# The Size of the Affordable Mortgage Market: 2018-2020 Enterprise Single-Family Housing Goals

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**Abstract**

This Federal Housing Finance Agency (FHFA) research paper documents the statistical forecast models that the modeling team has developed as part of the process for establishing the affordable housing goal benchmark levels for Fannie Mae and Freddie Mac for 2018 through 2020. The paper was prepared by Ken Lam, Jay Schultz, and Padmasini Raman of the Federal Housing Finance Agency.

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# 1    Introduction

The Federal Housing Enterprises Financial Safety and Soundness Act of 1992 (the Safety and Soundness Act), as amended, mandates that the Federal Housing Finance Agency (FHFA) establish annual housing goals for Fannie Mae and Freddie Mac (the Enterprises).[1] Since 2010, FHFA has adopted a two-part approach to establishing and measuring the Enterprise housing goals. The "benchmark" level is set prospectively by rule-making based on various factors set out in the statute, including FHFA's forecast of the goals-qualifying market based on the econometric models described in this paper. The actual market level is determined retrospectively by FHFA based on the Home Mortgage Disclosure Act (HMDA) data for the year when it becomes available. Both the benchmark market and the retroactive market levels are determined at the national level and for a full calendar year. In any given year, an Enterprise is deemed to have met the goal if it meets or exceeds either the benchmark level or the retrospective market level. Typically, HMDA data for a given calendar year is released the following September so that FHFA's retroactive market level determination of the Enterprise's housing goals performance is made the following year.[2]

The benchmark level is based on the market forecast model (and other factors) and is set in advance for the goal period in order to provide a planning target for Enterprise activities. The market forecast model referred to here is the national level statistical model that is estimated using monthly goal-qualifying share data from HMDA and the resulting monthly forecasts are then averaged into an annual forecast for each of the three years in the goal period.

The retroactive market level is based on FHFA's determination of the goal qualifying market for each year based on HMDA data. This is not a statistical modeling exercise but rather an aggregation based on applying counting rules to HMDA data.

The Safety and Soundness Act sets out seven factors that FHFA is expected to consider when setting the benchmark level.[3] FHFA's approach has been to incorporate as many of these factors into the statistical forecast model as possible, generating model forecasts for each of the goal years along with confidence intervals. For instance, four of the seven factors (national housing needs; economic, housing, and demographic conditions; other mortgage data; and the size of the conventional purchase money or refinance mortgage segment) are explicitly modeled in the statistical forecast models. Three factors (performance and effort of

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[1]12 U.S.C. 4561(a).

[2]Typically, FHFA will issue a preliminary determination of the each Enterprises' housing goals performance in a given calendar year, in the following October. The Enterprises will have 30 days to respond to the determination and FHFA typically issues a final determination in December.

[3]12 U.S.C. 4562(e)(2).

the Enterprises to lead the industry in making mortgage credit available; the ability of the Enterprises to do so; and the need to maintain sound financial condition of the Enterprises) are not readily quantifiable and there are no public data on these factors. As a result, they are not explicitly modeled in the statistical forecast models. FHFA incorporates these factors into the benchmark setting process while picking the specific point estimate within the model-generated confidence intervals for a given goal year. That process is documented in the preamble to the proposed rule-making and is beyond the scope of this paper. This paper will focus on documenting the statistical models and the associated confidence intervals of the estimates.

FHFA is required to establish three single-family home purchase goals and one refinance goal. FHFA has also established an additional single-family home purchase subgoal for low-income areas. The single-family goals are limited to conventional conforming mortgages on owner-occupied housing with a total of one to four units. Therefore, jumbo mortgages (with loan amounts above the conforming loan limit), mortgage loans to investors, mortgages on second homes, and non-conventional loans (loans with some form of government insurance on them) are all excluded.

The single-family home purchase goals and subgoal and the single-family refinance goal are defined as follows:

- **Low-Income Home Purchase (LIP) Goal**: This goal measures the share of each Enterprise's goal-qualifying purchase loans made to families with incomes no greater than 80 percent of Area Median Income (AMI).
- **Very Low-Income Home Purchase (VLIP) Goal**: This goal measures the share of each Enterprise's goal-qualifying purchase loans made to families with incomes no greater than 50 percent of AMI.
- **Low-Income Areas Home Purchase (LAS) Subgoal**: This goal measures the share of each Enterprises' goal-qualifying purchase loans made to two subgroups: a) families living in census tracts where the median census tract income is no greater than 80 percent of AMI; and b) families with incomes no greater that 100 percent of AMI living in census tracts with a minority population of 30 percent or more and median census tract income of less than 100 percent of AMI.
- **Low-Income Areas Home Purchase (LAD) Goal**: This goal measures the share of each Enterprises' goal-qualifying purchase loans made to the borrower groups covered by the low-income areas home purchase subgoal, and also includes families with incomes no greater than 100 percent of AMI living in designated disaster areas.
- **Low-Income Refinance (LIR) Goal**: This goal measures the share of each Enterprise's goal-qualifying refinance loans made to families with incomes no greater than

80 percent of AMI.

FHFA sets the low-income areas home purchase goal each year based on the low-income areas home purchase subgoal benchmark level, plus an additional increment based on federally-declared disaster areas over the past three years. As a result, FHFA does not create a separate statistical forecast model for the low-income areas home purchase goal.

The current set of statistical forecast models all use outcome variables (i.e., market share estimates for the four housing goals) that are derived from the HMDA data. We rely on thirteen years of HMDA data: data from 2004 until 2016, the latest year for which HMDA is available. As we will discuss in the next section of the paper, although HMDA data prior to 2004 is available, those data sets do not contain key variables needed to define the market shares for the outcome variables. A significant improvement in the current goal cycle is the use of Moody's Analytics DataBuffet.com web site as the primary data source for the driver variables. This has not only streamlined the data collection process, but has also permitted FHFA to rely on Moody's Analytics forecasts. There are some exceptions. For some of the driver variables, either Moody's forecasts were not available or their forecast values were not consistent with forecasts produced by other reputable organizations. For such cases, we use FHFA's own forecasts. The goal of FHFA's statistical forecast models is to provide our best estimate of various affordable market segment originations for the next housing goal period. This naturally relies on forecasts of the key driver variables for that period.

FHFA's new models include better model specifications and new key driver variables for all goal-qualifying shares while following generally accepted professional practices and standards adopted by economists at other federal agencies. The new models not only fit historical data well, they are also robust (as indicated by the out-of-sample tests). However, as is the case with any forecasting model, whether the model yields "accurate" forecasts is crucially dependent on the accuracy of the forecasts for the driver variables that are inputs to the model. Moreover, the length of the forecast period is important: the longer out the forecast period, the wider the confidence bands around the forecasts.

This paper provides technical documentation of the market models used to generate the single-family housing goal forecasts for the 2018-2020 period for the two Enterprises. It assumes familiarity with econometric methods and forecasting practices that are commonly used by economists. The paper is organized as follows. Section 2 describes the mortgage market and economic forecast data used construct the econometric models. Section 3 identifies the model driver variables and uses them to provide an overview of the housing and macro-economic environments that shape the mortgage market. Section 4 and Section 5 present the model for each of the four house goals. Finally, concluding remarks are provided in Section 6. Technical appendices on sensitivity analysis and data sources are attached at the end.

# 2 Sources of Data

The historical monthly time series data used in estimating the Enterprise housing goals forecast models are produced by a variety of sources. We use HMDA data to construct outcome variables—that is, the estimates for the goal-qualifying market shares for the two home purchase goals, one home purchase subgoal, and one refinance goal. Our Home Mortgage Disclosure Act (HMDA) dataset is provided by the Consumer Finance Protection Bureau (CFPB). The dataset contains loan-level records of mortgage originations that occurred during a calendar year, including the month of mortgage origination. HMDA data is considered to be broadly representative of the mortgage market in the United States. For the purpose of estimating the single-family mortgage market for goal-qualifying loans, we limit the HMDA records to originations of conventional conforming first lien, prime home purchase (or refinance) mortgages.[4] We further limit the data to originations since January 2004 because HMDA records from the pre-2004 time period do not include a number of variables that are critical in identifying the originations that are relevant to the housing goals. In particular, the pre-2004 HMDA data do not identify property type, lien status, Home Ownership Equity Protection Act (HOEPA) status, and the Average Prime Offer Rate (APOR) rate spread. The pre-2004 data were also less precise in identifying manufactured housing loans and subprime loans. Since 2004, HMDA data began including: (1) rate-spread information for high-cost loans, (2) an indicator for manufactured housing loans, and (3) an identifier for first-lien mortgages. The rate-spread and manufactured housing information help to better identify subprime and chattel loans. The latest available HMDA data are for mortgage originations through December 2016.

Historical and forecast values of the model driver variables were downloaded from Moody's Analytics DataBuffet.com web site. Moody's Analytics obtains the historical values of the variables from various government agencies and industry trade groups and then generates forecasts for the same using statistical models. Specifically, the unemployment rate, labor force participation rate, consumer price index, and new housing sales come from the Census Bureau and the Bureau of Labor Statistics. Constant maturity interest rates on Government notes and bonds are generated by the U.S. Department of the Treasury, while mortgage interest rates were obtained from Freddie Mac's Primary Mortgage Market Survey. The Housing Affordability Index (HAI) is provided by the National Association of Realtors (NAR) to Moody's. To measure house price changes, we use the House Price Index (HPI) (for all

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[4]For the purpose of this analysis, prime mortgage loans are defined as mortgage originations that are not high-priced. In HMDA data, we identify high-priced loans as those with a spread (difference) between the Annual Percentage Rate (APR) of the loan and the applicable Average Prime Offer Rate (APOR) of 1.5 percentage points or greater.

transactions and for home purchase loans, separately) published on the FHFA web site. The refinance rate and the government market share information are calculated from the HMDA data. The volume of refinance applications is captured by the refinance application index released by the Mortgage Bankers Association. The household debt service burden variable is collected by the Federal Reserve System. Per capita income information is released by the Bureau of Economic Analysis. Finally, a measure of the tightness of underwriting standards is constructed from data from the Senior Loan Officer Opinion Survey on Bank Lending Practices. The survey is conducted by the Federal Reserve System. For a complete list of data sources, see Appendix B.

The modeling team used Moody's forecasts published on November 25, 2017 (specifically the baseline scenario termed by Moody's as the "Consensus Forecast" scenario) for the macroeconomic drivers where available. This forecast scenario is designed by Moody's to incorporate the central tendency of baseline forecasts produced by reputable institutions and professional economists, including the Congressional Budget Office (CBO), Office of Management and Budget, Social Security Administration, and the Federal Reserve. In cases where Moody's forecasts were not available (in particular, for the government share of home purchases and refinances), the team generated and tested its own forecasts.

# 3 Housing And Mortgage Market Driver Variables

This section describes the historical and projected trends of key driver variables and the macroeconomic environment that has shaped the mortgage market for the study period.

## 3.1 Macroeconomic Outlook Embedded in the Models

Interest rates are arguably one of the most important variables in determining the trajectory of the mortgage market. The Federal Reserve launched its "interest rate normalization" process in December 2015 with a 0.25-percentage point increase. Since then, the Federal Reserve's Federal Open Market Committee (FOMC) voted to raise the rate once in 2016 and thrice in 2017. While storm-related disruptions and rebuilding, resulting from hurricanes Harvey, Irma, and Maria, will affect economic activity in the near term, there is some consensus among economists that the Federal Reserve will continue with the rate hikes over the next couple years if economic signals indicate that there is a need for it. Mortgage interest rates—in particular the 30-year fixed rate, which is closely tied to the federal funds rate and the 10-year Treasury note yield—are expected to continue to rise gradually from the historic low of 3.4 percent (August 2016) to 4.8 percent by 2020.

The unemployment rate has steadily fallen over the last few years to 4.4 percent in August 2017. It is expected to remain relatively flat (between 4.1 to 4.5 percent) over the next three years, given the expected growth of the economy at the modest range of 2.0 to 2.4 percent per year according to Moody's. Per capita disposable nominal income growth is forecast by Moody's to be modest as well: from $45,500 in 2018 to $48,400 in 2020. While household incomes are increasing slowly, the inflation rate is forecast to range between 1.9 to 2.3 percent throughout the period, although that depends in the near term on the recovery from the recent hurricane devastation and on the Federal Reserve's policies in the near and medium term.

The overall housing market is expected to continue its recovery, although the growth of house prices is not expected to be as large as the last few years given the interest rate environment. FHFA's purchase-only House Price Index (HPI) is forecast by Moody's to increase at the annual rates of 3.8, 4.8, and 2.9 percent in 2018, 2019, and 2020, respectively.[5]

Everything else being equal, the expected increase in mortgage interest rates and house prices will likely impact the ability of low- and very low-income households to purchase homes. Housing affordability, as measured by Moody's forecast of the National Association of Realtors' Housing Affordability Index (HAI), is expected to decline gradually from the index value of 156.5 in 2017 to 148.0 in 2020.

Over the past few years, low interest rates coupled with rising house prices have created an incentive for many homeowners to refinance. The refinance share has increased from 39.9 percent of overall mortgage originations in 2014 to 47.4 percent in 2016. However, assuming that interest rates are going to rise over the next few years, the refinance rate is expected to fall below 27 percent during the 2018 to 2020 period.

Exhibit 1 provides summary statistics on key macroeconomic indicators and the driver variables that are used in the forecast models. Variables that are forecasted by Moody's are presented in the first panel of the Exhibit, while those that are forecasted (or adjusted) by FHFA are presented in the second panel of the Exhibit.

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[5]The National Association of Realtors' (NAR) housing affordability index is a national index. It does not capture regional differences. It measures, nationally, whether an average family could qualify for a mortgage on a typical home. A typical home is defined as the national median-priced, existing single-family home as reported by NAR. An average family is defined as one earning the median family income. The calculation assumes a down payment of 20 percent of the home price and that the monthly payment cannot exceed 25 percent of the median family income. To interpret the index, a value of 100 means that a family with the median income has exactly enough income to qualify for a mortgage on a median-priced home. An index value above 100 signifies that family earning the median income has more than enough income to qualify for a mortgage loan on a median-priced home. A decrease in the index value over time means that housing is becoming less affordable.

**Exhibit 1:** Historical and Projected Trends of Key Macroeconomic Driver Variables

| | Historic Trends | | | | | | | Projected Trends | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| Real Gross Domestic Product (Billions 2009 $)... | $14,785 | $15,021 | $15,355 | $15,613 | $16,015 | $16,472 | $16,717 | $17,092 | $17,500 | $17,842 | $18,196 |
| Real GDP Growth Rate................................. | 2.5 | 1.6 | 2.2 | 1.7 | 2.6 | 2.9 | 1.5 | 2.2 | 2.4 | 2.0 | 2.0 |
| Unemployment Rate..................................... | 9.6 | 8.9 | 8.1 | 7.4 | 6.2 | 5.3 | 4.8 | 4.4 | 4.1 | 4.2 | 4.5 |
| Labor Force Participation Rate........................ | 64.7 | 64.1 | 63.7 | 63.3 | 62.9 | 62.7 | 62.8 | 62.9 | 63.1 | 63.0 | 62.9 |
| Inflation Rate (Change in CPI)......................... | 1.6 | 3.1 | 2.1 | 1.5 | 1.6 | 0.1 | 1.3 | 2.1 | 1.9 | 2.3 | 2.0 |
| Consumer Confidence Index............................ | 54.5 | 58.1 | 67.1 | 73.3 | 86.9 | 98.0 | 99.8 | 118.6 | 102.2 | 98.6 | 96.3 |
| 10-Year Treasury Yield.................................. | 3.2 | 2.8 | 1.8 | 2.4 | 2.5 | 2.1 | 1.8 | 2.4 | 2.9 | 3.1 | 3.2 |
| Yield Curve................................................. | 2.9 | 2.6 | 1.6 | 2.2 | 2.4 | 1.8 | 1.2 | 1.2 | 0.7 | 0.3 | 0.4 |
| 30-Year Mortgage Fixed Rate.......................... | 4.7 | 4.5 | 3.7 | 4.0 | 4.2 | 3.9 | 3.6 | 4.0 | 4.5 | 4.7 | 4.8 |
| 30-Year FHA Mortgage Fixed Rate................... | 5.0 | 4.7 | 3.8 | 4.2 | 4.4 | 4.2 | 4.2 | 4.5 | 4.8 | 5.0 | 5.1 |
| Per Capita Disposable Income (1000s $)........... | $36.3 | $37.8 | $39.5 | $39.2 | $40.9 | $42.4 | $43.2 | $44.2 | $45.5 | $47.0 | $48.4 |
| Household Debt Service Ratio......................... | 6.2 | 5.6 | 5.2 | 5.0 | 4.7 | 4.6 | 4.5 | 4.5 | 4.8 | 5.2 | 5.5 |
| Existing Home Sales (1000s)......................... | 3,703 | 3,793 | 4,125 | 4,475 | 4,339 | 4,627 | 4,828 | 4,928 | 5,458 | 5,843 | 5,482 |
| Net Percent of Banks Tightening Standards....... | 4.7 | 0.0 | -1.3 | -7.2 | -6.7 | -10.8 | -7.7 | -7.5 | -15.3 | -12.0 | -2.2 |
| Refinance Mortgage Application Share.............. | 72.5 | 70.5 | 77.3 | 63.2 | 51.8 | 53.7 | 55.3 | 41.4 | 34.7 | 38.4 | 39.3 |
| Housing Affordability Index............................. | 177.3 | 196.6 | 200.9 | 168.1 | 168.1 | 166.0 | 164.0 | 156.5 | 154.0 | 150.1 | 148.3 |
| Percent Change in House Prices (PO)[1]............ | -4.0 | -2.3 | 5.1 | 7.2 | 4.8 | 5.8 | 6.3 | 5.4 | 3.8 | 4.8 | 2.9 |
| Percent Change in House Prices (ALL)[2]........... | -2.7 | -3.0 | 0.7 | 4.8 | 5.3 | 5.5 | 5.8 | 5.4 | 3.6 | 4.4 | 3.3 |
| Refinance Mortgage Share............................. | 68.2 | 63.2 | 70.7 | 58.8 | 39.9 | 46.4 | 47.4 | 31.5 | 27.0 | 28.1 | 28.2 |
| Percent Gov. Insured Home Purchase Loans ..... | 45.9 | 42.8 | 38.7 | 33.0 | 31.7 | 34.1 | 33.9 | 34.1 | 37.0 | 39.7 | 42.1 |
| Percent Gov. Insured Refinance Loans............. | 13.8 | 12.4 | 14.5 | 14.4 | 16.3 | 21.2 | 22.7 | 21.0 | 22.7 | 23.2 | 24.0 |

Note: Historical values and projected trends are provided by Moody's Analytics. Government shares of the home purchase and refinance market are forecasted by FHFA.
[1] Purchase transactions only (Q4/Q4 % Change)
[2] All transactions (Q4/Q4 % Change)

## 3.2 Expectations Regarding Key Driver Variables

### 3.2.1 Interest Rates

Mortgage interest rates are affected by many factors. Trends in interest rates on longer term financial instruments such as mortgages typically follow the fluctuations of the 10-Year Treasury note yield, with approximately a 50 to 110 basis point spread between the 1-year and 10-year Treasury yields reflecting the differences in liquidity and credit risk expected for the 2018 through 2020 period. This expected rate spread is lower than what was experienced during the past five years (July 2012-June 2017). As noted before, interest rates are heavily influenced by the monetary policies of the Federal Reserve Board's Federal Open Market Committee (FOMC). Since mid-2008, the FOMC has maintained an accommodative monetary policy in support of its dual mandate of fostering maximum employment and price stability. But, while near-term risks to the economic outlook appear roughly balanced, the FOMC is monitoring the inflation rates closely. Exhibit 2 shows the historical and forecast values of the 30-year fixed mortgage interest rate.

Affordability in the mortgage market depends in part on the interest rate environment. The longer term 30-year fixed-rate mortgage (FRM) interest rate fell to a low of 3.3 percent

**Exhibit 2:** Historical and Projected Trends of Mortgage Rates



Yield Curve (Right Axis) — 10-Year Treasury — 30-Year Fixed Mortgage Rate
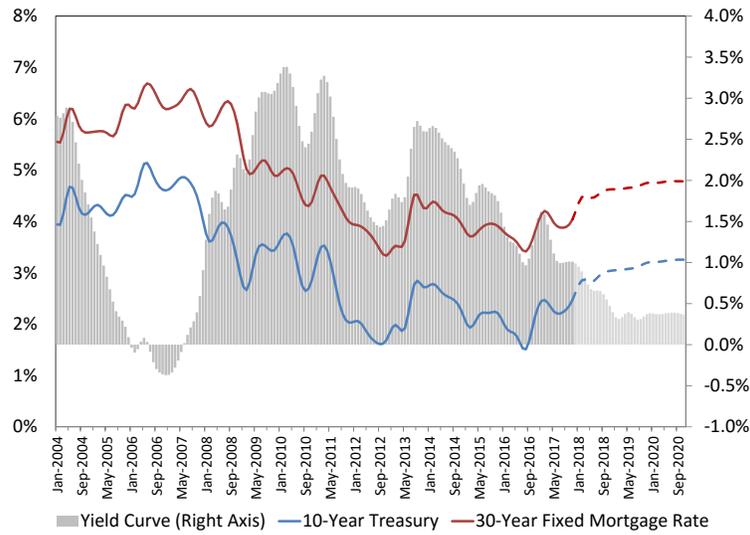
in November 2012 and rose to a high of 4.5 percent in September 2013, before eventually falling to its recent low of 3.4 percent in August 2016. Over the past year, the 30-year FRM rate has fluctuated around 4 percent. Lower interest rates directly affect the affordability of buying a home or refinancing a mortgage. For the 2018-2020 period, the forecast shows that all interest rates are expected to increase, including the interest rate on a 30-year fixed-rate mortgage, which is expected to rise to 4.5 percent in 2018, 4.7 percent in 2019, and 4.8 percent in 2020.

### 3.2.2  Unemployment

In addition to being an indicator of the health of the economy in general, the employment situation affects the housing market more directly because buying a house is the single largest investment for many households as well as a long-term commitment that requires stable employment. The unemployment rate has steadily fallen from 9.1 percent in August 2011 to 4.4 percent in August 2017. The labor force participation rate was 62.9 percent in August 2017 and has remained within a range of 62.0 to 64.0 percent over the past five years.

One of the stated objectives of the FOMC's interest rate policy is fostering maximum employment. Given the foreseeable monetary policy and the continued growth in the economy, the unemployment rate is expected to average 4.3 percent in the 2018 to 2020 period. Its impact on the affordable home purchase market will depend on the composition of the unemployment rate and could be expected to be greater if the unemployment rate of lower-wage earners is a big driver of the change in the overall unemployment rate.

### 3.2.3 Inflation

The second stated objective of the FOMC in determining its interest rate policy is maintaining price stability. Moody's forecast predicts inflation to be generally in check, averaging around 2.0 percent through 2020.

### 3.2.4 House Prices and Affordability

Trends in house prices influence the housing and mortgage markets. In periods of house price appreciation, home sales and mortgage originations may increase as the expected return on investment rises. In periods of price depreciation or price uncertainty, home sales and mortgage originations tend to decrease as risk-averse homebuyers are reluctant to enter the market. House prices generally fell during 2007 through 2011, but turned around with annual price increases in excess of 5.0 percent in FHFA's Purchase Only Home Price Index over the period 2012 through 2016. According to Moody's forecast, house prices are expected to continue to increase at rates of 3.8, 4.8, and 2.9 percent in 2018, 2019, and 2020, respectively. As discussed above, the expected increase in interest rates and house prices should lead to a decrease in housing affordability. To measure housing affordability, we use the housing affordability index published by the National Association of Realtors. Exhibit 3 presents the relationship between house price index and housing affordability index.

**Exhibit 3:** Historical and Projected Trends of House Prices
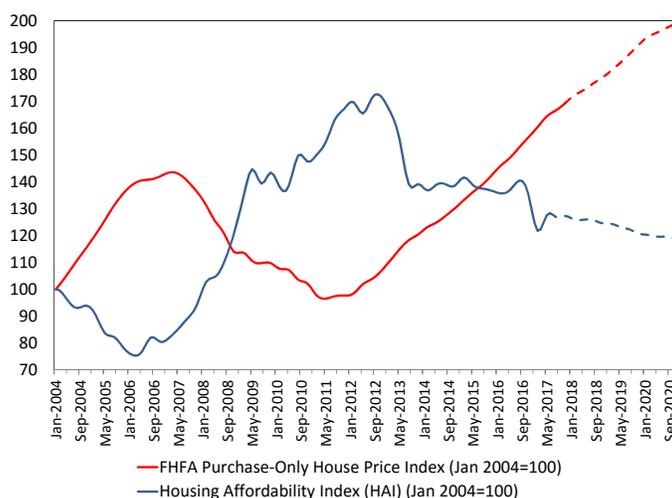


### 3.2.5 Refinance Rate

The size of the refinance mortgage market has an impact on the affordable share of refinance mortgages. Historically, refinance mortgage volume increases when the refinancing of

mortgages is motivated by low interest rates ("rate-and-term refinances"), and higher-income borrowers tend to make up a greater share of this increased volume. As a result, in periods of low interest rates, the share of lower-income borrowers tended to decrease. Likewise, refinancing that occurred when interest rates were high tended to have a higher proportion of lower-income homeowners who were consolidating their debts or who were drawing equity out of their homes for other uses. Exhibit 4 plots the historical (and projected) values of the 30-year fixed mortgage rate and refinance share of mortgage originations. It shows a rough (negative) correlation between the mortgage rate and refinance share. Moody's forecast for the refinance rate is that it will drop to 28.2 percent by 2020.

**Exhibit 4:** Historical and Projected Trends of Refinance Rate
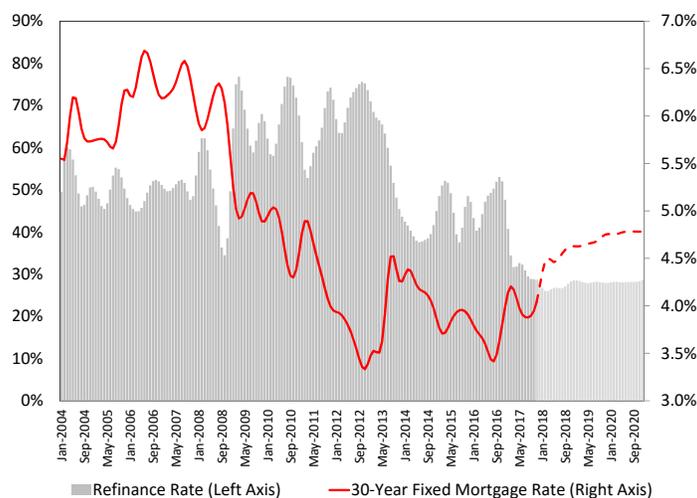


### 3.2.6 Underwriting Standards

Mortgage underwriting standards obviously have an impact on mortgage originations. Exhibit 5 presents the changes in the tightness of underwriting standards reported by lenders over time. During the housing boom years, as can be seen from the graph, underwriting standards became loose. Following the housing bust in 2006, lenders tightened underwriting standards considerably. The current underwriting standards, while looser than previous years, are still considered to be quite tight.

### 3.2.7 Share of Government-Insured and Guaranteed Mortgages

Moody's does not publish forecasts for the government share of home purchase and refinance originations. The modeling team developed basic forecast models to project these series through 2020. Government shares are modeled to be driven by trends in the unemployment

**Exhibit 5:** Historical and Projected Trends of Underwriting Standards



% Change of of Lenders Reported Tightening Underwriting Standards
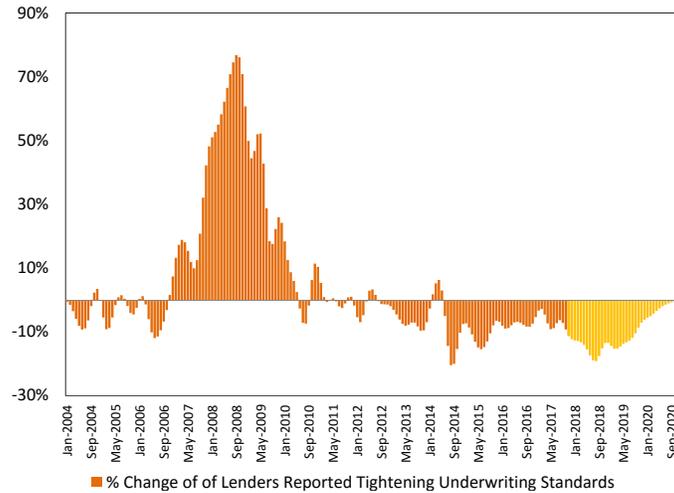
rate, interest rates, the spread between FHA and conventional mortgages, existing home sales, relative underwriting tightness, and house prices. We forecast that the government share of home purchases and refinances will reach 42.1 percent and 24.0 percent by 2020.

# 4 Econometric Models Of The Single-Family Housing Goals

The purpose of the statistical models is to forecast the market share of the goal-qualifying mortgage originations in the mortgage market for the 2018-2020 period. The focus is on generating reliable model forecasts, rather than testing economic hypotheses or trying to understand the relationship between the variables. Moreover, the forecast equation itself is in the nature of a reduced form equation for the affordable market. Separate models are developed for each of the four single-family housing goals. We use a type of time-series regression models called Autoregressive Integrated Moving Average (ARIMA) models. Widely used in the field of economic forecasting, ARIMA models are known for their flexibility and ability to generate good fit to various historical series. FHFA has employed these ARIMA models in past rule making cycles to generate market forecasts. We have updated the model specification of the ARIMA models in this goal cycle based on feedback received from various commenters in the last rule-making cycle.

The outcome variable for each of the models is expressed in percentage share format. It is constructed as a monthly time series using the 2004-2016 HMDA data, as described earlier. All the outcome variables and driver variables were first-differenced to ensure that all the data series have the statistical property that they are stationary. Once first-differenced, the

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augmented Dickey-Fuller test (ADF) was conducted on each series to confirm that all the variables (in first difference format) are stationary.

Fitting an ARIMA model on first-differenced variables means that the reported regression coefficients can no longer be interpreted in the way the "beta" coefficients are interpreted in linear regression. Not only are the estimated equations non-linear (indicating the slope of the line is dependent on the specific point the reader is interested in), the coefficients themselves represent the change in the first difference of the dependent variable. Fortunately, since the goal of our models is to forecast rather than explain the reduced form equation of the various housing goal "markets," we are able to rely on out-of-sample forecasts to test the robustness of various specifications.

In order to model the non-contemporaneous nature of the relationship between macroeconomic variables, both lagged and un-lagged versions of each driver variable were tested and the appropriate form of the variable chosen.[6] Further, to avoid multi-collinearity (or correlation among driver variables), the modeling team has tested correlation between potential driver variables and ensured that the final model specification did not include driver variables that are highly correlated. Monthly indicator variables are included in the models to control for the seasonal/cyclic patterns of the mortgage activities. Finally, to allow for non-linearity between the outcome variable and driver variables, we tested and then introduced some of the variables in natural logarithm scale. For example, the consumer confidence index variable is entered in logarithm scale in the model for the low-income home purchase market share because it provided a better fit to the data in that form.

During the model development process, we grouped the factors that are expected by housing market economists to have an impact on the market share of affordable housing into seven broad categories. They are:

- Demand side factors such as per capita income and household debt service indicators;
- Interest rate environment including the 30 year FRM mortgage rate;
- Expectation factors and indicators of the health of the economy such as the unemployment rate, labor force participation rate, the consumer confidence index and consumer confidence index;
- House price level including FHFA's house price indices and the Housing Affordability Index;
- Supply side factors including indicators of existing home sales;
- Underwriting standards including the Senior Loan Officer Opinion survey; and
- Other including the share of government insured or guaranteed mortgages.

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[6]Lagged variables are reported with a subscript such as $t-1$ in the tables for the regression coefficients.

For each category of variables, many variables were tested but only retained when they exhibited predictive power. For each model, we tested and succeeded in including at least one driver variable per category. We concentrated on the theoretical and behavioral implications when selecting the driver variables but since our goal was to develop robust forecasting models (rather than developing explanatory models), we retained driver variables depending solely on the strength of the explanatory power as long as each category was represented. The new set of models described in this paper includes new driver variables such as household debt service ratio, labor force participation rate and indicators for underwriting standards.

## 4.1   Market Forecast For Low-Income Home Purchase Goal (LIP)

Exhibit 6 reports the final set of model driver variables that we have selected for the low-income home purchase goal. It also reports the regression coefficients and their level of statistical significance. The driver variables that were found to be statistically significant are:

- Household debt service ratio (as percentage of disposable income)
- Per capita income
- Labor force participation rate (working age)
- Consumer confidence
- Consumer price index
- Housing affordability index
- Sale of existing homes
- Share of government insured or guaranteed mortgages

The Chi-square statistics and other model fit measures reported at the bottom of the table are reasonable for forecasting models for this kind of data. The Pr(Chi-square) statistic, for instance, indicates the probability that, after including the relevant driver variables in the model, the regression residuals are following a white noise distribution(therefore random).

To test for reliability and accuracy of the model's forecasts, we have conducted out-of-sample tests where we withhold the last 12 months (2016) of the HMDA series and estimated the model using the remaining data series (that is, 2004-2015). We then compared the model forecasts in the "hold-out" period (2016) to the actual values in the same period (2016). Results of this analysis are presented in Exhibit 7. The blue line represents the historical HMDA series, while the red line represents the model forecast. Focusing on the out-of-sample forecast period (2016), while the two lines do not track each other perfectly, the forecast model is able to capture the downturns and upturns in the actual data (blue line), albeit with a lag. This is an indication of the robustness of the model specification.

**Exhibit 6:** Regression Coefficients of Market Forecast Model for the Low-Income Home Purchase Goal

**Outcome Variable (First Difference)**

Share of Borrowers with Low Income

| Driver Variable (First Difference) | Coefficient Estimate |
|---|---|
| *Demand Side Factors* | |
| Household Debt Service Ratio (% of Disposable Income) $_{t-2}$ | 0.0330 ** |
| | (0.0133) |
| Per Capita Income $_{t-1}$ | 0.0065 ** |
| | (0.0028) |
| *Interest Rate Environment* | |
| 30-Year Fixed Mortgage Rate $_{t-2}$ | -0.0012 |
| | (0.0048) |
| *Expectations Factors & Health of Economy* | |
| Unemployment Rate | 0.0029 |
| | (0.0049) |
| Labor Force Participation Rate (Working Age) | -0.0206 *** |
| | (0.0078) |
| Ln(Consumer Confidence) | 0.0221 ** |
| | (0.0087) |
| Consumer Price Index (CPI) $_{t-1}$ | -0.0022 ** |
| | (0.0010) |
| *House Price Levels* | |
| Housing Affordability Index | 0.0006 ** |
| | (0.0003) |
| *Supply Side Factors* | |
| Sale of Existing Homes | 0.0201 *** |
| | (0.0046) |
| *Underwriting Standards* | |
| Senior Loan Officer Opinion Survey: Percent of lenders reported tightening of underwriting | -0.0053 |
| | (0.0138) |
| *Other* | |
| Share of Government-Insured or Guaranteed Mortgages | 0.1826 *** |
| | (0.0440) |
| AR(1) | -0.0407 |
| | (0.0889) |
| *Model Diagnostics* | |
| $\chi^2$ | 4.58 |
| Prob(>χ2) | 0.47 |
| AIC | -1159.81 |
| SBC | -1089.81 |

Notes:

All variables are in first-difference format. Model includes monthly dummy variables that control for seasonal variations.

Standard Errors are reported in paratheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01.

**Exhibit 7:** Robustness Test of Market Forecast Model for the Low-Income Home Purchase Goal
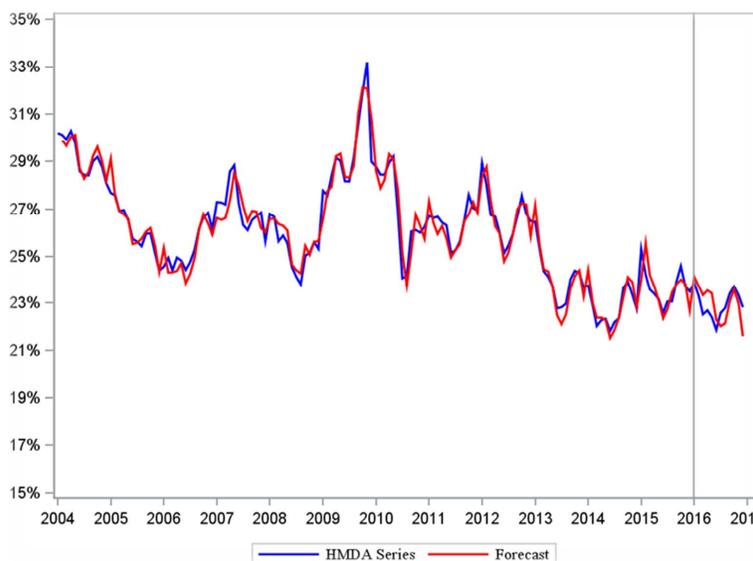


Exhibit 8 plots the monthly forecasts generated by the model for 2017-2020 period. The red line represents the forecast, while the yellow lines are the corresponding confidence intervals. The LIP market share is expected rise gradually in 2018 and 2019 before leveling out.

**Exhibit 8:** Model Forecast for the Low-Income Home Purchase Goal
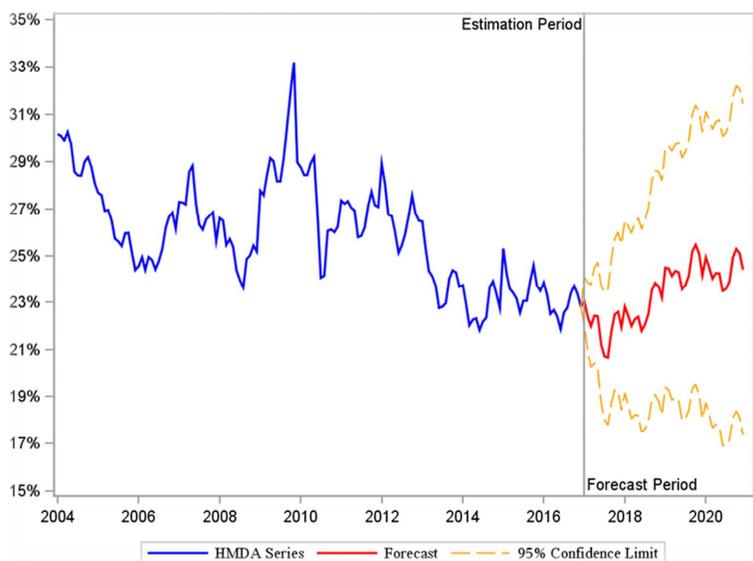


Exhibit 9 presents a summary of the annual forecasts (and their confidence intervals), together with the historical market shares (HMDA) and the benchmark levels that FHFA set for the Enterprises in the past. As a reference, it also shows the model forecasts for the 2014-2017 period that FHFA published in the Federal Register for the 2015 Final Rule. It

is worth noting that the model forecasts for 2014-2016 period are very close to the actual HMDA market shares for the corresponding years, indicating the accuracy of the models used in the last round of rule-making . Forecasts from the new model are shown in the last row: 22.7 percent for 2018, 24.4 percent for 2019, and 24.3 percent for 2020. The average annual forecast across the 2018-2020 period is 23.8 percent.

**Exhibit 9:** Historical Performance and Model Forecast for the Low-Income Home Purchase Goal

| | Historical Performance | | | | | | | Projected Performance | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| Actual Market | 27.2 | 26.5 | 26.6 | 24.0 | 22.8 | 23.6 | 22.9 | | | | |
| Benchmark | 27 | 27 | 23 | 23 | 23 | 24 | 24 | 24 | | | |
| 2015 Final Rule Market Forecast | | | | | 22.0 +/- 2.0 | 22.4 +/- 3.2 | 22.9 +/- 4.2 | 22.0 +/- 5.0 | | | |
| Current Market Forecast | | | | | | | | 21.9 +/- 2.5 | 22.7 +/- 4.3 | 24.4 +/- 5.5 | 24.3 +/- 6.5 |

## 4.2 Market Forecast For Very Low-Income Home Purchase Goal (VLIP)

The market model for the very low-income home purchase goal includes the same set of driver variables that are included in the model for the low-income home purchase goal. Among the driver variables, in addition to those that are found statistically significant in the low-income home purchase model, the unemployment rate is a significant driver variable for the very low-income home purchase model. The coefficient estimates and their level of significance are, of course, different from those for the model of the low-income home purchase goal. Exhibit 10 presents the model driver variables and the corresponding coefficient estimates as well as the model fit diagnostic measures.

Exhibit 11 presents the out-of-sample robustness test with the red line representing the model estimated on 2004-2015 data and the blue line representing the actual HMDA estimates for the entire period. As can be seen, for the out of sample period (2016), the model forecast (red line) does a good job capturing the turns in the actual data for 2016 (blue line), indicating the robustness of the model specification.

Exhibit 12 plots the monthly forecasts generated by the model for 2017-2020 period. The red line represents the forecast, while the yellow lines are the corresponding confidence intervals. It shows that similar to the LIP market, the VLIP market share is expected rise

**Exhibit 10:** Regression Coefficients of Market Forecast Model for the Very Low-Income Home Purchase Goal

| Outcome Variable (First Difference) | |
| --- | --- |
| Share of Borrowers with Very Low Income | |

| Driver Variable (First Difference) | Coefficient Estimate |
| --- | --- |
| *Demand Side Factors* | |
| Household Debt Service Ratio (% of Disposable Income) $_{t-2}$ | 0.0099 ** |
| | (0.0043) |
| Per Capita Income $_{t-1}$ | 0.0023 ** |
| | (0.0009) |
| *Interest Rate Environment* | |
| 30-Year Fixed Mortgage Rate $_{t-2}$ | -0.0001 |
| | (0.0016) |
| *Expectations Factors & Health of Economy* | |
| Unemployment Rate | 0.0027 * |
| | (0.0016) |
| Labor Force Participation Rate (Working Age) | -0.0073 *** |
| | (0.0026) |
| Ln(Consumer Confidence) | 0.0076 *** |
| | (0.0028) |
| Consumer Price Index (CPI) $_{t-1}$ | -0.0007 ** |
| | (0.0003) |
| *House Price Levels* | |
| Housing Affordability Index | 0.0003 *** |
| | (0.0001) |
| *Supply Side Factors* | |
| Sale of Existing Homes | 0.0068 *** |
| | (0.0015) |
| *Underwriting Standards* | |
| Senior Loan Officer Opinion Survey: Percent of lenders reported tightening of underwriting | 0.0016 |
| | (0.0045) |
| *Other* | |
| Share of Government-Insured or Guaranteed Mortgages | 0.0490 *** |
| | (0.0153) |
| AR(1) | -0.1435 |
| | (0.0897) |
| *Model Diagnostics* | |
| $\chi^2$ | 6.19 |
| Prob(>χ2) | 0.29 |
| AIC | -1483.06 |
| SBC | -1413.06 |

Notes:

All variables are in first-difference format.  Model includes monthly dummy variables that control for seasonal variations.

Standard Errors are reported in paratheses.  Significance levels: * p<0.1, ** p<0.05, *** p<0.01.

gradually in 2017 and 2018 reaching a peak in early 2018. From there, it eventually returns to the 2015 level in 2020.

**Exhibit 11:** Robustness Test of Market Forecast Model for the Very Low-Income Home Purchase Goal
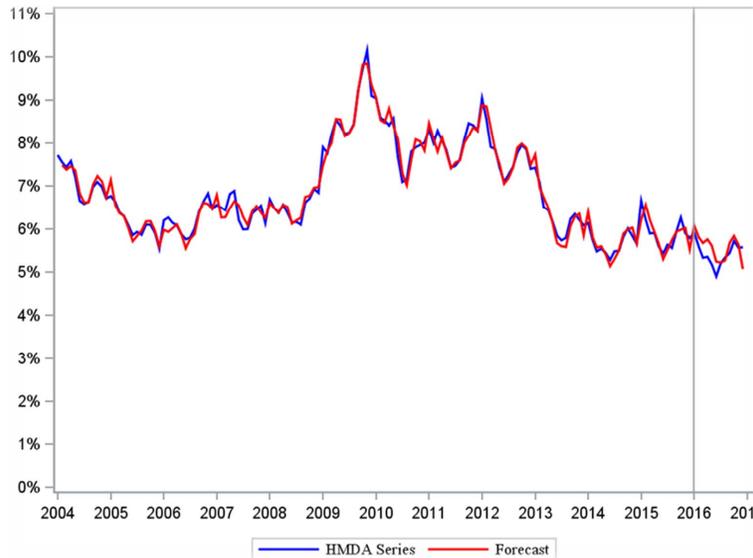


**Exhibit 12:** Model Forecast for the Very Low-Income Home Purchase Goal
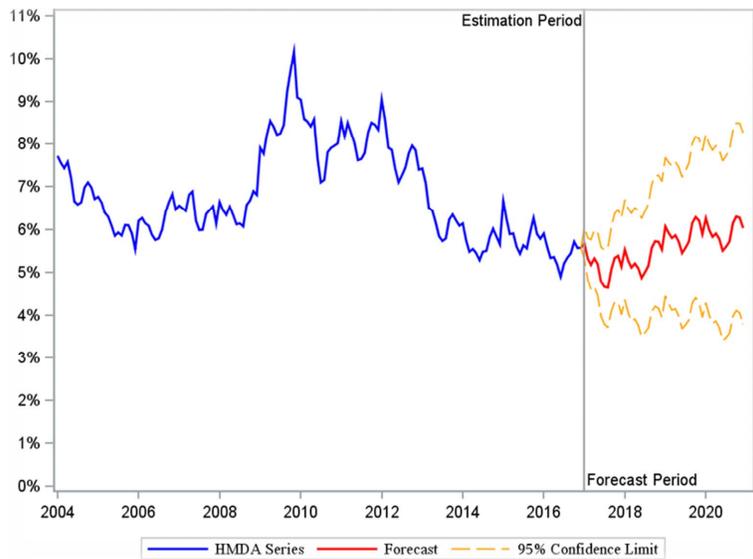


Exhibit 13 presents a summary of the annual forecasts (and their confidence intervals), together with the historical market shares (HMDA) and the benchmark levels that FHFA set for the Enterprises in the past. As a reference, it also shows the model forecasts for the 2014-2017 period that FHFA published in the Federal Register for the 2015 Final Rule. Forecasts from the new model are shown in the last row: 5.3 percent for 2018, 5.9 percent

for 2019, and 5.9 percent for 2020. The average annual forecast across the 2018-2020 period is 5.7 percent.

**Exhibit 13:** Historical Performance and Model Forecast for the Very Low-Income Home Purchase Goal

| | Historical Performance | | | | | | | Projected Performance | | | |
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Actual Market | 8.1 | 8.0 | 7.7 | 6.3 | 5.7 | 5.8 | 5.4 | | | | |
| Benchmark | 8 | 8 | 7 | 7 | 7 | 6 | 6 | 6 | | | |
| 2015 Final Rule Market Forecast | | | | | 5.7 +/- 1.4 | 5.9 +/- 2.5 | 6.0 +/- 3.2 | 5.7 +/- 3.8 | | | |
| Current Market Forecast | | | | | | | | 5.1 +/- 0.9 | 5.3 +/- 1.5 | 5.9 +/- 1.9 | 5.9 +/- 2.2 |

## 4.3 Market Forecast For Low-Income Areas Home Purchase Subgoal (LAS)

While the definition of goal-qualifying mortgages for the low-income and very low-income goals involves the borrower's income affordability alone, the definition of goal-qualifying mortgages for the low-income area subgoal involves both the borrower's income affordability and the (census tract) location of the borrower's residence. Specifically, the subgoal is intended to measure the share of home purchase mortgage originations associated with:

(A) Borrowers living in census tracts where the median census tract income is no greater than 80 percent of AMI; and

(B) Borrowers with incomes no greater that 100 percent of AMI living in census tracts with a minority population of 30 percent or more and median census tract income of less than 100 percent of AMI.

Thus, borrowers could qualify under both conditions. For example, in 2015, mortgages satisfying condition (A) above were roughly double the share of mortgages satisfying condition (B): 12.2 percent of mortgages met condition (A) in 2015 and 7.5 percent met condition (B) and 4.6 percent of mortgages met both conditions (i.e., the "overlap" segment).

From an economic modeling perspective, it is necessary to generate non-intersecting populations as that is a pre-requisite for accurate modeling.

In prior goal periods, this overlap issue was essentially avoided by design: one model was run for the combined population after ensuring that there was no double counting of the
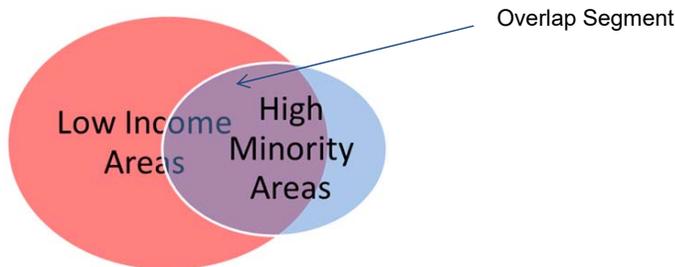
loans. This in effect implied that the drivers for the two populations were assumed to be the same variables. For the 2018-2020 goal period, the modeling team developed different models (with different drivers) for the non-intersecting subpopulations and found that this approach generated more accurate forecasts than the old practice. Thus, the modeling team constructed and ran models two ways: by grouping the overlap with the low income areas and by grouping the overlap with the high minority area components. If the overlap population of mortgages has more characteristics in common with the low income areas, we would expect the models that grouped the overlap with low income areas to perform better than the models that group the overlap with the high minority group. Indeed this is what the modeling team found: aligning the overlapping portion with the low-income area component yields forecast estimates that are more precise (in terms of a narrower confidence interval) than aligning the overlap with the high minority area.[7]

Therefore, we have two components to the LAS model: the low-income area component and high-minority area component that add up to the overall LAS share. The driver variables and regression coefficient estimates for the low-income area component model are shown in Exhibit 14.

---

[7]The two alternative model specifications are: (1) combine the low-income area component and high-minority area component into one outcome measure and build one model for it; and (2) combine the overlapping portion of the two components with the high-minority area component. The following table compares the confidence interval of the LAS forecast under different model specifications.

| | 2018 | 2019 | 2020 | 2018-2020 Average |
|---|---|---|---|---|
| **Final Model Specification:** | | | | |
| · Model low-income area component and high-minority area component separately | +/- 2.74% | +/- 3.23% | +/- 3.65% | +/- 3.20% |
| · Group overlap portion of the two components with low-income area component | | | | |
| **Alternative Model Specification #1:** | | | | |
| · Model low-income area component and high-minority area component together | +/- 3.44% | +/- 4.05% | +/- 4.58% | +/- 4.02% |
| **Alternative Model Specification #2:** | | | | |
| · Model low-income area component and high-minority area component separately | +/- 2.92% | +/- 3.44% | +/- 3.88% | +/- 3.41% |
| · Group overlap portion of the two components with high-minority area component | | | | |

**Exhibit 14:** Regression Coefficients of Market Forecast Model for the Low-Income Area Home Purchase Goal: Low-Income Area Component

**Outcome Variable (First Difference)**

Share of Borrowers Residing in Low-Income Areas

| Driver Variable (First Difference) | Coefficient Estimate |
|---|---|
| *Demand Side Factors* | |
| Household Debt Service Ratio (% of Disposable Income) $_{t-2}$ | 0.0025 |
| | (0.0054) |
| Per Capita Income $_{t-1}$ | -0.0014 |
| | (0.0012) |
| *Interest Rate Environment* | |
| 30-Year Fixed Mortgage Rate | 0.0066 ** |
| | (0.0029) |
| *Expectations Factors & Health of Economy* | |
| Unemployment Rate | -0.0061 *** |
| | (0.0021) |
| Labor Force Participation Rate (Working Age) | -0.0033 |
| | (0.0031) |
| Consumer Confidence $_{t-2}$ | 0.0002 *** |
| | (0.0001) |
| Consumer Price Index (CPI) $_{t-1}$ | -0.0003 |
| | (0.0004) |
| *House Price Levels* | |
| Housing Affordability Index | 0.0003 * |
| | (0.0002) |
| *Supply Side Factors* | |
| Sale of Existing Homes $_{t-6}$ | 0.0036 * |
| | (0.0019) |
| *Underwriting Standards* | |
| Senior Loan Officer Opinion Survey: Percent of lenders reported tightening of underwriting $_{t-4}$ | -0.0082 |
| | (0.0056) |
| *Other* | |
| Share of Government-Insured or Guaranteed Mortgages | 0.0320 |
| | (0.0216) |
| AR(1) | -0.2134 ** |
| | (0.0906) |
| AR(2) | -0.2516 *** |
| | (0.0901) |
| AR(3) | 0.1561 * |
| | (0.0922) |
| *Model Diagnostics* | 4.35 |
| $\chi^2$ | 0.23 |
| Prob(>χ2) | -1361.82 |
| AIC | -1285.74 |
| SBC | |

Notes:

All variables are in first-difference format.  Model includes monthly dummy variables that control for seasonal variations.

Standard Errors are reported in paratheses.  Significance levels: * p<0.1, ** p<0.05, *** p<0.01.

The driver variables that were found to be statistically significant are:

- 30-Year Fixed Mortgage Rate
- Unemployment Rate
- Consumer confidence
- Housing affordability index
- Sale of existing homes

The variables and coefficient estimates for the high-minority area component model are reported in Exhibit 15.

The driver variables that were found to be statistically significant are:

- Labor force participation rate (working age)
- Consumer confidence
- Housing affordability index
- Share of government insured or guaranteed mortgages

The Chi-square statistics reported at the bottom of both tables indicate that, after including the relevant driver variables in the model, the regression residuals are distributed randomly (following a white noise distribution).

Results of the out-of-sample forecast robustness tests are reported in Exhibit 16, separately for the two component models and for the overall LAS measure. Once again, the blue line represents the historical HMDA series, while the red line represents the model forecast. In each of the three cases, the red line tracks the blue line closely for the 2016 out-of-sample period, showing the robustness of the model estimates.

Exhibit 17 plots the monthly forecasts. This is done separately for the two component models and then combined to generate the LAS outcome measure. The red lines represent the forecasts, while the yellow lines are the corresponding confidence intervals. The forecasts exhibit noticeably seasonal/cyclical patterns. Over the 2017-2020 period, the share for the low-income area component is forecast to rise gradually while the share for the high-minority component is forecast to decline. These two trends offset each other as we combine them to obtain the overall LAS forecasts. As a result, the overall trend for the LAS market share is expected to be a slight decline for the 2017-2020 forecast period, notwithstanding the seasonal/cyclical patterns.

Exhibit 18 summarizes the annual forecasts (and their confidence intervals), together with the historical market shares (HMDA) and the benchmark levels that FHFA set for the Enterprises in the past. As a reference, it also shows the model forecasts for the 2014-2017 period that FHFA published in the Federal Register for the 2015 Final Rule. The model

**Exhibit 15:** Regression Coefficients of Market Forecast Model for the Low-Income Area Home Purchase Goal: High-Minority Area Component

| Outcome Variable (First Difference) | |
| --- | --- |
| Share of Borrowers Residing in High-Minority Areas | |

| Driver Variable (First Difference) | Coefficient Estimate |
| --- | --- |
| *Demand Side Factors* | |
| Household Debt Service Ratio (% of Disposable Income) $_{t-3}$ | 0.0031 |
| | (0.0024) |
| Per Capita Income $_{t-1}$ | 0.0000 |
| | (0.0005) |
| *Interest Rate Environment* | |
| 30-Year Fixed Mortgage Rate | 0.0007 |
| | (0.0012) |
| *Expectations Factors & Health of Economy* | |
| Unemployment Rate $_{t-1}$ | -0.0013 |
| | (0.0010) |
| Labor Force Participation Rate (Working Age) | -0.0038 ** |
| | (0.0015) |
| Consumer Confidence $_{t-1}$ | 0.0001 ** |
| | (0.0000) |
| Consumer Price Index (CPI) $_{t-6}$ | 0.0001 |
| | (0.0002) |
| *House Price Levels* | |
| Housing Affordability Index | 0.0002 ** |
| | (0.0001) |
| *Supply Side Factors* | |
| Sale of Existing Homes $_{t-6}$ | 0.0015 |
| | (0.0009) |
| *Underwriting Standards* | |
| Senior Loan Officer Opinion Survey: Percent of lenders reported tightening of underwriting | 0.0006 |
| | (0.0025) |
| *Other* | |
| Share of Government-Insured or Guaranteed Mortgages $_{t-4}$ | 0.0196 ** |
| | (0.0094) |
| AR(1) | -0.3697 |
| | (0.0840) |
| *Model Diagnostics* | |
| $\chi^2$ | 3.05 |
| Prob(>χ2) | 0.69 |
| AIC | -1553.73 |
| SBC | -1484.33 |

Notes:

All variables are in first-difference format.  Model includes monthly dummy variables that control for seasonal variations.

Standard Errors are reported in paratheses.  Significance levels: * p<0.1, ** p<0.05, *** p<0.01.

**Exhibit 16:** Robustness Test of Market Forecast Model for the Low-Income Area Home Purchase Goal



Low-Income Areas Component Home Purchase



High-Minority Areas Component Home Purchase



Low-Income Areas Home Purchase Subgoal
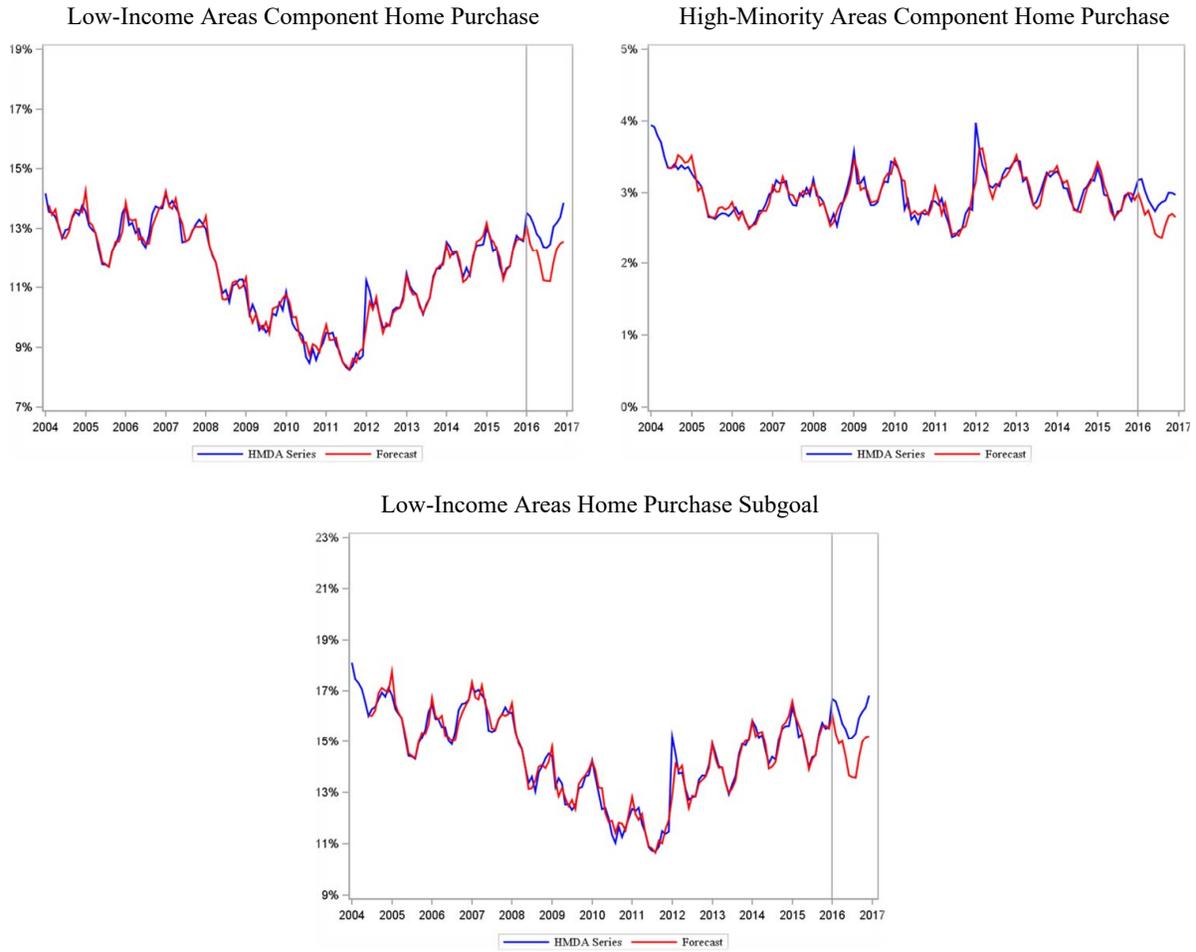
forecast for 2016 is quite close to the actual market level based on the HMDA data. Forecasts from the new model are shown in the last row: 16.6 percent for 2018, 16.8 percent for 2019, and 16.4 percent for 2020. The average annual forecast across the 2018-2020 period is 16.6 percent.

## 4.4 Market Forecast For Low-Income Refinance Goal (LIR)

The model for forecasting the share of low-income refinances is shown in Exhibit 19. As expected, the driver variables are quite different from those for the home purchase goal models because different factors determine a borrower's home purchase and refinance decisions. The driver variables that were found to be statistically significant are:

- Housing affordability index
- Share of government-insured or guaranteed refinance mortgages

**Exhibit 17:** Model Forecast for the Low-Income Area Home Purchase Goal

Low-Income Areas Component Home Purchase



High-Minority Areas Component Home Purchase



Low-Income Areas Home Purchase Subgoal
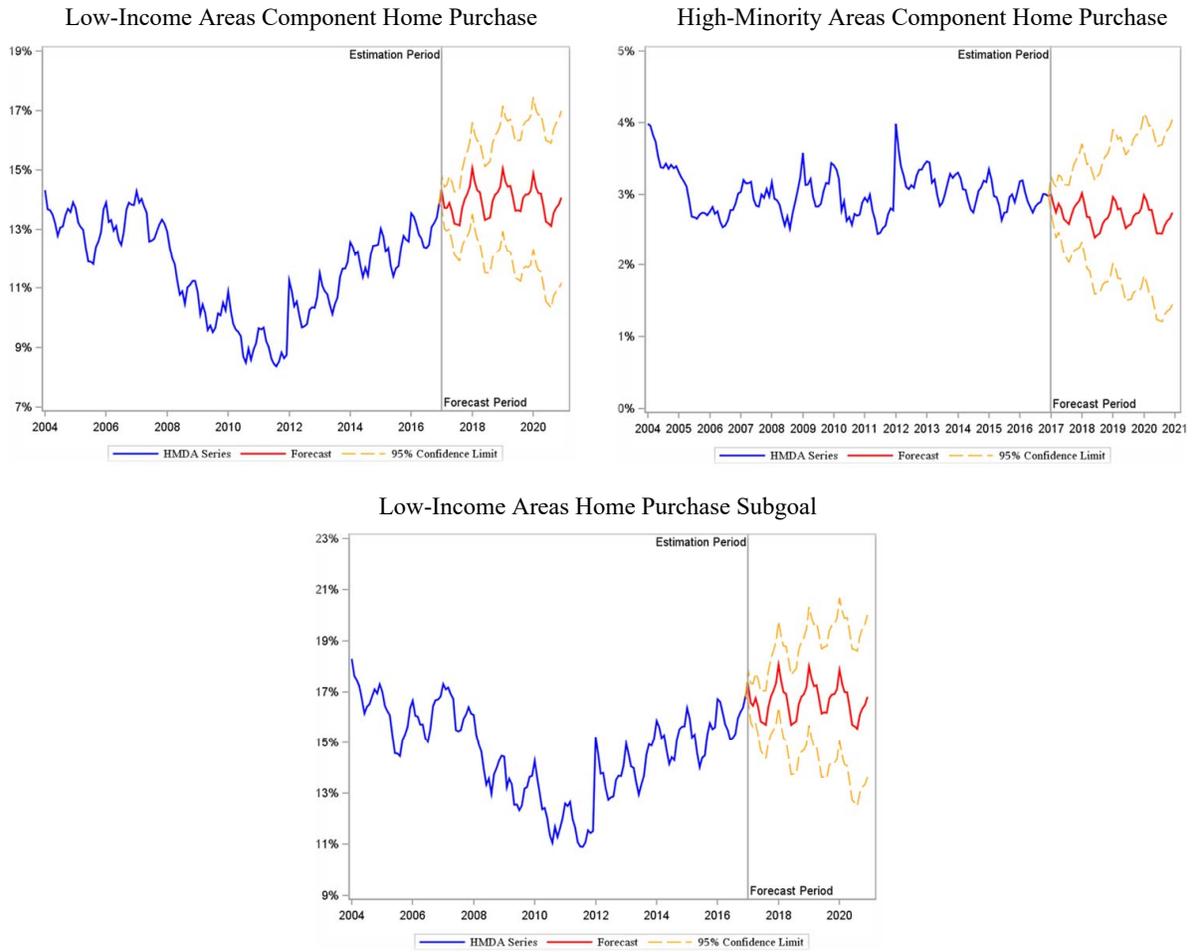


**Exhibit 18:** Historical Performance and Model Forecast for the Low-Income Area Home Purchase Goal

| | Historical Performance | | | | | | | Projected Performance | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| Actual Market | 12.1 | 11.4 | 13.6 | 14.2 | 15.0 | 15.2 | 15.9 | | | | |
| Benchmark | 13 | 13 | 11 | 11 | 11 | 14 | 14 | 14 | | | |
| 2015 Final Rule Market Forecast | | | | | 14.0 +/- 0.6 | 13.2 +/- 1.5 | 13.6 +/- 2.8 | 14.2 +/- 3.6 | | | |
| Current Market Forecast | | | | | | | | 16.5 +/- 1.2 | 16.6 +/- 2.0 | 16.8 +/- 2.5 | 16.4 +/- 3.0 |

25

- The refinance rate

**Exhibit 19:** Regression Coefficients of Market Forecast Model for the Low-Income Refinance Goal

| Outcome Variable (First Difference) | |
|---|---|
| Share of Refinance Borrowers with Low Income | |

| Driver Variable (First Difference) | Coefficient Estimate |
|---|---|
| *Demand Side Factors* | |
| Household Debt Service Ratio (% of Disposable Income) $_{t-3}$ | -0.0095 |
| | (0.0154) |
| Refinance Application Volume Index $_{t-1}$ | -0.0412 |
| | (0.0418) |
| *Interest Rate Environment* | |
| 30-Year Fixed Mortgage Rate $_{t-1}$ | -0.0052 |
| | (0.0248) |
| Refinance Incentive $_{t-1}$ | 0.0195 |
| | (0.0267) |
| *Expectations Factors & Health of Economy* | |
| Unemployment Rate | -0.0003 |
| | (0.0050) |
| Ln(Consumer Confidence) | 0.0112 |
| | (0.0107) |
| Consumer Price Index (CPI)$_{t-1}$ | -0.0013 |
| | (0.0013) |
| *House Price Levels* | |
| Housing Affordability Index $_{t-1}$ | 0.0012 ** |
| | (0.0005) |
| *Underwriting Standards* | |
| Senior Loan Officer Opinion Survey: Percent of lenders reported tightening of underwriting | 0.0107 |
| | (0.0171) |
| *Other* | |
| Share of Government-Insured or Guaranteed Refinance Mortgages | -0.1035 * |
| | (0.0578) |
| Refinance Rate | -0.2417 *** |
| | (0.0265) |
| AR(1) | -0.2978 *** |
| | (0.0847) |
| *Model Diagnostics* | |
| $\chi^2$ | 2.14 |
| Prob(>χ2) | 0.83 |
| AIC | -1046.40 |
| SBC | -976.40 |

Notes:

All variables are in first-difference format. Model includes monthly dummy variables that control for seasonal variations.

Standard Errors are reported in paratheses. Significance levels: * p<0.1, ** p<0.05, *** p<0.01.

The Chi-square statistics reported at the bottom of the table indicates that, after including the relevant driver variables in the model, the regression residuals are distributed randomly (following a white noise distribution).

Results of the out-of-sample forecast robustness test are presented in Exhibit **??**. The blue line represents the historical HMDA series, while the red line represents the model forecast. Focusing on the out-of-sample forecast period (2016), the forecast does a reasonably good job at tracking the actual HMDA observations. In particular, the model forecast is able to capture the upturns and downturns in the actual data (blue line).

Exhibit 21 plots the monthly forecasts generated by the model for 2017-2020 period. The red line represents the forecast, while the yellow lines are the corresponding confidence intervals. The plot shows that although the affordable share in the refinance market is forecast to rise in 2017 and 2018, we expect that it will eventually decline in 2019 and 2020.

**Exhibit 20:** Robustness Test of Market Forecast Model for the Low-Income Refinance Goal
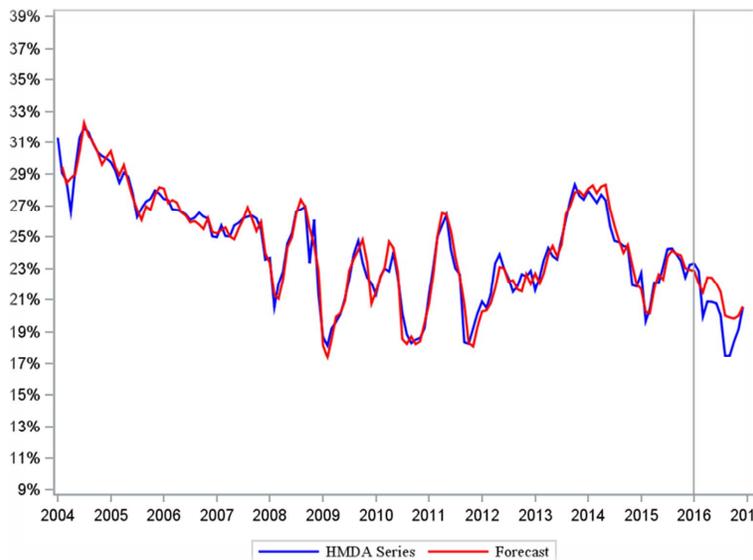


Exhibit 22 presents a summary of the annual forecasts (and their confidence intervals), together with the historical market shares (HMDA) and the benchmark levels that FHFA set for the Enterprises in the past. As a reference, it also shows the model forecasts for the 2014-2017 period that FHFA published in the Federal Register for the 2015 Final Rule. Model forecasts for 2014 and 2015 are quite close to the actual market shares reported by HMDA for the corresponding years. Forecasts from the new model are shown in the last row: 23.4 percent for 2018, 20.6 percent for 2019, and 18.0 percent for 2020. The average annual forecast across the 2018-2020 period is 20.7 percent.

# 5 Sensitivity of Model Estimates

The modeling team has also investigated the sensitivity of the model forecasts with respect to our assumption of future macroeconomic scenarios. Results are summarized in Appendix A.

**Exhibit 21:** Model Forecast for the Low-Income Refinance Goal
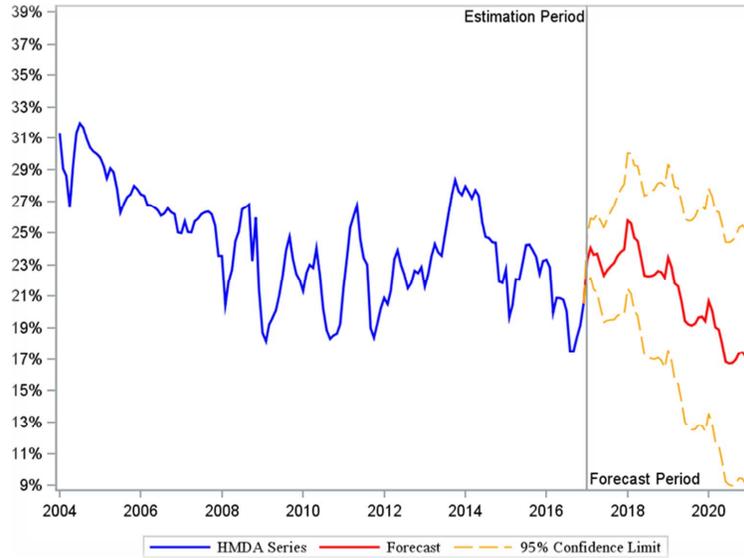


**Exhibit 22:** Historical Performance and Model Forecast for the Low-Income Refinance Goal

|  | Historical Performance | | | | | | | Projected Performance | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| Actual Market | 20.2 | 21.5 | 22.3 | 24.3 | 25.0 | 22.5 | 19.8 |  |  |  |  |
| Benchmark | 21 | 21 | 20 | 20 | 20 | 21 | 21 | 21 |  |  |  |
| 2015 Final Rule Market Forecast |  |  |  |  | 26.2 +/- 1.5 | 21.8 +/- 2.7 | 22.4 +/- 4.7 | 22.8 +/- 6.2 |  |  |  |
| Current Market Forecast |  |  |  |  |  |  |  | 23.4 +/- 3.0 | 23.4 +/- 5.1 | 20.6 +/- 6.5 | 18.0 +/- 7.7 |

Overall, we find that the forecasts are relatively insensitive to the use of alternative scenarios.

# 6 Concluding Remarks

This paper provides the technical details of the econometric models that we have developed to forecast the market share of the goal-qualifying mortgage originations in the mortgage market for each of the four single-family housing goals. Forecasts for the 2018-2020 period are presented. Model diagnostics and reliability of the forecasts have also been discussed. In addition, we present two scenario analyses in order to examine the sensitivity of the model forecasts to alternative macroeconomic environments for the forecast period.

# Appendix A:
# Sensitivity Of Model Estimates To Alternative Macroeconmic Forecast Scenarios

This section analyzes the extent to which our market share estimates are sensitive to the macroeconomic environments that we have assumed. The market share estimates we have reported so far in the paper are based on forecast values of the driver variables from Moody's Consensus Forecast scenario. This scenario incorporates the central tendency of baseline forecasts from a broad range of reputable institutions and professional economists, including the Congressional Budget Office, Office of Management and Budget, and the Federal Reserve. To assess the sensitivity of our market share estimates, we use forecast values of the driver variable from two alternative macroeconomic scenarios from Moody's. They are:

- **Stronger Near-Term Growth scenario**. This scenario assumes that the US economy will show a more robust economic growth in the near term as compared to the Consensus Forecast scenario. As Moody's notes, this scenario is designed so that there is a 10 percent probability that the economy will perform better than in this scenario.
- **Moderate Recession scenario**. This scenario assumes that, triggered by a sell-off in the stock market, the US will fall into a recession sometime in the first quarter of 2018. This scenario is designed so that there is a 10 percent probability that the overall economy will perform worse. Rising unemployment will cause purchasing power and house prices to drop. The recession will be less severe than the 2008-2009 downturn but it will last through most of 2018. However, the trough is well above that of the 2011 trough following the Great Recession. The recovery is assumed to begin in the first quarter of 2019. Based on historical experience, we assume that the maximum share of the government mortgages (FHA, VA, and RHS) cannot exceed 55 percent of the overall mortgage market. As this share approaches its maximum we expect that there would be other policy intervention to address the growing share of government financed mortgages.

The differences in the driver variables for both scenarios are presented in Exhibit 1 and as can be seen the differences in a number of the variables themselves are more subtle than stark.

To generate the alternative market share forecasts, we input the forecast values of the driver variables from each of the alternative scenarios into the regression equations. Monthly forecast results are then aggregated into yearly forecasts. We compare these to the market share forecasts based on the Consensus scenario. Exhibit 2 provides a summary of the results

by year, while Exhibit 3 presents the monthly forecast results. Results for the low-income purchase share are shown in the first panel of Exhibit 2. The first row of each panel highlights the results based on the Consensus Forecast scenario, while the following two rows show results from using the alternative scenarios. Average annual market performance over the 2018-2020 period are presented in the last column. The results show that the share forecasts for the low-income home purchase goal change slightly in response to alternative macroeconomic environments. The scenarios themselves are close in terms of assumptions (despite the names assigned by Moody's) and this closeness translates into the closeness of the results across different scenarios. Average forecast for the low-income purchase (LIP) share in the 2018-2020 period according to the Stronger Near-Term Growth scenario deviates from the one based on the Consensus Forecast scenario by 1.2 percentage points. If the Moderate Recession scenario is assumed, the differential is 0.2 percentage point only. These are small differences. The same is true for the share forecasts for the very-low income home purchase goal and the low-income areas home purchase subgoal in general. The only exception is that, for the low-income areas subgoal, if the Moderate Recession scenario is assumed, the share forecast will drop by 2.4 percentage points.

Comparisons for the low-income refinance goal are presented in the bottom panel of Exhibit 2. Under the Stronger Near-Term Growth scenario, market share is forecast to be 23.0 percent for the 2018-2020 period, as compared to 20.7 percent under the Consensus scenario. This represents an increase of 2.3 percentage points. If the Moderate Recession scenario is assumed, the market share is forecast to be 19.1 percent, representing a decrease of 1.6 percentage points.

Overall, we find that the share forecasts are reasonably robust across alternative macroeconomic scenarios.

**Exhibit 1:** Comparison of Forecast Scenarios

| | Consensus Forecast | | | | Near-Term Growth | | | | Moderate Recession | | | |
| | Projected Trends | | | | Projected Trends | | | | Projected Trends | | | |
| | 2017 | 2018 | 2019 | 2020 | 2017 | 2018 | 2019 | 2020 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Real Gross Domestic Product (Billions 2009 $) | $17,092 | $17,500 | $17,842 | $18,196 | $17,092 | $17,786 | $18,350 | $18,564 | $17,092 | $17,072 | $17,004 | $17,313 |
| Real GDP Growth Rate | 2.2 | 2.4 | 2.0 | 2.0 | 2.2 | 4.1 | 3.2 | 1.2 | 2.2 | -0.1 | -0.4 | 1.8 |
| Unemployment Rate | 4.4 | 4.1 | 4.2 | 4.5 | 4.4 | 3.6 | 3.6 | 4.3 | 4.4 | 6.3 | 7.7 | 7.5 |
| Labor Force Participation Rate | 62.9 | 63.1 | 63.0 | 62.9 | 62.9 | 63.2 | 63.1 | 63.0 | 62.9 | 62.4 | 61.9 | 62.3 |
| Inflation Rate (Change in CPI) | 2.1 | 1.9 | 2.3 | 2.0 | 2.1 | 3.4 | 3.5 | 2.7 | 2.1 | 0.8 | 1.5 | 2.3 |
| Consumer Confidence Index | 118.6 | 102.2 | 98.6 | 96.3 | 118.6 | 112.1 | 105.7 | 95.1 | 118.6 | 58.2 | 45.3 | 49.9 |
| 10-Year Treasury Yield | 2.4 | 2.9 | 3.1 | 3.2 | 2.4 | 3.5 | 4.5 | 4.4 | 2.4 | 2.9 | 2.0 | 2.1 |
| Yield Curve | 1.2 | 0.7 | 0.3 | 0.4 | 1.2 | 0.8 | 0.1 | 0.2 | 1.2 | 1.9 | 1.3 | 1.3 |
| 30-Year Mortgage Fixed Rate | 4.0 | 4.5 | 4.7 | 4.8 | 4.0 | 4.9 | 5.8 | 5.6 | 4.0 | 4.6 | 3.8 | 3.9 |
| 30-Year FHA Mortgage Fixed Rate | 4.5 | 4.8 | 5.0 | 5.1 | 4.5 | 5.2 | 6.2 | 6.0 | 4.5 | 4.9 | 4.2 | 4.2 |
| Per Capita Disposable Income (1000s $) | $44.2 | $45.5 | $47.0 | $48.4 | $44.2 | $46.2 | $48.7 | $50.4 | $44.2 | $44.4 | $44.8 | $46.2 |
| Household Debt Service Ratio | 4.5 | 4.8 | 5.2 | 5.5 | 4.5 | 4.7 | 5.2 | 5.5 | 4.5 | 4.8 | 5.2 | 5.3 |
| Existing Home Sales (1000s) | 4,928 | 5,458 | 5,843 | 5,482 | 4,928 | 5,451 | 5,896 | 5,303 | 4,928 | 4,063 | 3,648 | 3,958 |
| Net Percent of Banks Tightening Standards | -7.5 | -15.3 | -12.0 | -2.2 | -7.5 | -18.7 | -13.7 | -4.0 | -7.5 | -10.1 | -10.3 | -1.4 |
| Refinance Mortgage Application Share | 41.4 | 34.7 | 38.4 | 39.3 | 41.4 | 29.5 | 26.1 | 24.5 | 41.4 | 38.1 | 42.6 | 48.6 |
| Housing Affordability Index | 156.5 | 154.0 | 150.1 | 148.3 | 156.5 | 149.3 | 147.4 | 148.4 | 156.5 | 166.4 | 168.6 | 164.3 |
| Percent Change in House Prices (PO)[1] | 5.4 | 3.8 | 4.8 | 2.9 | 5.4 | 6.3 | 3.2 | 1.6 | 5.4 | -7.6 | 0.3 | 6.9 |
| Percent Change in House Prices (ALL)[2] | 5.4 | 3.6 | 4.4 | 3.3 | 5.4 | 5.6 | 3.3 | 1.8 | 5.4 | -6.5 | -0.8 | 7.4 |
| Refinance Mortgage Share | 31.5 | 27.0 | 28.1 | 28.2 | 31.5 | 20.9 | 14.1 | 11.8 | 31.5 | 31.3 | 33.3 | 40.3 |
| Percent Gov. Insured Home Purchase Loans | 34.1 | 37.0 | 39.7 | 42.1 | 33.4 | 33.4 | 37.2 | 41.3 | 36.6 | 55.0 | 55.0 | 59.3 |
| Percent Gov. Insured Refinance Loans | 21.0 | 22.7 | 23.2 | 24.0 | 21.0 | 22.4 | 24.6 | 26.1 | 21.0 | 25.7 | 28.7 | 29.2 |

Note: Historical values and projected trends are provided by Moody's Analytics. Government shares of the home purchase and refinance market are forecasted by FHFA.
[1] Purchase transactions only (Q4/Q4 % Change)
[2] All transactions (Q4/Q4 % Change)

**Exhibit 2:** Summary of Market Model Forecasts Based on Different Scenarios

| | | 2018 | 2019 | 2020 | 2018-2020 Average |
|---|---|---|---|---|---|
| **LIP** | Consensus Forecast | 22.7% | 24.4% | 24.3% | 23.8% |
| | Stronger Near-Term Growth | 21.4% | 23.3% | 23.0% | 22.6% |
| | Moderate Recession (Max Gov Share=55%) | 23.8% | 24.5% | 23.7% | 24.0% |
| **VLIP** | Consensus Forecast | 5.3% | 5.9% | 5.9% | 5.7% |
| | Stronger Near-Term Growth | 4.8% | 5.4% | 5.5% | 5.2% |
| | Moderate Recession (Max Gov Share=55%) | 5.9% | 6.4% | 6.2% | 6.2% |
| **LAS** | Consensus Forecast | 16.6% | 16.8% | 16.4% | 16.6% |
| | Stronger Near-Term Growth | 17.0% | 17.5% | 16.5% | 17.0% |
| | Moderate Recession (Max Gov Share=55%) | 15.4% | 13.8% | 13.5% | 14.2% |
| **LIR** | Consensus Forecast | 23.4% | 20.6% | 18.0% | 20.7% |
| | Stronger Near-Term Growth | 24.9% | 23.8% | 20.4% | 23.0% |
| | Moderate Recession (Max Gov Share=55%) | 22.2% | 19.4% | 15.6% | 19.1% |

**Exhibit 3:** Market Model Forecasts Based on Baseline and Alternative Scenarios



LIP Market Forecast



VLIP Market Forecast



LAS Market Forecast



LIR Market Forecast
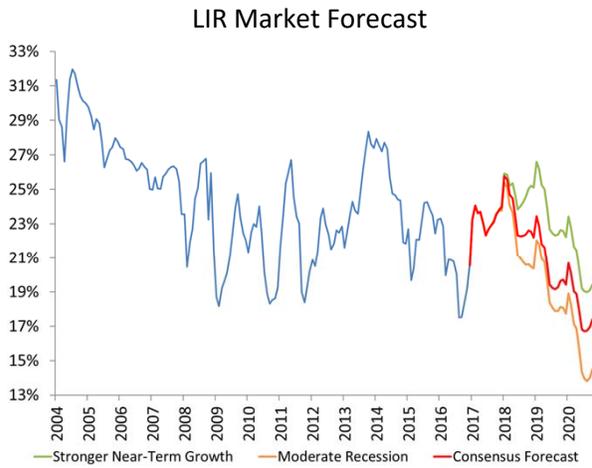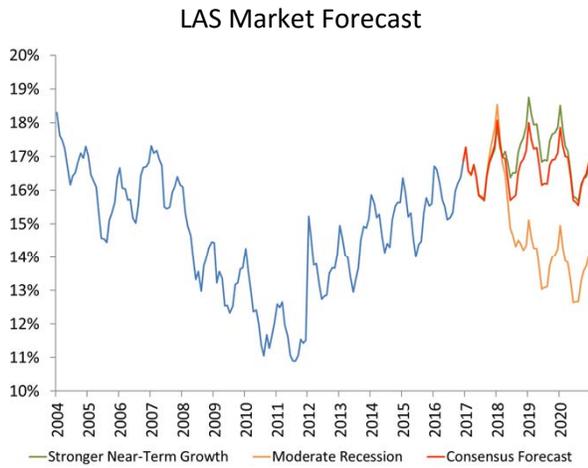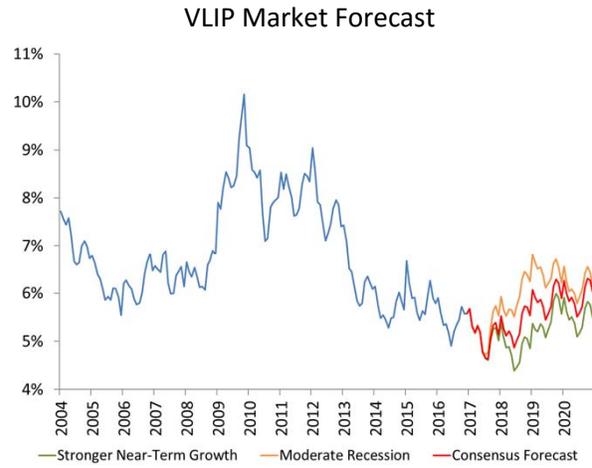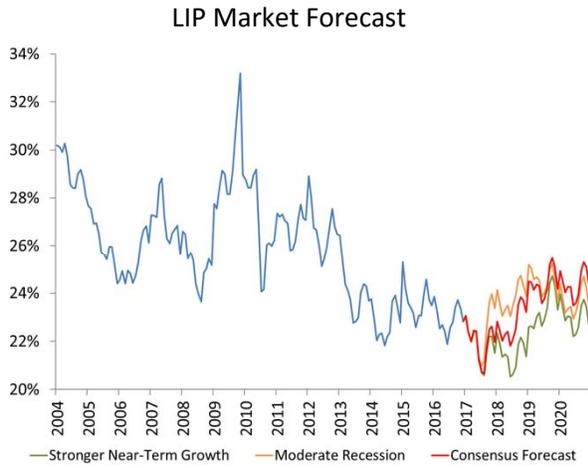
# Appendix B:
# List Of Data Sources

**Moody's Analytics**

https://www.economy.com/products/tools/data-buffet

**Federal Housing Finance Agency: House Price Index**

http://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index.aspx

**Mortgage Bankers Association**

http://www.mortgagebankers.org/ResearchAndForecasts/ForecastsAndCommentary

**Freddie Mac**

http://www.freddiemac.com/finance/ehforecast.html

**Fannie Mae**

http://www.fanniemae.com/portal/research-and-analysis/emma.html

**Wells Fargo**

https://www.wellsfargo.com/com/insights/economics/monthly-outlook

**PNC Financial**

https://www.pnc.com/webapp/unsec/NCAboutMicrositeNav.do?siteArea=/pnccorp/PNC/Home/About+PNC/Media+Room/Economic+Reports

**National Association of Home Builders**

http://www.nahb.org/reference_list.aspx?sectionID=138

**Wall Street Journal Survey**

http://projects.wsj.com/econforecast