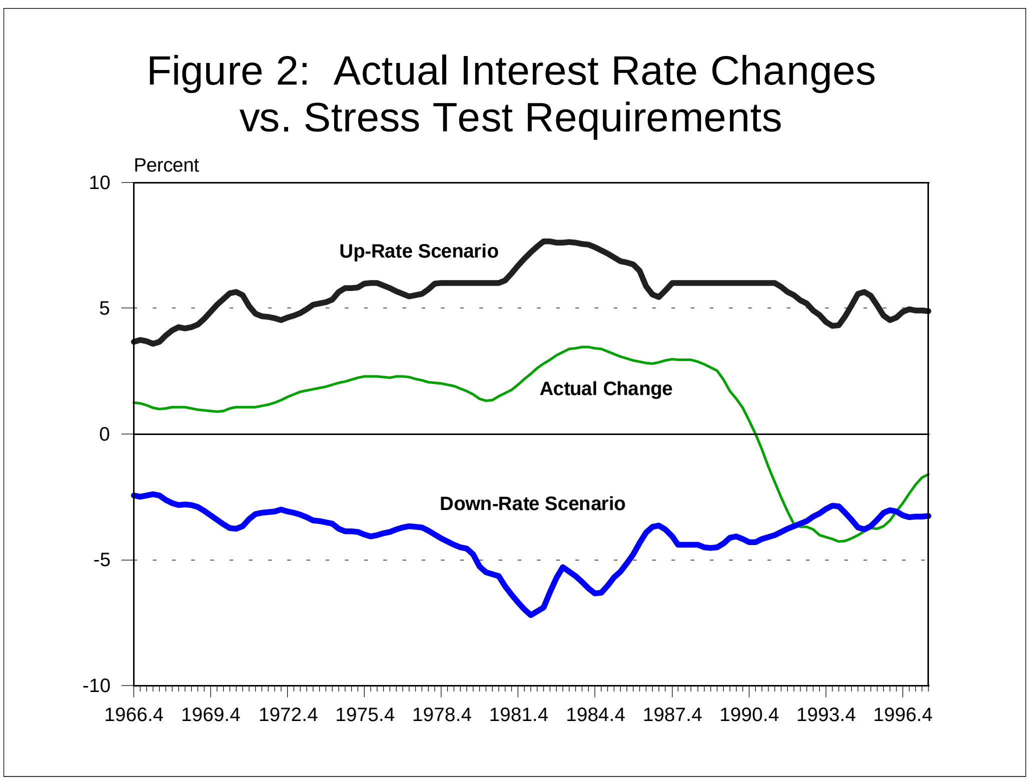


Figure 2: Actual Interest Rate Changes vs. Stress Test Requirements
Percent
10
5
0
-5
-10
Up-Rate Scenario
Actual Change
Down-Rate Scenario
1966.4
1969.4
1972.4
1975.4
1978.4
1981.4
1984.4
1987.4
1990.4
1993.4
1996.4

nominal interest rates that would have been required had the stress test been performed then. In the chart, this line is labeled "up-rate scenario". This required change can then be compared to the actual change in the average yield during the prior year to the average during the following decade. This line is labeled "actual change". Given the decade-long "lead" of interest rates required in the calculation, historical data can be used to construct this chart only through the 1988. To bring the chart up to date, we used the forecast of long-term interest rates through 2007 reported in the October 1997 edition of Blue Chip Economic Indicators. As an example, suppose the stress test had been performed at the beginning of 1988. Given the level of interest rates in 1987, the stress test then would have prescribed an up-rate scenario in which the average yield during the next decade rose 600 basis points. The actual level of rates over the next decade turned out to be only 294 basis point higher than in 1988.

Obviously, one objective of the test is to run an experiment in which Freddie Mac's portfolio of mortgages is subject to prolonged and unusual periods of stress. However, as the chart makes clear, nothing approaching the up-rate scenario has ever come close to transpiring. The most severe up-rate episode occurred during the decade beginning in 1984, during which the average level of yields rose 342 basis points relative to the prior year. In retrospect we now recognize this as a period during which a sharp rise in inflation (and inflation expectations) initially pushed up interest rates at the same time a combination of loose fiscal and tight monetary policies put upward pressure on the real rate as well. Yet dramatic as the rise in rates was in the 1980s, it was only about half the increase dictated by the stress test. Indeed, the chart also shows from 1966 onward the decline in the nominal interest rate that would have been required under the down-rate scenario. Provided that the Blue Chip forecasts of interest rates through 2002 are anywhere near the mark, the down-rate scenario actually has occurred since interest rates began falling in the late 1990s as inflation subsided and as the federal budget deficit shrank.

The Inflation Adjustment

FHEFSSA requires an adjustment to the general rate of price inflation when the prescribed rise in the yield exceeds 50% of the average yield during the preceding nine months. FHEFSSA offers no guidance as to either the magnitude or the timing of the adjustment. Therefore, we are left to argue a reasonable adjustment on the basis of theoretical macroeconomics.

Darby[7] argues that a reasonable adjustment to inflation is between 75% and 100% of the change in the nominal yield. The essence of his argument is that, as we have just argued, the only plausible macroeconomic scenario in which both nominal interest rates and inflation rise immediately and dramatically and permanently is one in which credible monetary authorities pre-announce and then execute a sustained increase in the rate of monetary growth. For the most part, this leaves the economy's real configuration unchanged including, as a first approximation, the real after-tax interest rate, r. Suppose r is defined as:

$$r = \rho(1-\tau) - \pi ,$$

where ρ is the nominal before-tax rate of return, π is the inflation rate, and τ is the marginal tax rate. If r is fixed, normalizing this expression onto the inflation rate and taking first differences gives:

$$\Delta\pi = (1-\tau)\Delta\rho.$$

Therefore, to preserve a given value of r, the inflation rate must rise by $(1-\tau)$% of an assumed increase in nominal yield. Darby's review of the empirical literature suggests to him that the range of the "inflation adjustment" is between a lower bound of 75%

[7] Michael R. Darby, "Consistent Macroeconomic Conditions for a Risk-Based Capital Stress Test" (June 1997).

(implying τ = .25) and an upper bound of 100% (or τ = 0). His preference is for the lower end of that range, consistent, he argues, with a marginal tax rate approaching 25%.

If private saving is a function of the after-tax rate of return, the economy is closed, and private investment is insensitive to the user cost of capital, then Darby's relatively simple calculation is foolproof. If, however, the economy is open, and investment does depend (inversely) on the user cost of capital, the calculations relating inflation and the nominal interest rate also depend in a complicated way on the interactions between inflation, the business tax code, and foreign capital flows.[8] The most important of these tax interactions are that depreciation allowances are claimed at historical cost, that inventory profits are taxed nominally, that firms can deduct nominal interest expenses but not nominal dividends, and that nominal capital gains are taxed rather than real gains. In such a complicated setting it is virtually impossible to size up the overall relationship between inflation and nominal interest rates without a full numerical computable GE macro model. Fortunately, our GE model described earlier includes most of the key interactions. So, as a way of checking the inflation adjustment for the current set of economic conditions and given today's tax parameters, we used the GE macro model to simulate the effects on nominal interest rates of a permanent increase in the growth of the money stock. This simulation produced an inflation adjustment of roughly 83%. That is, the ultimate increase in inflation was only 83% of the ultimate increase in nominal interest rates. This sits comfortably in the lower third of the range suggested by Darby, and so gives us confidence that if we consider the upper and lower bounds of that range we will have bracketed the true result.

Simulation Experiments

We began by using the model of the housing market to establish a baseline in which the nominal bond rate is 6.4% forever and the assumed general rate of price inflation is 2.5%

[8] Indeed, once the business tax code is introduced, in theory the inflation adjustment can *exceed* 100%; i.e., inflation can rise *more* than the increase in nominal rates. See Laurence H. Meyer and Anandi Sahu, "Inflation Non-Neutralities and the Response of Interest Rates to Inflation" Eastern Economics Journal, Winter 1994. Meyer and Sahu produce empirical evidence in support of a full inflation adjustment.

per year. The baseline presumes the housing market remains in equilibrium through time. Therefore, the real prices of land, structures and housing services all are constant, but the corresponding nominal prices all rise at the same 2.5% per year as the general price level. This baseline is summarized in Table 1. Then we simulated the up-rate scenario, first with a full inflation adjustment (the upper end of Darby's range) and then with a partial inflation adjustment (the lower end of his range). The results are summarized below.

(1) Up-Rate Scenario with Full Inflation Adjustment

In this scenario, both the nominal yield and the rate of general price inflation are assumed to rise 460 basis points, to 11% and 7.1%, respectively; the real after-tax interest rate declines 110 basis points, to 1.4%. The impact of this experiment on nominal house prices is shown in figure 3, while a fuller set of results is reported in tables 2A and 2B. In the baseline, the nominal price rises 2.5% per year. In the up-rate scenario, the price initially rises sharply above the baseline level as the decline in the real interest rate sharply increases the demand for housing services. Note that the initial real price rise is much larger when expectations are myopic (i.e., when homeowners fail to anticipate the expansion in supply that undermines the initial rise in real values) than when expectations are forward-looking.

Thereafter, nominal house prices continue to rise, but more slowly, because an expansion in the supply of housing services puts downward pressure on real housing values that mitigates the effects on nominal house prices of the higher rate of general price inflation. After 10 years, nominal house prices are about 64% higher than in the baseline. More than 4/5 of that rise is attributable to the inflation adjustment, which pushes the general price level up 55% relative to the baseline. Real house prices are only about 6% higher. If the price elasticity of supply for housing services were infinite, eventually the baseline path of real prices would be restored. Since we have assumed an inelastic supply of land, the real price of housing ultimately remains 5.5% above the baseline.

Figure 3: Nominal Price of Housing
Up-Rate Scenario with Full Inflation Adjustment

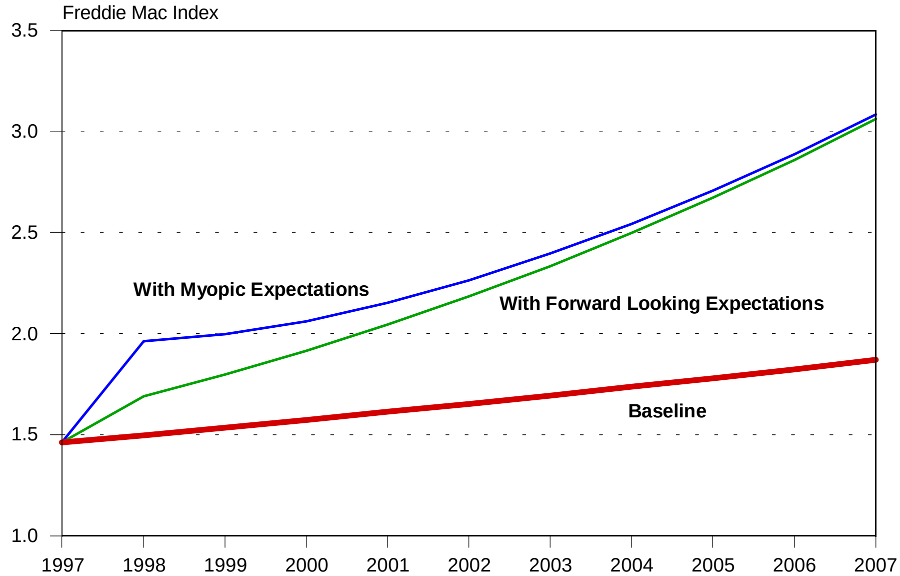
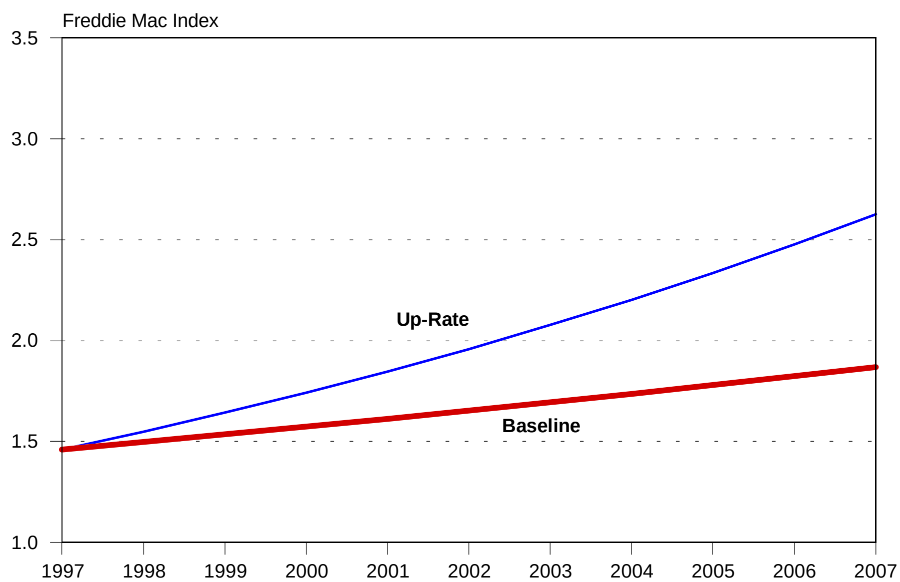


Figure 4: Nominal Price of Housing
Up-Rate Scenario with Partial Inflation Adjustment



(2) Up-Rate Scenario with Partial Inflation Adjustment

In the second up-rate scenario the nominal bond yield is assumed to rise 460 basis points, from 6.4% to 11%. In addition, following Darby's argument advanced earlier, the general inflation rate is assumed to rise by 350 basis points, from 2.5% to 6%. The magnitude of the inflation adjustment is governed by our estimate (= 23%) of the marginal tax rate. The impact of this experiment on nominal house prices is depicted graphically in figure 4, while a fuller set of results is reported in tables 3A and 3B. Despite the complexity of the underlying model of housing prices, the results of this experiment are simple to describe. The inflation adjustment is just large enough to prevent any change in the real after-tax interest rate, and it is the real after-tax interest rate that drives housing demand. Therefore, the real housing market remains unperturbed. All that happens is that nominal house prices immediately start rising at a 6% rate instead of 2.5% as in the baseline. The distinction between myopic and forward-looking expectations of changes in real housing supply and demand is irrelevant in this experiment, since only nominal variables change.

Summary and Concluding Comments

In both of these scenarios, nominal house prices are always higher than current levels. They are also higher than the rising baseline values. The results reveal the power of the inflation adjustment in raising nominal house prices over time.

The model suggests a strong and immediate negative relationship between the real interest rate and real house prices. This is seemingly at odds with the strikingly low correlation between near-term changes in real interest rates and changes in real house prices revealed by post-war data for the United States. The low correlation in the actual data is probably best explained by assuming that homeowners, when confronted with a sharp change in real interest rates, are uncertain whether it is a permanent or temporary increase. If they form their expectations of real interest rates in a "Bayesian" manner, homeowners' initial reaction to a new mortgage rate is to assume that the change is mostly temporary. Consequently, there might be little immediate change in real house prices. However, as the new rate persists, homeowners eventually come to view it as permanent. So, house prices do move towards a new equilibrium, but more gradually than implied by our housing model. If this argument is correct, then figure 3 might overstate the near-term rise in real house prices.[9]

[9] It is worth repeating here that one inference drawn from the model is that there may not be any historical near-term correlation between house prices and nominal interest rates. House prices initially rise, fall or remain unchanged depending on whether historically the increase in interest rates is accompanied by a partial or complete inflation offset. However, whatever the immediate relationship between house prices and nominal rates, in the postwar experience it is clear that the periods during which house prices rose the fastest (i.e. in the late 1970s and early 1980s) were also the periods when nominal interest rates were the highest.

Table 1. Baseline Values for All Scenarios

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Macroeconomic Assumptions:											
Real Disposable Income	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Bond Rate	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
Expected Inflation	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Housing Market Parameters:											
Elasticity of Demand: Income	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Elasticity of Demand: Price	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47
Share of Land in Production	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Elasticity of Supply: Land	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Elasticity of Supply: Structures	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00	999.00
Adjustment Speed	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Common Elements of User Costs:											
Inflation Deduction	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Property Tax Rate	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Pre-Tax Risk Premium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mortgage/Bond Rate Spread	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Marginal Income Tax Rate	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
Deductions Tax Rate	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
Leverage Ratio	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
Uncommon Elements of User Costs:											
Depreciation Rate - Land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Depreciation Rate - Structures	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Maintenance Rate - Land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maintenance Rate - Structures	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
The General Price Level:	1.125	1.153	1.182	1.211	1.241	1.272	1.304	1.337	1.370	1.404	1.440
The Real Price of Housing:											
Current Equilibrium	1.299	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310
Steady-State Equilibrium	1.299	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310
Myopic Expectations	1.299	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310
Forward Looking Expectations	1.299	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310
The Nominal Price of Housing:											
Current Equilbrium	1.461	1.510	1.548	1.586	1.626	1.667	1.708	1.751	1.795	1.840	1.886
Steady-State Equilibrium	1.461	1.510	1.548	1.586	1.626	1.667	1.708	1.751	1.795	1.840	1.886
Static Expectations	1.461	1.510	1.548	1.586	1.626	1.667	1.708	1.751	1.795	1.840	1.886
Rational Expectations	1.461	1.510	1.547	1.586	1.626	1.666	1.708	1.751	1.795	1.839	1.885

Table 2A. Alternative Scenario: Up-Rate Scenario with Full Inflation Offset

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Macroeconomic Assumptions:											
Real Disposable Income	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Bond Rate	0.064	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
Expected Inflation	0.025	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.071
Housing Market Parameters:											
Elasticity of Demand: Income	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
Elasticity of Demand: Price	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470
Share of Land in Production	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280
Elasticity of Supply: Land	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Elasticity of Supply: Structures	999.000	999.000	999.000	999.000	999.000	999.000	999.000	999.000	999.000	999.000	999.000
Adjustment Speed	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Common Elements of User Costs:											
Inflation Deduction	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Property Tax Rate	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Pre-Tax Risk Premium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mortgage/Bond Rate Spread	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Marginal Income Tax Rate	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
Deductions Tax Rate	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
Leverage Ratio	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
Uncommon Elements of User Costs:											
Depreciation Rate - Land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Depreciation Rate - Strucutres	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Maintenance Rate - Land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maintenance Rate - Structures	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
The General Price Level:	1.125	1.204	1.290	1.382	1.480	1.585	1.697	1.818	1.947	2.085	2.233
The Real Price of Housing:											
Current Equilbrium	1.299	1.383	1.383	1.383	1.383	1.383	1.383	1.383	1.383	1.383	1.383
Steady-State Equilibrium	1.299	1.383	1.383	1.383	1.383	1.383	1.383	1.383	1.383	1.383	1.383
Myopic Expectations	1.299	1.643	1.560	1.505	1.467	1.441	1.423	1.411	1.402	1.397	1.392
Forward Looking Expectations	1.299	1.415	1.404	1.397	1.393	1.389	1.387	1.386	1.384	1.384	1.383
The Nominal Price of Housing:											
Current Equilbrium	1.461	1.665	1.784	1.910	2.046	2.191	2.347	2.513	2.692	2.883	3.088
Steady-State Equilibrium	1.461	1.665	1.784	1.910	2.046	2.191	2.347	2.513	2.692	2.883	3.088
Myopic Expectations	1.461	1.979	2.013	2.079	2.171	2.284	2.416	2.565	2.730	2.912	3.109
Forward Looking Expectations	1.461	1.704	1.812	1.931	2.061	2.202	2.354	2.519	2.695	2.885	3.088

Table 2B. Changes from Baseline: Up-Rate Scenario with Full Inflation Offset

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Macroeconomic Assumptions:											
Real Disposable Income	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Bond Rate	0.00	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
Expected Inflation	0.00	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
Housing Market Parameters:											
Elasticity of Demand: Income	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elasticity of Demand: Price	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Share of Land in Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elasticity of Supply: Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elasticity of Supply: Structures	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment Speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Elements of User Costs:											
Inflation Deduction	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Property Tax Rate	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pre-Tax Risk Premium	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mortgage/Bond Rate Spread	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Marginal Income Tax Rate	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Deductions Tax Rate	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Leverage Ratio	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Uncommon Elements of User Costs:											
Depreciation Rate - Land	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Depreciation Rate - Strucutres	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maintenance Rate - Land	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maintenance Rate - Structures	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
The General Price Level:	0.00%	4.49%	9.18%	14.08%	19.20%	24.55%	30.13%	35.98%	42.08%	48.45%	55.12%
The Real Price of Housing:											
Current Equilbrium	0.00%	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%
Steady-State Equilibrium	0.00%	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%	5.57%
Myopic Expectations	0.00%	25.46%	19.13%	14.89%	12.01%	10.04%	8.68%	7.73%	7.08%	6.62%	6.31%
Forward Looking Expectations	0.00%	8.01%	7.23%	6.70%	6.34%	6.09%	5.92%	5.79%	5.71%	5.65%	5.60%
The Nominal Price of Housing:											
Current Equilbrium	0.00%	10.31%	15.26%	20.43%	25.83%	31.48%	37.38%	43.55%	49.99%	56.72%	63.75%
Steady-State Equilibrium	0.00%	10.31%	15.26%	20.43%	25.83%	31.48%	37.38%	43.55%	49.99%	56.72%	63.75%
Myopic Expectations	0.00%	31.09%	30.06%	31.06%	33.51%	37.04%	41.42%	46.49%	52.14%	58.29%	64.90%
Forward Looking Expectations	0.00%	12.86%	17.08%	21.72%	26.75%	32.13%	37.83%	43.85%	50.19%	56.84%	63.81%

Table 3A. Alternative Scenario: Up-Rate Scenario with Partial Inflation Offset

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Macroeconomic Assumptions:											
Real Disposable Income	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Bond Rate	0.064	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
Expected Inflation	0.025	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
Housing Market Parameters:											
Elasticity of Demand: Income	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
Elasticity of Demand: Price	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470	-0.470
Share of Land in Production	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280
Elasticity of Supply: Land	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Elasticity of Supply: Structures	999.000	999.000	999.000	999.000	999.000	999.000	999.000	999.000	999.000	999.000	999.000
Adjustment Speed	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Common Elements of User Costs:											
Inflation Deduction	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Property Tax Rate	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Pre-Tax Risk Premium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mortgage/Bond Rate Spread	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Marginal Income Tax Rate	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
Deductions Tax Rate	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
Leverage Ratio	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
Uncommon Elements of User Costs:											
Depreciation Rate - Land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Depreciation Rate - Strucutres	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Maintenance Rate - Land	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maintenance Rate - Structures	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
The General Price Level:	1.125	1.193	1.265	1.341	1.422	1.508	1.599	1.696	1.798	1.907	2.022
The Real Price of Housing:											
Current Equilbrium	1.299	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310
Steady-State Equilibrium	1.299	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310
Myopic Expectations	1.299	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310
Forward Looking Expectations	1.299	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310	1.310
The Nominal Price of Housing:											
Current Equilbrium	1.461	1.562	1.656	1.756	1.863	1.975	2.094	2.221	2.355	2.497	2.648
Steady-State Equilibrium	1.461	1.562	1.656	1.756	1.863	1.975	2.094	2.221	2.355	2.497	2.648
Myopic Expectations	1.461	1.562	1.656	1.756	1.863	1.975	2.094	2.221	2.355	2.497	2.648
Forward Looking Expectations	1.461	1.562	1.656	1.756	1.862	1.975	2.094	2.221	2.355	2.497	2.648

Table 3B. Changes from Baseline: Up-Rate Scenario with Partial Inflation Offset

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Macroeconomic Assumptions:											
Real Disposable Income	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Bond Rate	0.00	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
Expected Inflation	0.00	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Housing Market Parameters:											
Elasticity of Demand: Income	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elasticity of Demand: Price	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Share of Land in Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elasticity of Supply: Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Elasticity of Supply: Structures	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Adjustment Speed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Elements of User Costs:											
Inflation Deduction	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Property Tax Rate	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pre-Tax Risk Premium	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mortgage/Bond Rate Spread	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Marginal Income Tax Rate	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Deductions Tax Rate	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Leverage Ratio	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Uncommon Elements of User Costs:											
Depreciation Rate - Land	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Depreciation Rate - Strucutres	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maintenance Rate - Land	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maintenance Rate - Structures	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
The General Price Level:	0.00%	3.46%	7.03%	10.73%	14.56%	18.51%	22.61%	26.85%	31.23%	35.76%	40.46%
The Real Price of Housing:											
Current Equilbrium	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Steady-State Equilibrium	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Myopic Expectations	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Forward Looking Expectations	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
The Nominal Price of Housing:											
Current Equilbrium	0.00%	3.46%	7.03%	10.73%	14.56%	18.51%	22.61%	26.85%	31.23%	35.76%	40.46%
Steady-State Equilibrium	0.00%	3.46%	7.03%	10.73%	14.56%	18.51%	22.61%	26.85%	31.23%	35.76%	40.46%
Myopic Expectations	0.00%	3.46%	7.03%	10.73%	14.56%	18.51%	22.61%	26.85%	31.23%	35.76%	40.46%
Forward Looking Expectations	0.00%	3.46%	7.03%	10.73%	14.56%	18.51%	22.61%	26.85%	31.23%	35.76%	40.46%

APPENDIX 6

"Results for Multifamily Mortgage Modeling and Risk-Based Capital Assessment"

Property and Portfolio Research

2000

March 7, 2000

Mr. Edward Golding
Vice President for Financial Research
Freddie Mac
8200 Jones Branch Drive
McLean, Virginia 22102

Re: Results for Multifamily Mortgage Modeling and Risk-Based Capital Assessment

Dear Mr. Golding:

Thank you for contracting Property & Portfolio Research, Inc. (PPR) to execute your multifamily mortgage modeling and risk based capital assessment project. As you are aware, we are an *independent*, unconflicted applied real estate research and strategy company. Our firm is purely interested in the accurate assessment of the historical and future performance of markets to better guide any participant in the institutional real estate markets. We are a unique firm and have no competitors who can offer the rigor of the analytic framework used by PPR in the service of our 30+ institutional investor clients. The types of entities which now rely on PPR's analytic framework to guide their decision making include several of the largest Wall Street investment banks, some of the largest pension funds in the world, the largest source of private investment capital, super-regional and regional banks, dominant insurance companies, real estate money managers, and a rating agency. As is clear, our model is widely accepted, and is currently being used by our clients to aid their management of more than $200 billion dollars of commercial property investments.

Since we have views on the expected and historical performance of real estate, market by market and property type by property type (60 cities and 5 property types able to be "linked" to all *other* urban areas), we are able to create applications for our clients that enable them to directly analyze their investment choices. One such application is our "Mortgage Model." This tool uses the distinct market behaviors that drive real estate cash flows and valuation to assess the credit risk of any individual loan structure, and/or an entire mortgage portfolio. This is the model used to answer the ultimate question posed within your RFP, namely, how reasonable are the specific capital levels OFHEO has proposed in its Notice of Proposed Rule Making?

Our Analysis

Specifically, PPR performed the following analysis to estimate appropriate credit costs for the Freddie Mac portfolio:

Modeled the prospective performance of a representative sample of loans from Freddie Mac's multifamily whole loan portfolio using PPR's existing mortgage model to estimate expected credit costs to this portfolio under five scenarios proposed by Freddie Mac. In all of these scenarios except scenario E, Freddie Mac provided PPR with the exact economic values that characterize the scenario. More specifically, Freddie Mac provided a ten-year time series of quarterly growth rates for NOI and capital value for each scenario. In scenarios A and C, these values were derived to exactly match those contained in or implied by OFHEO's proposed rule. In scenarios B and D the rent and vacancy paths remained the same as those proposed by OFHEO, but the capital value paths differed from those implied by OFHEO. Scenario E will be created by PPR utilizing its proprietary econometric model. A brief description of each of the scenarios is as follows:

A. OFHEO's "Up Rate Scenario - Base Case" — this scenario is characterized by a sharp increase in interest rates, a sharp decrease in capital values and vacancy rates, and modest increases in rental levels. Each loan experiences identical NOI declines on its underlying collateral, whereas the capital value declines experienced by the underlying collateral are loan specific.

B. OFHEO's "Up Rate Scenario - Modified Capital Values" — this scenario will be identical to the above scenario, except that the path of capital values was modified by Freddie Mac to provide a more realistic and internally consistent path. Each loan experiences identical NOI and capital value declines for its underlying collateral.

C. OFHEO's "Down Rate Scenario - Base Case" — this scenario is characterized by a sharp decrease in interest rates, a sharp increase in capital values and vacancy rates, and modest increases in rental levels. Each loan experiences identical NOI declines on its underlying collateral, whereas, the capital value declines experienced by the underlying collateral are loan specific.

D. OFHEO's "Down Rate Scenario — Modified Capital Values" - this scenario will be identical to Scenario C, except that the path of capital values was modified by Freddie Mac to provide a more realistic and internally consistent path. In particular, they were changed from increasing to decreasing. Each loan experiences identical NOI and capital value declines for its underlying collateral.

E. PPR's "Worst 2-Year Downturn" — This scenario was defined by PPR based on the worst recorded two-year period that the average of the sixty largest MSAs experienced in terms of NOI and capital value declines. PPR constructed a 10-year stress period that includes the 2-year reference period within it. Each loan experiences identical NOI and capital value declines for its underlying collateral.

A summary of the specific cumulative Capital Value and NOI growth rates used in each scenario are outlined below in Tables 1 and 2.

Table 1

Median Cumulative Capital Value Change by Economic Scenario					
Year-End	A	B	C	D	E
1	-18.77%	-3.83%	13.23%	-3.83%	-2.35%
2	-20.58%	-5.28%	11.39%	-5.28%	-7.73%
3	-16.49%	-5.40%	17.13%	-5.40%	-12.60%
4	-19.35%	-9.33%	13.11%	-9.33%	-16.03%
5	-15.64%	-11.01%	18.31%	-11.01%	-17.07%
6	-8.86%	-5.20%	24.06%	-8.17%	-18.04%
7	-1.54%	-1.68%	30.24%	-7.62%	-17.53%
8	11.70%	4.01%	43.57%	-4.91%	-15.52%
9	22.61%	11.57%	52.96%	-0.31%	-12.17%
10	30.20%	19.07%	57.65%	4.21%	-8.81%

Table 2

Median Cumulative Change in NOI by Economic Scenario					
Year-End	A	B	C	D	E
1	-3.77%	-3.77%	-3.77%	-3.77%	-3.79%
2	-3.79%	-3.79%	-3.79%	-3.79%	-13.08%
3	1.17%	1.17%	1.17%	1.17%	-16.18%
4	-2.30%	-2.30%	-2.30%	-2.30%	-17.19%
5	2.19%	2.19%	2.19%	2.19%	-17.07%
6	10.41%	7.16%	10.41%	7.16%	-16.57%
7	19.28%	12.50%	19.28%	12.50%	-15.88%
8	35.31%	24.01%	35.31%	24.01%	-13.89%
9	48.54%	32.13%	48.54%	32.13%	-10.62%
10	57.72%	36.17%	57.72%	36.17%	-7.79%

Results

Table 3 outlines the final results of the analysis. Specifically, the credit costs for the sample Freddie-Mac portfolio are presented in terms of basis points for each of the five scenarios defined above. The statistical benchmarking for the default probabilities assumes a normal distribution, and it was assumed that no prepayments occurred.

Table 3
Estimated Credit Cost by Scenario

Scenario	Scenario Description	Expected Credit Costs (bp)
A	OFHEO's "Up Rate Scenario - Base Case"	**607**
B	OFHEO's "Up Rate Scenario - Modified Capital Values"	**155**
C	OFHEO's "Down Rate Scenario - Base Case"	**129**
D	OFHEO's "Down Rate Scenario - Modified Capital Values"	**155**
E	PPR "Worst 2-year Downturn"	**699**

Naturally, the credit costs vary by scenario, and they fall within an approximate range of 130-700 basis points. The differences are driven by each scenario's assumptions regarding the underlying collateral (specifically the minimum levels of NOI and capital value encountered during the life of the individual loans). Coupling this with the protection available from the varying loan structures of the sample portfolio produces differing estimates of credit costs.

Of all the scenarios, OFHEO's "Up Rate Scenario - Base Case" (Scenario A) proves to be the most expensive of the OFHEO scenarios in terms of credit costs. The severe individual collateral value declines assumed in this scenario strongly impact the credit of the loan portfolio. As a result, expected costs under this situation are nearly quadruple that of the alternate OFHEO-based scenarios. The more severe capital value declines are consistent with an upward movement in interest rates, although it is our opinion that these capital value assumptions are not in line with the very light stress in NOI assumed under this scenario. We would expect more severe downturn in NOIs to drive strong capital value declines under a true period of economic stress. As a result, the credit costs under this scenario may be a little on the low side, although overall we feel that this range of 600 basis points is a very reasonable representation for the costs associated with this representative portfolio.

The scenario using modified capital values for OFHEO's "Up Rate Scenario - Base Case" (Scenario B) utilizes changes in collateral value that are somewhat more in line with the assumed changes in NOI. These less severe capital value declines reduce credit costs for the portfolio to a level of only 155 basis points. It is our opinion however that a severe stress scenario will more seriously decay the level of NOIs. As a result the costs outlined under this scenario are almost certainly too bullish, and are not a true representation of a period of strong economic stress.

OFHEO's "Down Rate Scenario - Base Case" (Scenario C) produces the lowest overall credit costs for the Freddie Mac sample portfolio. This is consistent with a downward move in interest rates as this positively affects capital values. However, these NOI and value assumptions are not likely to be representative of a "severe downturn"; more specifically, it is highly unlikely to observe increases in capital values during a severe downturn. As a consequence, we view this level of credit costs as highly likely to be exceeded in a truly stressed environment.

Although the adjusted capital values of Scenario D (OFHEO's "Down Rate Scenario - Modified Capital Values") increase the credit costs compared to OFHEO's "Down Rate Scenario - Base Case," (Scenario C), the assumptions of Scenario D may also be misleading for prediction of performance under a truly stressed environment. It is our opinion that both the NOI and capital value declines are too light, and the credit costs are therefore too low.

The final scenario, PPR's Worst 2-year Downturn (Scenario E), is representative of a true period of severe stress for multifamily real estate. Apartment performance during the late 1980's and early 1990's was abysmal (although not as poor as that of other commercial property types). It is believed that this period encompasses the most severe downturn for property markets since the great depression. Compared to the OFHEO scenarios, our data appropriately characterizes this stress scenario with more severe declines in levels of NOI driving heavy declines in capital values.

As a result, the credit costs encountered for the portfolio under Scenario E are the most expensive of the five scenarios. The nearly 700 basis point cost is substantially greater than all OFHEO scenarios except the "Up Rate Scenario - Base Case" (Scenario A). We believe that Scenario E provides a more appropriate benchmark for assessing possible credit costs under a severe downturn, as it is much more likely to be an accurate portrayal of the performance of the sample portfolio under severe economic conditions. Here we encounter more severe downturns in NOI driving more severe, longer term, downturns in capital value.

Another check that reinforces this opinion is based upon several studies completed by Mark Snyderman, et al. Mr. Snyderman reviewed the lifetime default costs on loans held by life insurance companies from 1972 through 1997. The findings indicate an average cost of 682 basis points. Overall, this result is consistent with our findings, but it is also important to note that certain origination cohorts in the Snyderman study experienced costs upwards of 1200 basis points. These particular cohorts encountered the most severe portion of the last downturn, and are more representative of costs under extreme economic stress.

We believe that the lower costs associated with the Freddie Mac portfolio are appropriate for two reasons. First, the life company loans were not collateralized solely by apartments. These life portfolios contained loans on other property types, such as office buildings, that experienced more severe declines in NOI and value. Second, the Freddie Mac portfolio is more conservative in terms of underwriting guidelines. For example, the average LTV on the Freddie Mac portfolio is roughly 67%, while that of life company loans is nearer to 73%.

It is therefore our opinion that a reasonable capital reserve for the Freddie Mac portfolio using OFHEO's scenarios should be based upon expected credit costs of approximately 600 basis points. Overall, we believe that this portfolio judgement is based upon the most appropriate determination of stressed scenarios defined by OFHEO as they apply to a national lender with the types of loan structures outlined by the sample portfolio.

Thank you again for providing PPR with the opportunity to perform this analysis. We enjoy working with you, and we hope this research will satisfy your needs. Please contact me with any questions you have. We look forward to working with you again in the near future.

Sincerely,

George J. Pappadopoulos, CFA
Director, Risk Management & Debt Research

cc: Susan Hudson-Wilson, CFA
Founder & CEO