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Making Homeownership More Accessible by Improving the Fixed-Rate Mortgage

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When it was first developed over 50 years ago, the 30-year fixed-rate fully-amortizing mortgage (or "traditional fixed-rate mortgage") represented a substantial innovation in the mortgage market; however, it has three major flaws. First, since homeowner equity accumulates slowly during the first decade, homeowners are essentially renting their homes from lenders. With so little equity accumulation, many lenders require large down payments. Second, in each monthly mortgage payment, homeowners substantially compensate capital markets investors for the ability to prepay. The homeowner might have better uses for this money. Finally, refinancing mortgages is often very costly.

I propose a new fixed-rate mortgage, which is called the fixed-payment-COFI mortgage (or "the fixed-COFI mortgage"), that resolves the three problems with the traditional fixed-rate mortgage. This mortgage has fixed monthly payments equal to payments for traditional fixed-rate mortgages and no down payment. Also, unlike traditional fixed-rate mortgages, fixed-COFI mortgages do not bundle mortgage financing with insurance products to compensate capital markets investors for bearing prepayment risks; products many homeowners do not need.

The fixed-COFI mortgage exploits the often-present prepayment-risk wedge between the fixed-rate mortgage rate and the estimated cost of funds index (COFI) mortgage rate. Committing to a savings program based on the difference between fixed-rate mortgage payments and payments based on COFI plus a margin, the homeowner uses this wedge to accumulate home equity quickly. In "normal" times, the fixed-COFI mortgage leads to rapid home equity accumulation by the household (almost always resulting in homeownership) and remains a highly profitable asset for the mortgage lender.

The fixed-COFI mortgage may help renters, who are paying rents as high as comparable mortgage payments in high-cost metropolitan areas and do not have enough savings for a down payment, gain access to homeownership.

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Introduction

Affordable housing is a substantial problem in the United States. In particular, potential first-time home buyers face higher home prices and limited starter home inventory in recent years (Duncan et al. 2016). With both rents and home prices at relatively high levels in many metropolitan areas, many renters may not be able to save for a conventional mortgage down payment.

The 30-year fixed-rate fully-amortizing mortgage (or "traditional fixed-rate mortgage") is the dominant mortgage in the United States (see Green and Wachter, 2005, for a history of U.S. mortgages). Campbell (2013) and Shiller (2014) note the lack of innovation in U.S. mortgage contracts since the traditional fixed-rate mortgage was established during the Great Depression, despite compelling reasons to believe a better mortgage contract could be designed for households, bankers, and investors alike. In Hancock and Passmore (2016a), we analyzed the feasibility as well as the potential costs and benefits of an adjustable-rate mortgage product tied to a nationwide bank cost of funds index (COFI), which is equal to the total interest expenses of domestic commercial banks divided by their total interest-bearing liabilities.[1] We considered the costs and benefits associated with these contracts from household, banker, investor, and policymaker perspectives using estimated COFI-based mortgage rates from historical data over 2000-2014, inclusive.[2] We found substantial benefits for market participants had they used these COFI-based mortgages, but adjustable-rate mortgages lack the desirable feature of fixed payments.

Here, I propose a new type of fixed-payment mortgage, which is called the Fixed-COFI Mortgage. The mortgage is designed for renters, who may be paying rents that are as high as

[1] Quarterly data of total interest expenses and interest-bearing liabilities for US commercial banks are reported in Federal Financial Institutions Examination Council Consolidated Reports of Condition and Income (FFIEC, 2016). After merger adjustment, monthly COFIs are inferred by linearly interpolating between quarterly data points. Throughout this paper, I synonymously refer to depository institutions and U.S. commercial banks.

[2] This mortgage product also includes actuarial-based government-backed tail-risk insurance provided either to bankers directly or to investors who purchase pools of such mortgages. The premiums for this actuarial-based tail-risk insurance were estimated using an expected loss distribution constructed in Hancock and Passmore (2016b). This insurance makes the mortgage more tradable in secondary mortgage markets, similar to 30-year fixed-rate mortgages securitized by Fannie Mae and Freddie Mac. Here, we put aside the topic of secondary market viability (discussed in Hancock and Passmore, 2016a) and focus on housing affordability. However, we use a gross margin that includes compensation for these risks.

comparable mortgage payments, but have little or no savings for a down payment. In essence, this mortgage is a traditional 30-year, fixed-payment mortgage with little or no down payment. However, a traditional fixed-rate mortgage often bundles a second product into the mortgage: compensation for capital market investors bearing prepayment risks. This second product is often very expensive and is unneeded by many mortgage borrowers. In addition, the Fixed-COFI mortgage avoids the deadweight costs associated with mortgage refinancing (cite).

When homeowners pay capital markets investors for bearing prepayment risks, they are in essence purchasing a lottery ticket along with mortgage financing. Both homeowners and capital markets investors are betting on the direction of interest rates. Homeowners are betting that interest rates will fall substantially so they can exercise their prepayment option and refinance at a lower mortgage rate. Capital markets investors are betting that interest rates will not fall enough to make refinancing profitable. If one party wins, the other loses. Like a lottery, the odds favor the house: capital markets investors get compensated by premiums greater than the expected value of the prepayment option. In addition, there may be a large payment for investor risk aversion and systemic risk built into model-based prepayment premiums (see Chernov, Dunn and Longstaff, 2016). Thus, even when the homeowner "wins" the lottery, i.e. rates fall, and a homeowner refinances at an appreciably lower mortgage rate, the casino has often already collected a substantial sum of money needed to cover a difficult to hedge risk.

Could the homeowner do something better with this money? With the Fixed-COFI mortgage, the household uses this money to purchase home equity.[3] The mortgage is designed to assure that a depository institution can usually hold the mortgage profitability. In addition, the household savings program usually leads to the rapid accumulation of home equity, which lowers default risk relative to a conventional traditional 30-year fixed-rate mortgage that has no down payment. Finally, the mortgage is affordable; for some households, the monthly payment would be smaller than the household's current rent payments.

The Fixed-COFI mortgage exploits the often-present wedge between fixed-rate mortgage rates and estimated COFI mortgage rates. These contracts have the following key characteristics:

[3] The influence of the down payment on mortgage performance is much debated. Economists generally find that lower down payments lead to a greater likelihood of default, but others argue that mortgages with lower down payments that are appropriately underwritten can perform very well and also increase access to housing (See Freeman and Harden, 2015).

(1) the bank receives COFI plus a reasonable (and highly profitable) margin; (2) the household makes monthly payments calculated to amortize the principle over 30 years using the 30-year fixed-rate mortgage rate prevailing at origination; (3) excess payments are placed into a home equity savings account, which pays down the principle and weathers high interest rate periods; (4) the bank assures the household that the mortgage payment never exceeds the fixed-rate mortgage payment based on the fixed-rate mortgage rate prevailing at origination; and (5) the household puts forth little to no down payment. With Fixed-COFI mortgages, renters, who can qualify for a mortgage on a cash-flow basis (e.g., high rents), are able to purchase a home and often accumulate savings quickly to build their home equity.

Figure 1 outlines the cash flows associated with this mortgage contract. As shown in the top panel, when COFI plus the gross margin (*GM*) are less than the fixed-rate mortgage rate, the bank receives a mortgage payment based on the rate COFI + *GM* and the remainder of the household's payment goes to its home equity account.[4] When COFI + *GM* is greater than the fixed-rate mortgage rate (at origination) and the book loan-to-value ratio (LTV) is less than 100 (middle panel), the bank receives a mortgage payment based on the rate COFI + *GM* , with the shortfall in the household's payment covered by a withdrawal from its home equity account. Finally, when COFI + *GM* is greater than the fixed-rate mortgage rate and the book LTV is greater than 100 (lower panel), the bank is owed a mortgage payment based on the rate COFI + *GM* but is responsible for covering the homeowner's shortfall. As we show later, the bank's cost of providing this insurance against payment shortfalls is trivial.

What does the homeowner lose by choosing a Fixed-COFI mortgage rather than a traditional 30-year, fixed-rate mortgage? First, they lose the ability to freely spend refinancing gains on non-housing items. Second, they can no longer "win the lottery" played with capital markets investors each month and lock in a substantially lower rate for the remainder of the mortgage. With the Fixed-COFI mortgage, the homeowner substantially gains from lower mortgage rates by accumulating home equity faster, but she cannot "lock-in" a mortgage contract that continues those gains regardless of future interest rates. Not surprising, this "lock-in" feature

[4] The gross margin covers guarantee fees for credit risk and fees for mortgage servicing, as well as a hefty return-on-equity. See Hancock and Passmore (2016).

for a traditional fixed-rate mortgage contract is expensive, and the Fixed-COFI borrower can save a lot of money by foregoing it.

The Fixed-COFI mortgage addresses the serious problem of high rents in many metropolitan areas. The popular real estate website, Zillow.com, calculated that the nationwide average renter would need to rent a house "a scant 1.9 years" before purchasing the home would be more financially advantageous (Olsen, 2016a). This calculation assumes a 20 percent down payment. However, high rents in the most populous American cities prevent many renting households from saving enough for a down payment. Specifically, Zillow finds that roughly 50 percent of households paying rents of more than 25 percent income do not save (Olsen, 2016b). Furthermore, 52.3 percent of renting households nationwide pay gross rents of 30 percent or more of their income (Federal Reserve Bank of Richmond, 2015).

A recent survey of "millennials" in the U.S. found that the top reason for not owning a home is that they have not saved enough for a down payment.[5] In addition, this lack of savings was in part due to high rents (DiClerico, 2016). Other survey evidence indicates that the down payment is the major impediment to home ownership for relatively poorer households (Fuster and Zafar, 2014). As shown in the top panel of figure 2, rent-to-home-value ratios in most American cites has increased sharply over the past 20 years.[6] Rents for comparable single-family housing units are often more than twice the 30-year, fixed-rate mortgage payments (middle panel). High rents relative to home values make it more difficult for households to save for the down payment needed to purchase a home. These households are not able to take advantage of the relative price decrease from rental properties to purchased homes (bottom panel). Moreover, the inability to move into homes may imply less wealth accumulation by these households, particularly for households with low and moderate incomes (Grinstein-Weiss et al., 2013).

This paper proceeds as follows: Section 2 compares time-series of estimated Fixed-COFI mortgage rates based on historical U.S. data and the mortgage rates on traditional 30-year fixed-rate mortgages and provides an example of how the Fixed-COFI mortgage works. Section 3 calculates the historically-based probabilities that COFI mortgage rates can exceed the mortgage rates on traditional 30-year fixed-rate mortgages. Section 4 simulates the payoff structure of Fixed-

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[5] "Millennials" are defined as people born between 1987 and 1998.

[6] This data is from Zillow (2016).

COFI mortgages and discusses when these mortgages are successful. Section 5 concludes with observations relevant to the policy of promoting this type of affordable homeownership mortgage.

2. COFI and Homeownership

We provide a comprehensive review of mortgages based on COFIs in Hancock and Passmore (2016a), including developing a method of estimating the gross margin for a nationwide COFI that yields competitive rate of returns to the mortgage-holding bank. We show that a profitable margin that covers historical servicing costs, credit risks, and mark-ups on mortgages assets almost always fall between 1.75 percent and 2.5 percent over COFI.[7] Here, I extend the history of that time-series as a first step in developing a comparison between a Fixed-COFI mortgage and a traditional 30-year fixed-rate mortgage.

In figure 3, the time-series for effective rates on 30-year fixed-rate first-lien prime conventional conforming home purchase mortgages with a loan-to-value of 80 percent from Freddie Mac surveys is compared to the time-series for estimated rates for COFI.[8] COFI is presented as an actual nationwide COFI plus gross margins ranging from 1.75 percent to 2.5 percent. As noted above, this range is consistent with (almost) all profitable COFI mortgages.

Although the estimated COFI rates are similar to 30-year fixed-rate mortgage rates in some periods (e.g., during the thrift/banking crisis in the late 1980s and during the run-up to the recent financial crisis), the range of profitable COFI mortgage rates are generally considerably below 30-

[7] The mean profitable gross margin is 2.2 percent with a standard deviation of 16 basis points. See table 2 in Hancock and Passmore (2016a). We use a time-varying technique to calculate net margins in Hancock and Passmore (2016a). But the profitability can be readily established by the following "back-of-the-envelope" calculation. Let the bank's net interest income for a COFI mortgage be $Income = (\alpha + COFI) * A - COFI * L$, where A is COFI-based assets, L is interest-bearing liabilities and α is the gross margin. Let $L = A - K$, where K is equity capital. Then the return-on-equity is $\frac{Income}{K} = (\alpha * LEV + COFI)$ where LEV is the bank's leverage or $A/_K$. If leverage is 20 times on a mortgage (the current risk-based capital weight on mortgages), then the gross margin return-on-equity for a margin of 2 percent, and a COFI of 5 percent is 45 percent. For a leverage of 10 times capital, a gross margin of 2 percent and a COFI of 2 percent, this return-on-equity is 22 percent. So long as non-interest bearing liabilities and non-interest expenses are not large, this calculation suggests a relatively high return.

[8] To calculate the effective 30-year fixed-rate mortgage rate, we assume that the points and fees reported in the Freddie Mac Primary Mortgage Market Survey are evenly allocated over the average life of a mortgage loan that is equal to six years, which is consistent with the results for low spread, low coupon conforming mortgages in Mattey and Wallace (2001) and the estimates for the empirical prepayment functions for conforming mortgages of Schwartz and Torous (1989).

year fixed mortgage rates. These fixed-rate mortgage rates are typically higher than adjustable mortgage rates because the borrower must compensate the lender for the risk that market rates might rise in the future and for the option to prepay the mortgage when desired. Moreover, fixed-rate mortgages (which here reflect limited credit risk to the lender because they conform to Government-Sponsored Enterprise (GSE) standards for mortgages and reflect the GSE credit guarantee fee) may also reflect market risk premiums (e.g., uncertainties and risk-premiums) that are not reflected in the deposit rates that predominate in the COFI. Indeed, during periods of market uncertainty, there may be greater inflows to insured deposits, which would drive COFI lower. We will discuss other possible reasons for the persistence of this wedge between the fixed-rate mortgage rate and COFI mortgage rates in our discussion at the end of this paper.

To examine the attractiveness of Fixed-COFI mortgages for households with borrowing constraints, we consider monthly payments associated with a 30-year fixed-rate mortgage contracts that have an embedded COFI contract. These monthly payments are calculated as a percent of the home price (as is done in figure 4).[9]

Let's start with an example. Consider a fixed-rate mortgage originated in April 1985. As shown in figure 4, the monthly fixed-rate mortgage payment (heavy black ball-and chain line) is equal to 1.13 percent of the house price. This payment has two components: the interest owed on the mortgage (red dashed line) and the amortization of the mortgage (solid blue line). By design, the mortgage pays off in thirty years, as the amortizing portion of the mortgage payment becomes larger over time.

For the Fixed-COFI mortgage, the household makes the same fixed-rate mortgage payment each month, but the bank only receives a payment based on the COFI rate plus a gross margin that embeds a profitable rate of return. Like the fixed-rate mortgage, the COFI payment has two components: interest and amortization. The interest payment (the red "right-slanted" hatched band) follows the decline in both the remaining principal and COFI (and interest rates generally) over this period. The amortization that is associated with these COFI payments is also shown (blue

[9] Monthly mortgage payments for each type of mortgage contract considered are calculated as follows:

$$Monthly\ Mortgage\ Payment = (LTV * House\ Price) * \frac{r * (1+r)^m}{(1+r)^m - 1},$$

where $r = \frac{Annual\ Mortgage\ Rate}{12}$ and m is the number remaining months of the mortgage. When expressed as a percent of the home price, the house price drops out.

"left-slanted" hatched band). The band width of COFI payments represent a range of profitable gross margins from 1.75 percent to 2.5 percentage points.

When the COFI mortgage rate is lower than the fixed-rate mortgage rate, the difference is put into the home equity savings account and used to pay down the mortgage loan. These pay downs are shown by the green vertical hatched band in figure 4. As a result of the pay downs, the Fixed-COFI mortgage pays off around 1998, roughly 13 years after the mortgage is originated. The Fixed-COFI mortgage used the "wedge" that is almost always present between the traditional fixed-rate mortgage and a profitable COFI mortgage to accelerate the pay down of the mortgage loan.

Because of these additional principal pay downs (based on the wedge between the fixed-rate mortgage rate and the COFI mortgage rate), the Fixed-COFI mortgage is paid off rapidly. As shown in figure 5, the equity accumulates quickly for the Fixed-COFI mortgage. After the first five years, the homeowner's equity is between 22 percent and 27 percent of the home value. After ten years, home equity has risen to between 67 percent and 76 percent. In contrast, a traditional fixed-rate mortgage holder owns 1.8 percent of her home after five years and 5.3 percent after ten years. In this example, the Fixed-COFI mortgage holder owns her house after 12 to 14 years, depending on the gross margin charged by the bank.

The increasing home equity associated with Fixed-COFI mortgages implies that default risks to the bank fall substantially early in the life of the mortgage.[10] After five years, the bank holds the equivalent of a 25-year fixed-rate mortgage with a down payment of more than 20-percent (if home prices hold constant), and thus there is a considerably lower risk of homeowner default than the traditional fixed-rate mortgage without a down payment. In addition, the household has substantially increased its wealth and has the resources to weather future financial stress. We now turn to quantifying the risks to the household and the bank, particularly in those first five years.

[10] Negative equity is a necessary, but not a sufficient, cause of mortgage default. See Campbell and Cocco (2015), Gerardi et al. (2015), and Mayer, Pence and Sherlund (2009) for discussions of the importance of negative home equity in determining mortgage default.

4. Fixed-Rate Mortgage Rates versus Fixed-COFI Mortgage Rates

Our example highlights the potential homeowner equity gains from a Fixed-COFI mortgage. To begin to assess how representative this example is, we derive a distribution for long-run COFI. Based on estimating models of COFI and Treasury rates, we consider the likelihood of a shock to interest rates that pushes the expected path of the COFI mortgage rates higher than the fixed-rate mortgage rate.

COFI is best modelled as a partial adjustment process that incorporates a concurrent shorter-term Treasury rate (see Stanton and Wallace 1995, Passmore 1993, Roll 1987, and Cornell 1987):

$$COFI_t = \alpha \, COFI_{t-1} + \beta T_t + \delta_t, \text{ where } \delta_t \sim N\left(0, \sigma_\delta^2\right) \text{ and } 0 < \alpha, \beta < 1.$$

Our COFI is the nationwide average cost of funds index for the banking system and is derived from quarterly FFIEC Call Reports. On figure 6, we shown the daily one-year Treasury rate (the light solid line) and the quarterly-averaged one-year Treasury rate (the dashed line). We use the quarterly average of Treasury rates to estimate the model above (since nationwide COFI is currently only available quarterly). While COFI is quite distinct from the one-year Treasury yield, the partial adjustment model tightly fits the historical COFI.

As shown in table 1, this partial adjustment model suggests that COFI in the current period is almost a weighted-average of last period’s COFI (roughly 75 percent) and this period’s quarterly one-year Treasury rate (roughly 23 percent). As we show below, our model suggests that long-run COFI has an expected value of 91 percent of the initial one-year Treasury rate. The regression’s summary statistics highlight the close fit of fitted and actual COFI data.

We model the one-year Treasury rates as a random walk.[11] Empirically, this assumption seems well-justified, as the coefficient on the first-lag of Treasury rates is close to one and highly significant (table 2).[12] Define ε_t as the change in Treasury yields in period *t*:

$$T_t = T_{t-1} + \varepsilon_t.$$

We find T_t in terms of the Treasury rate at origination, T_0:

$$T_t = T_0 + \sum_{i=1}^{t} \varepsilon_i.$$

and assume $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$, which implies the following:

$$E[T_t] = T_0.$$

We can then derive $COFI_t$ in terms of COFI and the Treasury rate at origination, $COFI_0$ and T_0:

$$\begin{aligned}
COFI_t &= \alpha\, COFI_{t-1} + \beta T_t + \delta_t \\
&= \alpha[\alpha\, COFI_{t-2} + \beta T_{t-1} + \delta_{t-1}] + \beta T_t + \delta_t \\
&= \alpha[\alpha[\alpha\, COFI_{t-3} + \beta T_{t-2} + \delta_{t-2}] + \beta T_{t-1} + \delta_{t-1}] + \beta T_t + \delta_t \\
&= \alpha^3\, COFI_{t-3} + \alpha^2 \beta T_{t-2} + \alpha^2 \delta_{t-2} + \alpha\beta T_{t-1} + \alpha\delta_{t-1} + \beta T_t + \delta_t \\
&= \alpha^t COFI_0 + \sum_{i=1}^{t} \alpha^{t-i}(\beta T_i + \delta_i) \\
&= \alpha^t COFI_0 + \sum_{i=1}^{t} \alpha^{t-i}\left(\beta\left[T_0 + \sum_{j=1}^{i} \varepsilon_j\right] + \delta_i\right)
\end{aligned}$$

[11] In other words, the coefficient on the autoregressive (AR(1)) term is one. But the historical data for one-year Treasury rates from Q1 1985 to Q3 2015 fail to pass many tests for stationarity that are often used when specifying the degree of differencing for an ARIMA models. However, we use this AR(1) "random walk" process both for its simplicity in analyzing Fixed-COFI mortgages analytically and for its features when numerically simulating payment paths for these mortgages. When we estimate an empirically-determined integrated process, it imposes the significant downward trend of interest rates (as observed in our sample) on any simulated series. Under current conditions, with interest rates at their lowest-recorded levels, modeling interest rates using a process that includes this trend disproportionally considers low interest-rate environments that are unlikely to be seen in the near and medium-term future. In contrast, employing a random walk process for Treasury rates, our simulations are agnostic to the future trends of interest rates, and thus they provide more *conservative* estimates for the performance of Fixed-COFI mortgages by considering both downward and upward trends symmetrically. In addition, we bound our simulated Treasury rates to fall between zero and the maximum observed Treasury rate in our sample (9.29 percent).

[12] Table 2 also shows the maximum likelihood estimators for σ_ε^2.

$$= \alpha^t COFI_0 + \beta T_0 \sum_{i=1}^{t} \alpha^{t-i} + \beta \sum_{i=1}^{t} \alpha^{t-i} \sum_{j=1}^{i} \varepsilon_j + \sum_{i=1}^{t} \alpha^{t-i}\, \delta_i.$$

Since $COFI_t$ is a linear combination of independent normal random variables (δ_i and ε_j), $COFI_t$ is also normal with the following mean and variance:

$$E[COFI_t] = E\left[\alpha^t COFI_0 + \beta T_0 \sum_{i=1}^{t} \alpha^{t-i} + \beta \sum_{i=1}^{t} \alpha^{t-i} \sum_{j=1}^{i} \varepsilon_j + \sum_{i=1}^{t} \alpha^{t-i}\, \delta_i\right]$$

$$= \alpha^t COFI_0 + \beta T_0 \sum_{i=1}^{t} \alpha^{t-i} + \beta \sum_{i=1}^{t} \alpha^{t-i} \sum_{j=1}^{i} E[\varepsilon_j] + \sum_{i=1}^{t} \alpha^{t-i}\, E[\delta_i]$$

$$= \alpha^t COFI_0 + \beta T_0 \sum_{i=1}^{t} \alpha^{t-i} + \beta \sum_{i=1}^{t} \alpha^{t-i} \sum_{j=1}^{i} (0) + \sum_{i=1}^{t} \alpha^{t-i}\, (0)$$

$$= \alpha^t COFI_0 + \beta T_0 \sum_{i=1}^{t} \alpha^{t-i}$$

$$Var[COFI_t] = Var\left[\alpha^t COFI_0 + \beta T_0 \sum_{i=1}^{t} \alpha^{t-i} + \beta \sum_{i=1}^{t} \alpha^{t-i} \sum_{j=1}^{i} \varepsilon_j + \sum_{i=1}^{t} \alpha^{t-i}\, \delta_i\right]$$

$$= 0 + Var\left[\beta \sum_{i=1}^{t} \alpha^{t-i} \sum_{j=1}^{i} \varepsilon_j\right] + Var\left[\sum_{i=1}^{t} \alpha^{t-i}\, \delta_i\right]$$

$$= \beta^2 \sum_{i=1}^{t} \alpha^{2(t-i)} \sum_{j=1}^{i} \sigma_\varepsilon^2 + \sum_{i=1}^{t} \alpha^{2(t-i)}\, \sigma_\delta^2.$$

Now that we have characterized the distribution of COFI, we can find a long-run COFI value based on the conditions at origination by taking the limit as t goes to infinity of the expected value of $COFI_t$:

$$\lim_{t\to\infty} E[COFI_t] = \lim_{t\to\infty} \alpha^t COFI_0 + \beta T_0 \sum_{i=1}^{t} \alpha^{t-i}$$

$$= 0 * COFI_0 + \beta\, T_0 \frac{1}{1-\alpha}$$

$$= \frac{\beta}{1-\alpha} T_0,$$

and define this long-run expected COFI as $\overline{COFI} = \lim_{t \to \infty} E[COFI_t]$.

What values of an initial shock, ε^*, to Treasury rates will push the long-run COFI mortgage rate higher than the fixed-rate mortgage rate at origination, $\overline{COFI} + GM > FR_0$?

$$\overline{COFI} + GM > FR_0$$

$$\frac{\beta}{1-\alpha} (T_0 + \varepsilon^*) + GM > FR_0$$

$$\varepsilon^* > \frac{1-\alpha}{\beta} (FR_0 - GM) - T_0$$

The probability that the fixed-rate mortgage rate is lower than the expected long-run COFI mortgage rate is

$$\Pr\left\{\varepsilon^* > \frac{1-\alpha}{\beta} (FR_0 - GM) - T_0\right\}, \text{where } \varepsilon^* \sim N(0, \sigma_\varepsilon^2).$$

Tables 3 and 4 calculate this probability for five historical Treasury rates and associated fixed-rate mortgage rates. In table 3, we take the distribution of all quarterly Treasury rates from 1985 to 2014, and calculate the Treasury rates at the 10th, 25th, 50th, 75th and 90th percentiles, respectively. We also set the associated fixed-rate mortgage rates at origination as an average of the mortgage rates in a ±10 percentile spread around the chosen Treasury rate. For example, the Treasury rate at the 10th percentile of the distribution is .18 percentage points, and the associated mortgage rate at origination (4.2 percent) is the average of mortgage rates associated with Treasury rates from the 0th percentile (0.09) to the 20 percentile (0.479) of the Treasury distribution. The long-run expected COFI is .17 percentage points. The rows of table 3 repeat these calculations for the other percentiles of the Treasury rate distribution.

The spreads of fixed-rate mortgage rates to Treasury rates, of fixed-rate mortgage rates to initial COFI-index rates, and of fixed-rate mortgage rates to long-run COFI are particularly large when one-year Treasury rates are very small. This may seem odd because prepayment risks are particularly low for fixed-rate mortgages in low interest rate environments. However, the effect of offering a mortgage with a very long effective maturity dominates the prepayment compensation when interest rates are low. Note that these spreads are also high when Treasury rates are high, reflecting high prepayment risks. Spreads are smallest for Treasury rates in the middle of the Treasury-rate distribution.

As shown in table 4, we calculate the probability that a Treasury shock results in the COFI mortgage rates (that is, the COFI rate plus a gross margin) exceeding the fixed-rate mortgage rate. We perform this calculation for four gross margins over COFI—1.75 percent, 2.0 percent, 2.25 percent, and 2.5 percent. As shown in the first row of the table, the long-run expected COFI rate collected by the depository institution never exceeds the fixed-rate mortgage rate made by the household for a margin of 1.75 percent. In addition, the fixed-rate payment is always adequate to cover the depository institution's costs and profits when the Treasury rate is from the bottom 25 percent of the Treasury rate distribution. In contrast, at the median initial Treasury rate, the fixed-rate mortgage rate falls short of the COFI rate about 1.3 percent of the time with a 2 percentage point gross margin and 14.1 percent of the time with a 2.5 percent gross margin. These percentages fall for higher initial Treasury rates. This pattern reflects the spread between the fixed-rate mortgage rate and the long-run COFI rate, which is most narrow for the Treasury rate at the 50th percentile of the distribution.

The relationship between the spread of fixed-rate mortgage rates to Treasury rates (or "fixed-rate-to-Treasury spread") and the probability of expected long-run COFI exceeding the fixed-rate mortgage rate is shown in figure 7. Empirically, the long-run COFI rate is never above the fixed-rate when the spread is greater than three percentage points. However, when the spread is below two, the odds rise rapidly for COFI mortgage rates that have high gross margins.

The odds that a household making a fixed-rate mortgage payment cannot cover the payment on a COFI mortgage are very low. The time path of payments, however, is important because we want to examine zero or low down payment mortgages. The concept is that renters in high-cost cities may not be able to save for a down payment but have adequate incomes to make monthly mortgage payments.

Using the mean and variance for the normally distributed $COFI_t$ found above, we can calculate the odds that a sequence of Treasury rate realizations will result in a COFI rate (include the gross margin) in excess of the fixed-rate mortgage rate. A typical path for COFI mortgage rates is shown in figure 8. The expected long-run values of COFI rates are below the initial fixed-rate mortgage. Depending on the gross margin, realizations of Treasury rates that could drive the COFI mortgage rate above the fixed-rate mortgage rate occur with a positive probability. Note that for the lowest gross margin we consider (1.75 percent), this possibility only becomes meaningful (greater than 2.5 percent) roughly 4 years after the Fixed-COFI mortgage is originated, allowing the household to accumulate substantial home equity. At a gross margin of 2.5 percent, this crossing point is reached after only a couple of quarters.

As shown in the top panel of figure 9, when Treasury rates are relatively low, the odds of COFI plus gross margin rising above the fixed-rate are particularly low (especially for the lower gross margins). The household is likely to have paid off most of the home before this a substantial concern. But as shown in the middle and bottom panels (displaying high gross margins), the odds of the payment on a Fixed-COFI mortgage being inadequate in a given month are high much earlier in the life of the mortgage. Thus, we now turn to simulating interest rate paths to estimate which Fixed-COFI mortgages successfully avoid these inadequate payments. Later, we will also calculate the expected value of the inadequate payments, to estimate how much mortgage originators need to charge the homeowner to cover this risk.

5. Simulating the Payoffs of Fixed-COFI Mortgages

Monthly mortgage payment cost savings for COFI mortgages relative to 30-year fixed-rate mortgages can be large, and the probability that COFI rates will exceed an initial fixed-rate mortgage rate are very small. As suggested at the beginning of our paper, these facts suggest there is low-risk opportunity to create a mortgage that allows homeowners to move into a home with little or no savings and allows them to accumulate equity in that home quickly.

We simulate the payment stream for Fixed-COFI mortgages for the historical relationships between the one-year Treasury rates, the fixed-rate mortgage rates, and COFIs. We undertake these simulations using all historical combinations of Treasury rates, fixed-rate mortgage rates, and COFI from Q1 1985 to Q3 2015.

As shown in figure 10, we order these rates from smallest to largest fixed-rate mortgage rate and COFI spreads (or “fixed-rate-to-COFI spread”) and show their historical occurrence from the 10th to 90th percentile. For each spread percentile, we take a range of one-year Treasury rates, fixed-rate mortgage rates, and COFI rates that occurred within a range from negative 10 percentile smaller than the chosen Treasury rate to positive 10 percentile greater than the chosen Treasury rates. We average these Treasury, mortgage, and COFI values to get the Treasury rate, fixed-rate mortgage rate, and COFI that is associated with the particular spread percentile.

The green dashed line in figure 10 is the fixed-rate-to-COFI spread. It ranges from a low of two percent to a high of four percent. The associated fixed-rate-to-Treasury spread (the purple dashed line) moves closely with the fixed-rate-to-COFI spread. One-year Treasury rates start off slightly higher than COFIs and then fall slightly below COFIs based on this ordering. The fixed-rate mortgage rate starts off close to eight percent and then hovers a little below seven percent. The hatched "left-slanted" green band is the range of the fixed-rate-to-COFI spreads, where the gross margin varies from 1.75 percent to 2.5 percent.

We use each of these 81 spread percentiles (the average spread within each one percentile, inclusive between 10 and 90) as the basis for one set of historical simulations. For each set of initial conditions, we begin our simulation by drawing a simulated time-series of monthly Treasury rates using the model discussed above. We follow by building the COFI series generated by this sequence of Treasury rates and then add the gross margin. With the COFI mortgage series in hand, we calculate the Fixed-COFI payment stream, where the household makes a fixed-rate mortgage payment based on the initial fixed-rate mortgage (set to amortize over 30 years), and the depository institution receives a payment based on the COFI plus gross margin.

For the Fixed-COFI mortgage, any positive remainder plus the normal amortization of the mortgage is added to a home equity savings account that is used to pay down the principle of the mortgage. If the remainder is negative, the home's equity savings account is used to cover the difference and make the payment to the depository institution. If the household's home equity savings account becomes negative, the bank covers the deficit in the mortgage payments. The Fixed-COFI mortgage has no ultimate payback period (recall, the mortgage by design is almost always profitable for a bank to hold). We terminate the simulations after 70 years.[13]

[13] Note that if an end point is imposed on the mortgage, such that the loan must be paid off by a given time period, then defaults can be pa created because large "balloon payments" are needed for the final payments under some scenarios. For example, a household that has accumulated 80 percent equity in the home might be forced to default because the final payment exceeds the home equity plus the last monthly payment.

We do 10,000 simulations for each set of initial conditions. With 81 initial sets of conditions, there are 810,000 total mortgage payment simulations for each combination of COFI gross margin and down payment. After 70 years, almost all mortgages have been successfully paid off. For example, if the gross margin is 1.75 percent and the down payment is 0 percent, then at the end of 70 years, only 2.36 percent of the mortgage simulations have not had a successful outcome because of the paths of the interest rates.

Using fixed-rate-to-COFI spreads are a good way to order our simulations because the amount of savings and the resulting success of the Fixed-COFI mortgage hinge on this spread. As shown in figure 11, the larger the spread, the higher the average interest savings over the life of the mortgage (averaged over 10,000 simulations). Savings are particularly large for low gross margins and a low down payment.

Note that throughout our simulations, we are considering two different levels of the fixed-rate mortgage payment—in the first case, the initial mortgage balance is assumed to be 100 percent of the home value, whereas in the second case the initial mortgage balance is assumed to be 80 percent of the home value. The first assumes that the prevailing fixed-rate mortgage rate for a conforming mortgage where 100 percent of the house is financed is the same as the fixed-rate mortgage reported by Freddie Mac. However, this mortgage rate is not strictly comparable because the Freddie Mac mortgage rate is based on rates that reflect a 20 percent down payment. Since fixed-rate mortgage-rates with 100 percent down payment are not available, I use the Freddie Mac rate as the most conservative estimate of such a mortgage rate.

The second mortgage payment uses the same fixed-rate mortgage rate, but assumes the household is only financing 80 percent of the house value. This is the type of fixed-rate mortgage (with a 20 percent down payment) that is reflected by the rates surveyed by Freddie Mac.

The two types of fixed-rate mortgage payments represent two different types of thought experiments. The first simulates the performance of the Fixed-COFI mortgage as being proposed in the paper, in the sense that there is no down payment. The second provides an upper bound on the results when the household is given the opportunity to make a down payment, which lowers its monthly fixed-rate mortgage payment; that is, it lowers its level of forced savings over time. [14]

[14] Naturally, if a household can make a down payment in excess of 20 percent, it would opt for a traditional mortgage product.

To what extend does the down payment substitute for this type of forced savings? For example, if the household was given an option to put down a 10 percent down payment, how does the performance of this Fixed-COFI mortgage compare to a zero down payment Fixed-COFI mortgage? The results for 10 percent down would be spanned by the zero down payment and 20 percent down payment mortgage results.

How long does it take for a homeowner with a Fixed-COFI mortgage and a low or no down payment to accumulate 20 percent equity in the home? As shown in figure 12, with a 10 percent down payment and with a 1.75 percent gross margin (the green solid line), and with a 3.5 percent fixed-rate-to-COFI spread (shown by the right vertical black line), a homeowner typically (using the average simulation) acquires 20 percent equity at around 50 months. A higher 2.5 percent gross margin (the green dashed line) results in hitting 20 percent at around 64 months. Holding these conditions constant and lowering the fixed-rate-to-COFI spread to 3.0 percent (the middle black vertical line) raises the average number of months to 78 months. Lowering the down payment to zero percent and holding the gross margin at 2.5 percent (the red dashed line), and keeping the spread at 3.0 percent, increases the average number of months to 148 months. Depending on the conditions, Fixed-COFI homeowners can hold at least 20 percent equity in their homes in four to ten years. A traditional amortizing fixed-rate mortgage with zero down payment takes about 20 years to reach this proportion of home equity.

The Fixed-COFI mortgages result in homeowners owning their home because the home equity accounts combined with payments by the mortgage financer cover any payment shortfall or, in other words, periods of negative amortization. If a homeowner defaults for exogenous reasons, these reasons would apply whether the homeowner choose a traditional fixed-rate, 30-year mortgage or a Fixed-COFI mortgage. As shown in figure 13, all homeowners pay off their mortgage in less than 360 months (30 years). If margins are low and spreads are wide, homeowners often pay off their mortgage in less than 240 months (20 years).

In general, for fixed-rate-to-COFI spreads above 3.5 percent, Fixed-COFI mortgages with zero down payment mortgages are very successful in creating new homeowners. As shown with the bold red line on figure 15, these spreads are common. Even for spreads above 3.0 percent (the bold red line), homeowners are very likely to successfully acquire their homes with zero down payment Fixed-COFI mortgage.

6. The Cost of Insuring the Cap on the Mortgage Payment

How much does it cost the bank to assure the household that the mortgage payment never exceeds the mortgage payment based on the fixed-rate mortgage rate at origination? The present value of the income from the actuarially-fair insurance premium (P) charged for putting a cap on the fixed-rate mortgage payment is

$$Present\ value\ of\ income = \sum_{t=1}^{N} P \prod_{i=1}^{t} (1+T_i)^{-i}.$$

The present value of payouts if the COFI mortgage rate exceeds the fixed-rate mortgage rate is

$$Present\ value\ of\ payouts = \sum_{t:COFI_t+GM>FR_0\ \&\ LTV_t\geq 100} (COFI_t + P - FR_0) \prod_{i=1}^{t} (1+T_i)^{-i}.$$

Set present value of income equal to present value of payout:

$$\sum_{t=1}^{N} P \prod_{i=1}^{t} (1+T_i)^{-i} = \sum_{t:COFI_t+GM>FR_0\ \&\ LTV_t\geq 100} (COFI_t + P - FR_0) \prod_{i=1}^{t} (1+T_i)^{-i},$$

or

$$\begin{aligned} P \sum_{t=1}^{N} \prod_{i=1}^{t} (1+T_i)^{-i} \\ &= P \sum_{t:COFI_t+GM>FR_0\ \&\ LTV_t\geq 100} \prod_{i=1}^{t} (1+T_i)^{-i} \\ &+ \sum_{t:COFI_t+GM>FR_0\ \&\ LTV_t\geq 100} (COFI_t - FR_0) \prod_{i=1}^{t} (1+T_i)^{-i}. \end{aligned}$$

The equation above implies the following:

$$P = \frac{\sum_{t:COFI_t+GM>FR_0\ \&\ LTV_t\geq 100} (COFI_t - FR_0) \prod_{i=1}^{t} (1+T_i)^{-i}}{\sum_{t:COFI_t+GM\leq FR_0\ |\ LTV_t<100} \prod_{i=1}^{t} (1+T_i)^{-i}}.$$

The gross margin makes a substantial difference in the proportion of mortgages that require an insurance payout by the bank to avoid a payment shortfall by the homeowner. As shown in the top panel of figure 14, fixed-rate-to-COFI spreads of 3.5 percent and greater (right of the right vertical black line), fewer than 4 percent of Fixed-COFI mortgages with a gross margin of 1.75 percent require such a payout. If the gross margin is increased to 2.5 percent, then the proportion of mortgages that experience a period of negative amortization such that the LTV exceed 100 percent can rise as high as 12 percent. At a 2.5 percent spread (left black vertical line), these proportions rise to between 4 and 10 and between 20 and 30 percent respectively, depending on the size of the down payment.

Numerical simulation can be used to solve the insurance premium, because the margin affects the odds that the bank makes a pay-off to the homeowner. As shown in the bottom panel of figure 14, the estimated value of the insurance premium is 3 basis points. Here, we show only the most generous mortgage we have considered: a COFI margin of only 1.75 percent and a zero down payment. Higher down payments lower the insurance premiums, whereas higher margins raise overall income but make pay-outs more likely. Regardless, the cost of providing this actuarially-fair insurance to the homeowner is very low.

7. When should Fixed-COFI Mortgages be offered and why the wedge?

When the fixed-rate-mortgage-rate-to-COFI-mortgage-rate spread is wide, take a Fixed-COFI mortgage. This advice is consistent with the comparison of fixed-rate mortgages to adjustable-rate mortgages from the perspective of optimal household risk management in Campbell and Cocco (2003): "When the yield spread [between fixed-rate mortgage rates and adjustable-rate mortgage rates] is unusually high, more homeowners should take out adjustable-rate mortgages; when it is unusually low, more homeowners should take out fixed-rate mortgages." Although their modelling is more sophisticated than presented here and allows a variety of different risks (e.g. income and inflation risks), the household's objective of wealth accumulation is the same. Furthermore, many homeowners take this advice; the adjustable-rate mortgage share of mortgage originations rises when this spread is wide (Nothaft and Wang, 1992).

A similar rule might apply to banks—particularly risk-averse banks—wanting to offer Fixed-COFI Mortgages. If the bank were risk-neutral, then it would offer the Fixed-COFI mortgage under almost any conditions. A risk-neutral bank would weight duration-risk insurance payouts by the frequency of their occurrence and then discount the cash flows (this is how the actuarially-fair premiums were calculated at the bottom of figure 14). However, a risk-averse bank may want to set a floor on losses, regardless of how frequent (or far in the future) such losses are likely to happen. When fixed-rate-to-COFI spreads fall below 3.0 percent, the payouts run about 75 basis points for large gross margins. These payouts rise to 130 basis points with a spread of 2.5 percent (albeit they usually occur infrequently and in the far future). Thus, when the fixed-rate-mortgage-rate-to-COFI-mortgage-rate spreads are 2.5 percent or higher, Fixed-COFI mortgages would likely still be very profitable for the bank. However, suppose the bank is risk-averse and wants to avoid outcomes in which its gross margin is markedly diminished by payouts to cover homeowner mortgage payments. The size of the absolute payouts (not expected values) are shown in the top panel of figure 15 and suggest potential negative profits for spreads under 2.5 percent in some periods in the far future.

Does the Fixed-COFI mortgage provide homeowners with a “free lunch”? Why does a positive spread between the mortgage rates on traditional fixed-rate mortgages and profitable COFI mortgage rates persist? Why does there seem to be such a large premium built into the fixed-rate mortgage rate over COFI?

I argue that the fixed-rate mortgage rate is heavily influenced by the marginal costs of capital markets investors who invest in mortgage-backed securities (MBS) sponsored by the government-sponsored enterprises, Fannie Mae and Freddie Mac. For MBS investors, the funding risks of 30-year, fixed-rate mortgages can be broken into four components: interest rate risk, basis risk, prepayment risk, and uncertainty. Since many mortgage originators are reluctant to bear these risks, fixed-rate mortgages are often securitized (Fuster and Vickery, 2015). Thus, financing falls to MBS investors, who often try to purchase hedges against these risks using a cost basis and financial instruments that are poorly suited to this task.

The first risk component—interest rate or duration risk—is simply that mortgage holder’s cost of funds (which for a bank would be COFI, but for a market-based MBS holder it would likely be either London Interbank Offered Rate (LIBOR) or some function of Treasury rates) rises above the rate on a previously originated 30-year, fixed-rate mortgage. Many investors use interest rate swaps to mitigate this risk, or try to “match fund” by setting the duration of their fixed-rate mortgage portfolio equal to the duration of liabilities.

The second component risk is basis risk, which is often a consequence of using interest rate swaps. The yields on such swaps are typically benchmarked to Treasury or LIBOR rates, which may be poorly correlated to the investors' underlying source of funding. In addition, the fixed-rate mortgage rate itself may also be difficult to reliably correlate with the capital markets investor's cost of financing an MBS security.

The third risk component—prepayment risk—is the risk that interest rates fall, the homeowner refinances, and the fixed-rate mortgage holder (or MBS holder) is left with a low-yielding asset funded by higher cost liabilities. This prepayment risk is difficult and costly to hedge because it depends on many non-economic factors that are difficult to forecast. Combinations of interest rate swaps and "swaptions" (swaps with options) are often used to hedge against this risk.

The final component is the uncertainty associated with models of prepayment. Prepayment models embed both a forecast of future interest rates (including the relative changes in such rates) and homeowner behavior. Such models are notorious for their poor performance. In addition, all the prices of these hedging instruments mentioned above represent an aggregation of many investor's beliefs over all of these components, which may be difficult to untangle and predict. Moreover, there may be a substantial payment for investor risk aversion built into model-based, fixed-rate mortgage, prepayment premiums. In addition, there are systemic risk components to aggregate prepayment, making portfolios of MBS more difficult to hedge (see Chernov, Dunn and Longstaff, 2016, on both points).

With the Fixed-COFI mortgage, the bank or mortgage investor still bears the duration risk and will charge for that risk. As shown above, the insurance premium for this risk is very small. In contrast, consider basis risks and prepayment risks. In Hancock and Passmore (2016a), we show that capital markets investors usually charge around 70 basis points for bearing these risks. But for the homeowner with a Fixed-COFI mortgage, mortgage refinancing opportunities and the associated lower interest rates represent additional opportunities for home equity accumulation. The homeowner's sacrifice is that her savings are constrained to home equity accumulation and mortgage payment insurance for the bank and not consumption and/or more general investment. This asymmetric perspective on the risks of mortgage refinancing, combined with the risk aversion and uncertainty about prepayment faced by market investors, suggests that the prepayment penalty embedded in fixed-rate mortgages may usually be greater than compensation needed by homeowners to bear the prepayment risks associated with the Fixed-COFI mortgage.[15]

A related, but somewhat different, explanation for the persistence of the positive spread between the fixed-rate mortgage rate and COFI mortgage rate is that fixed-rate mortgage investors may consistently overestimate the ability of homeowners to refinance these mortgages for all possible occurrences of favorable refinancing conditions. One can think of the Fixed-COFI mortgage as a fixed-rate mortgage that always refinances and the household's refinancing savings are forced to be early principle pay downs of the mortgage. Investors must price prepayment options as if households can refinance at any occurrence of a profitable refinancing opportunity. But many households miss such opportunities and, as a result, the compensation for prepayment risks charged by capital markets investors is "too large." Investors are unable to compete by offering lower prepayment margins because it's not possible to precisely model which refinancing opportunities are missed (and which households miss them). In addition, households may themselves be overconfident about their ability to prepay their mortgages, making them more willing to accept higher prepayment premiums charged by investors.[16]

Conclusion

The Fixed-COFI Mortgage exploits this often-present prepayment-risk wedge between the fixed-rate mortgage rate and the estimated COFI mortgage rate. Instead of providing this insurance, the household uses this wedge to accumulate home equity quickly. The homeowner commits to a savings program based on the difference between fixed-rate mortgage payments and payments based on COFI plus a margin. The margin is designed to allow the mortgage financier to profit. The Fixed-COFI mortgage leads to rapid home equity accumulation and almost always results in homeownership. This mortgage may be one method to make homeownership a more realistic possibility for renters located in high-cost metropolitan areas.

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[15] Moreover, the high level of the investors' prepayment premiums partly represents these costs and uncertainties associated with lost income when mortgages refinance, which cause investors to "front-load" the income from financing mortgages. Thus, it may not be surprising that actual savings from refinancing, on average, are much larger than the actual losses incurred COFI rises above the fixed-rate mortgage rate.

[16] For the consequences of consumer overconfidence and the persistence of "high prices", see Grubb (2015).

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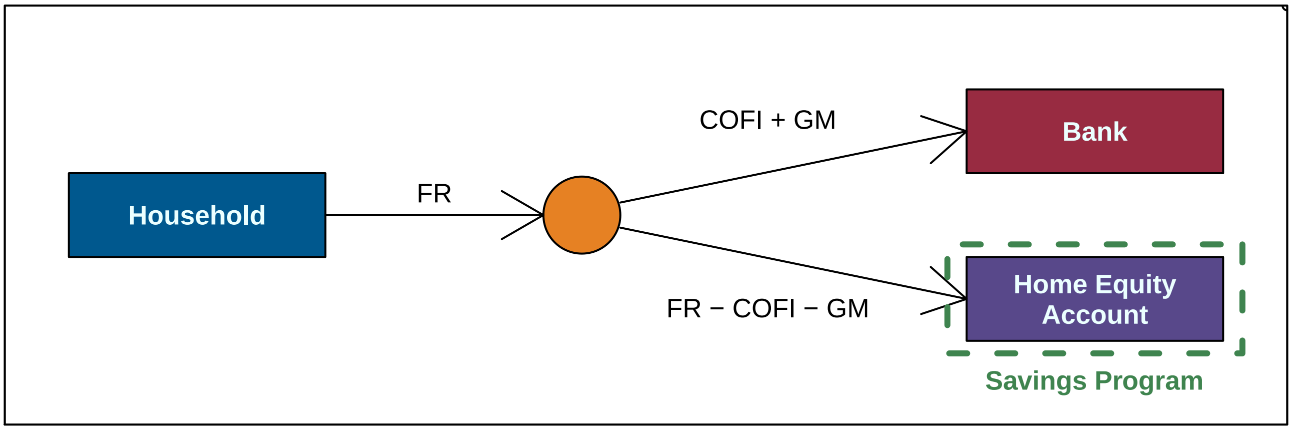
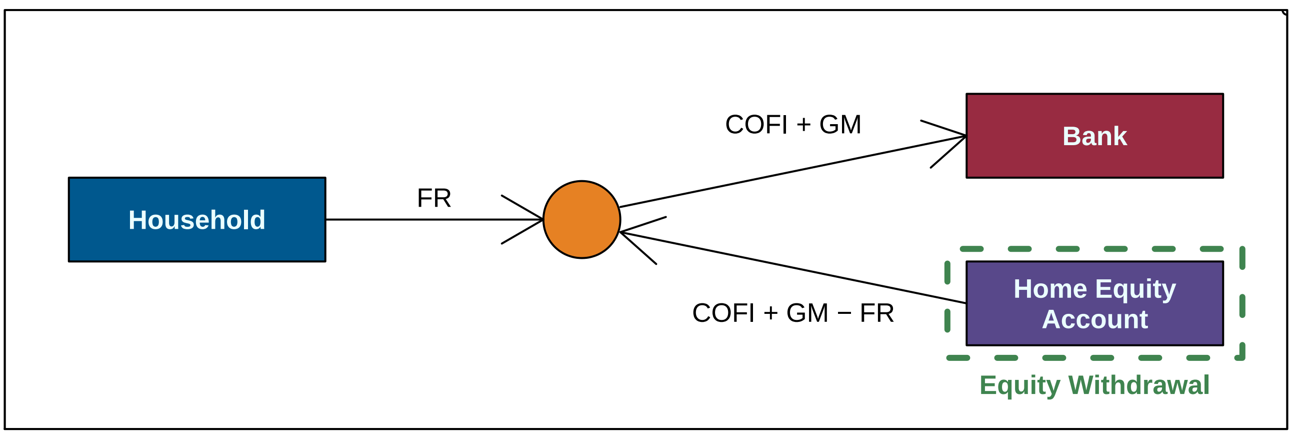
Figure 1

Fixed−COFI Mortgage Contract Mechanics

COFI + GM < FR



COFI + GM > FR and LTV < 100



COFI + GM > FR and LTV > 100

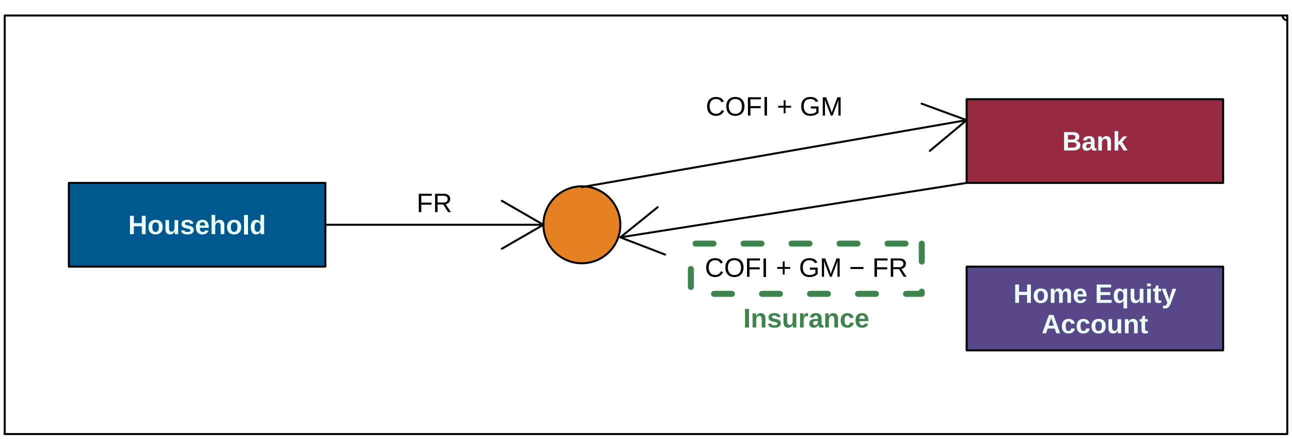
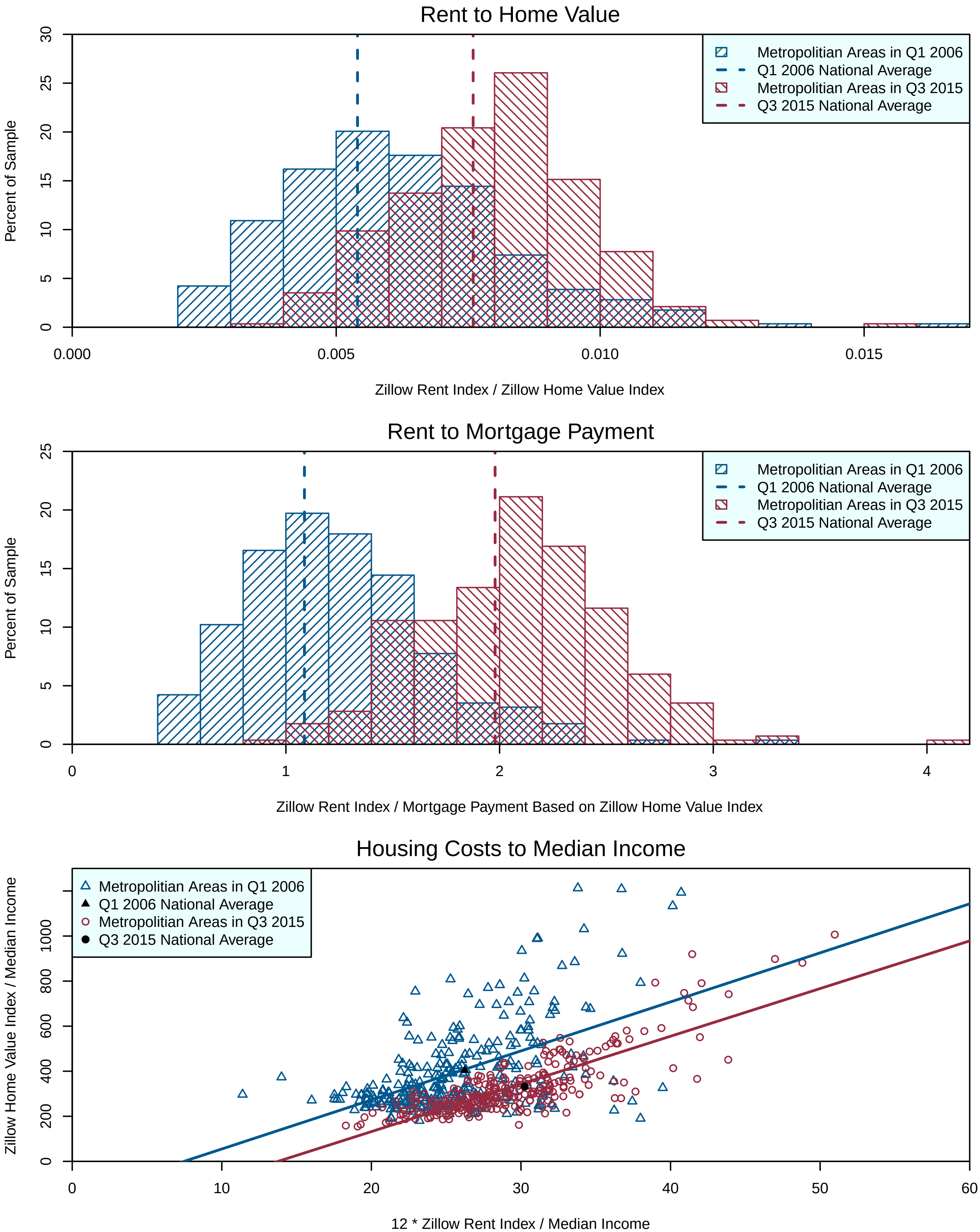


Figure 2

Changing Affordability of Housing in Metropolitan Areas

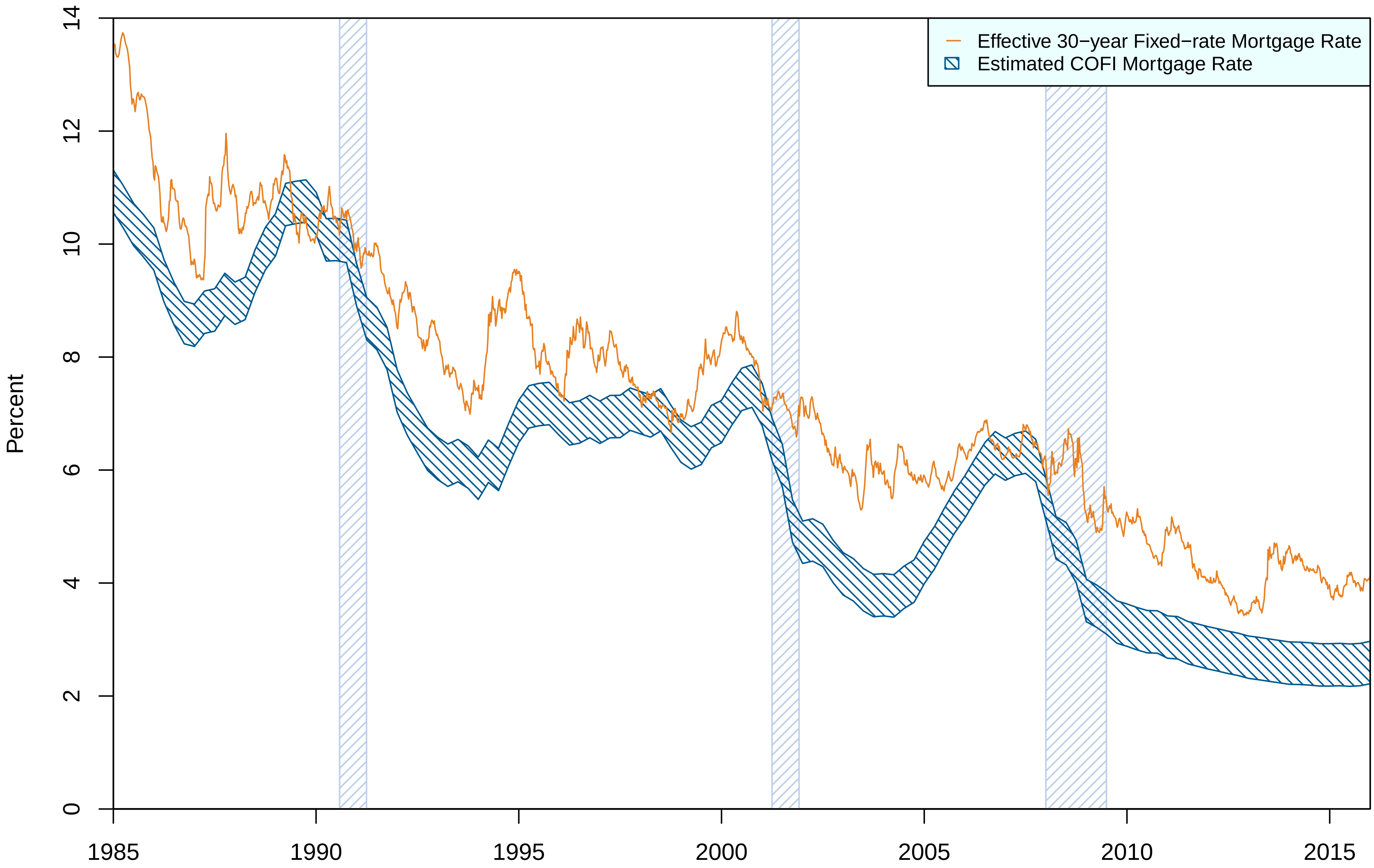


Notes: The Zillow Home Value Index and Zillow Rent Index measure median home values and rents in a given metropolitan area. Mortgage payments are calculated for a 30−year fixed−rate mortgage with a 20 percent down payment. 381 metropolitan areas.

Data source: Fixed−rate Mortgage Rates (Freddie Mac Primary Mortgage Market Survey data available at http://www.freddiemac.com/pmms/pmms_archives.html, quarterly averages of weekly values); and Zillow Home Value Indexes, Zillow Rent Indexes, and Median Incomes (Zillow, available at http://www.zillow.com/research/data/).

Figure 3

Comparison of Actual Fixed−rate Mortgage Rates and Estimated COFI Mortgage Rates



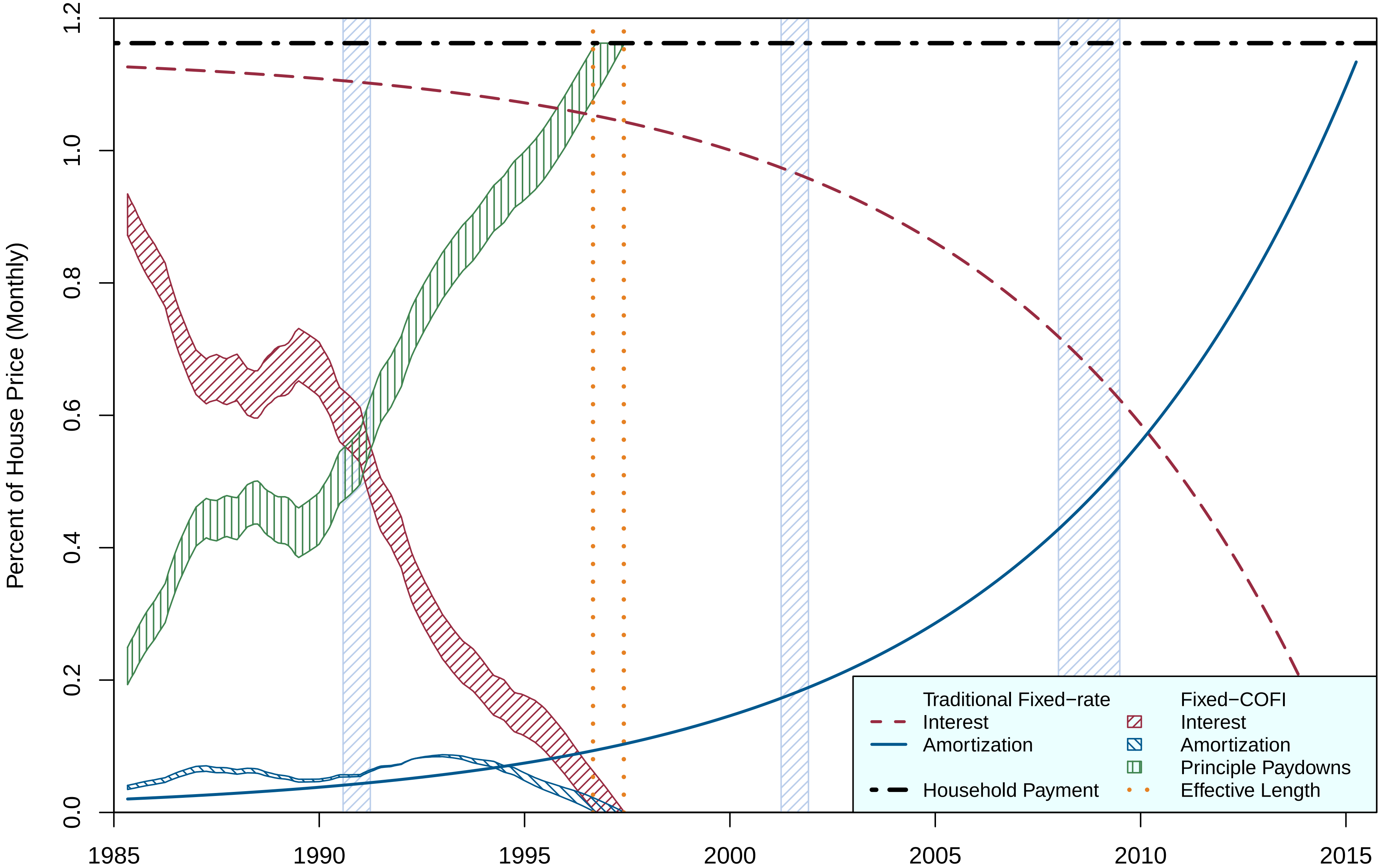
Created: 2016−10−04.

Notes: Estimated COFI mortgage rates are quarterly with gross margins ranging from 1.75 to 2.5 percentage points.

Data sources: Cost of Funds Index (constructed from quarterly Federal Financial Institutions Examination Council Call Report data available at https://cdr.ffiec.gov/public/); Estimated COFI−Cat Mortgage Gross Margins (Hancock and Passmore forthcoming); and Fixed−rate Mortgage Rates (Freddie Mac Primary Mortgage Market Survey data available at http://www.freddiemac.com/pmms/pmms_archives.html, monthly averages of weekly values).

Figure 4

Payment Breakdown for Example Traditional Fixed−rate Mortgage and Fixed−COFI Mortgage



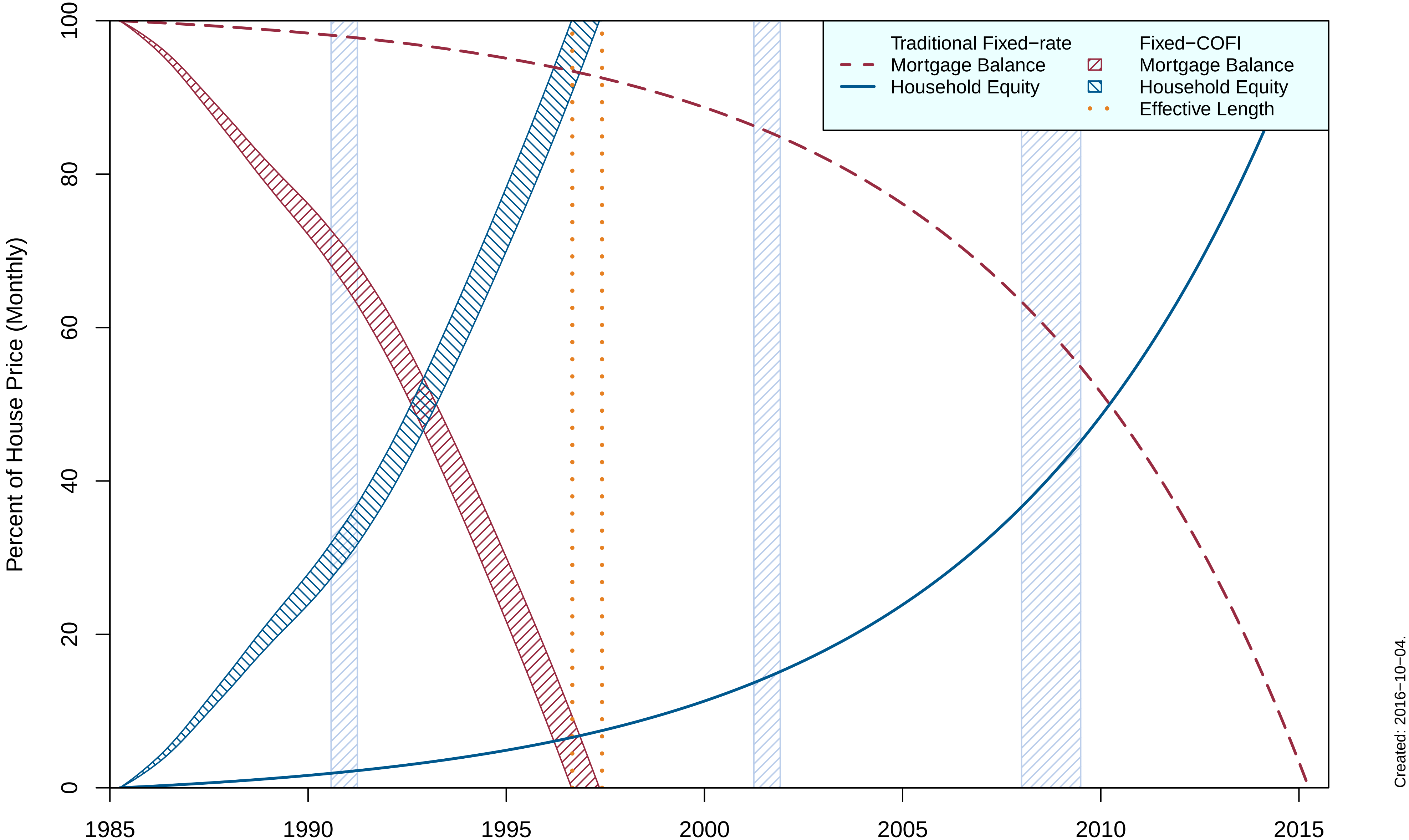
Created: 2016−10−04.

Notes: Mortgages originated in April 1985 with 100 percent LTV and 30−year maturity. COFI mortgage gross margins range from 1.75 to 2.5 percentage points. For both mortgages, household payment is 1.16 percent of house price. Effective length of Fixed−COFI mortgage is between 147 and 138 months.

Data sources: Cost of Funds Index (constructed from quarterly Federal Financial Institutions Examination Council Call Report data available at https://cdr.ffiec.gov/public/); Estimated COFI−Cat Mortgage Gross Margins (Hancock and Passmore forthcoming); and Fixed−rate Mortgage Rates (Freddie Mac Primary Mortgage Market Survey data available at http://www.freddiemac.com/pmms/pmms_archives.html, monthly averages of weekly values).

Figure 5

Mortgage Balance and Household Equity for Traditional Fixed−rate Mortgage and Fixed−COFI Mortgage

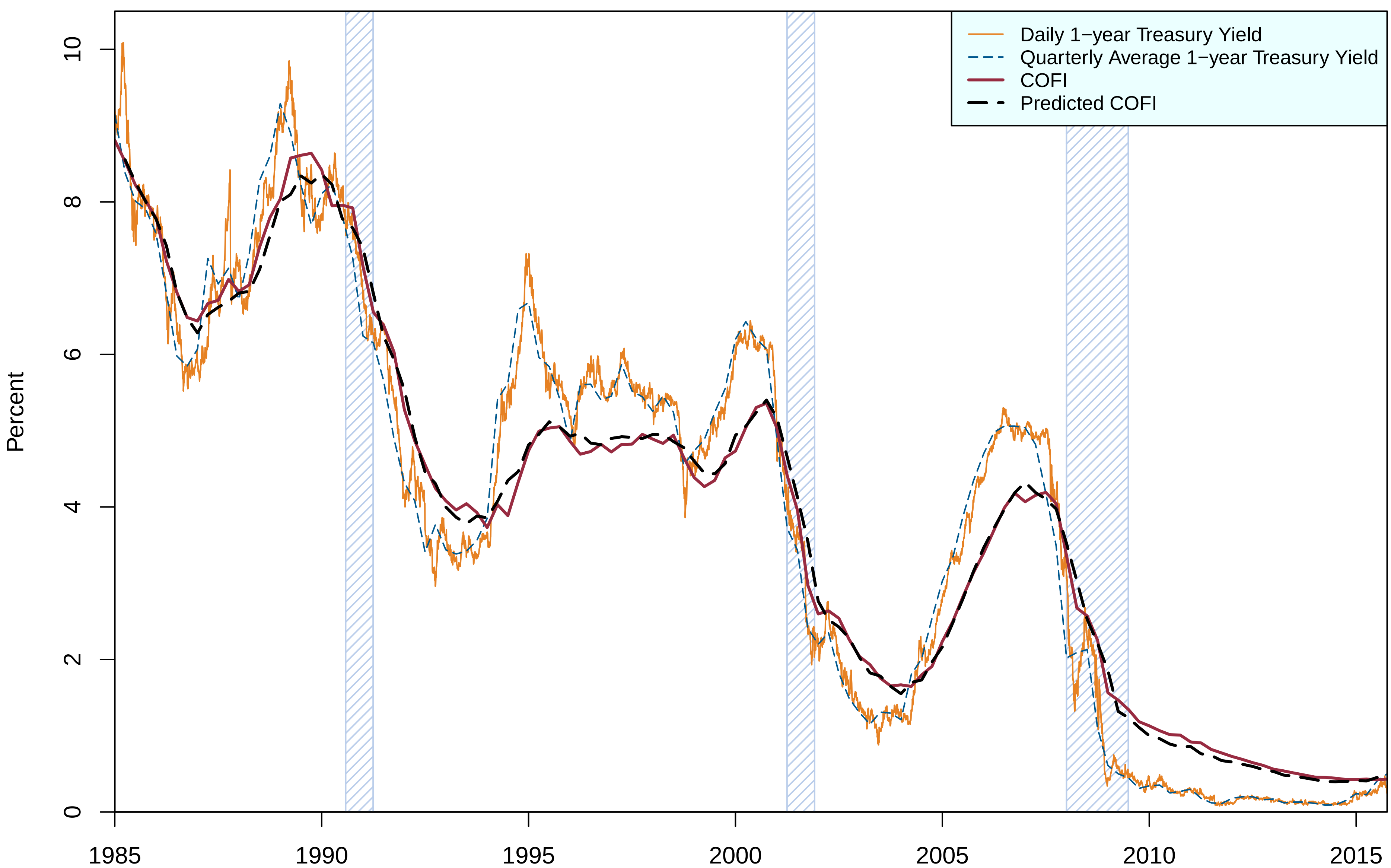


Notes: Mortgages originated in April 1985 with 100 percent LTV and 30−year maturity. Estimated COFI mortgage gross margins ranging from 1.75 to 2.5 percentage points. Effective length of Fixed−COFI mortgage is between 147 and 138 months.

Data sources: Cost of Funds Index (constructed from quarterly Federal Financial Institutions Examination Council Call Report data available at https://cdr.ffiec.gov/public/); Estimated COFI−Cat Mortgage Gross Margins (Hancock and Passmore forthcoming); and Fixed−rate Mortgage Rates (Freddie Mac Primary Mortgage Market Survey data available at http://www.freddiemac.com/pmms/pmms_archives.html, monthly averages of weekly values).

Figure 6

Cost of Funds Partial Adjustment Model Fitted Values



Created: 2016−10−04.

Notes: Predicted COFI based on model from Table 1.

Data sources: Cost of Funds Index (constructed from quarterly Federal Financial Institutions Examination Council Call Report data available at https://cdr.ffiec.gov/public/); and 1−year Treasury Yield (US Treasury available at https://www.treasury.gov/resource−center/data−chart−center/interest−rates/Pages/TextView.aspx?data=yield).

Table 1: Cost of Funds Partial Adjustment Model

	Dependent variable:
	Cost of Funds Index
Lag Cost of Funds Index	0.746^{***}
	(0.016)
1-year Treasury Yield	0.232^{***}
	(0.015)
Constant	0.036
	(0.027)
Observations	124
Quarterly	*p<0.1; **p<0.05; ***p<0.01

Notes: Data from Q1 1985 to Q1 2016.

Data sources: Cost of Funds Index (constructed from quarterly Federal Financial Institutions Examination Council Call Report data available at https://cdr.ffiec.gov/public/); and 1-year Treasury Yield (US Treasury available at https://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yield, quarterly averages of daily values).

Hlavac, Marek (2015). stargazer: Well-Formatted Regression and Summary Statistics Tables. http://CRAN.R-project.org/package=stargazer.

Created: 2016-10-04.

Table 2: AR(1) Treasury Yield Models

	Dependent variable:			
	Average 1-year Treasury Yield			
	Quarterly	Monthly	Weekly	Daily
	(1)	(2)	(3)	(4)
Lagged Average 1-year Treasury Yield	0.977***	0.992***	0.998***	1.000***
	(0.015)	(0.005)	(0.001)	(0.0002)
Constant	0.023	0.009	0.001	0.0002
	(0.074)	(0.025)	(0.005)	(0.001)
Observations	124	374	1630	8152
R-squared	0.97	0.989	0.998	1
Adjusted R-squared	0.97	0.989	0.998	1
$\widehat{Var}(\hat{\varepsilon})_{MLE}$	0.216	0.078	0.014	0.003

*p<0.1; **p<0.05; ***p<0.01

Notes: Data from January 1, 1985 to March 31, 2016.

Data sources: Treasury Yields (US Treasury available at https://www.treasury.gov/, specified averages of daily values).

Hlavac, Marek (2015). stargazer: Well-Formatted Regression and Summary Statistics Tables. http://CRAN.R-project.org/package=stargazer.

Created: 2016-10-04.

Table 3: Initial Conditional of Treasury Yields, Fixed-rate Mortgage Rates and COFI

Treasury Yield Percentile	T_0	Mean FR_0	Mean $COFI_0$	$\overline{COFI}$	FR_0 T_0 Spread	FR_0 $COFI_0$ Spread	FR_0 $\overline{COFI}$ Spread
10	0.21	4.32	0.72	0.19	4.11	3.60	4.13
25	1.18	5.65	1.74	1.08	4.47	3.92	4.57
50	4.32	7.20	4.22	3.94	2.88	2.98	3.26
75	5.98	8.81	5.42	5.46	2.83	3.39	3.35
90	7.66	10.80	7.41	7.00	3.14	3.39	3.81

Table 4: Treasury Yield Shocks to Steady-state COFI

Treasury Yield Percentile	$\varepsilon^*_{1.75}$	$Pr\{\varepsilon^*_{1.75}\}$	$\varepsilon^*_{2.00}$	$Pr\{\varepsilon^*_{2.00}\}$	$\varepsilon^*_{2.25}$	$Pr\{\varepsilon^*_{2.25}\}$	$\varepsilon^*_{2.50}$	$Pr\{\varepsilon^*_{2.50}\}$
10	2.60	0	2.33	0	2.06	0	1.78	0
25	3.09	0	2.82	0	2.54	0	2.27	0
50	1.65	0	1.38	0.20	1.10	0.90	0.83	3.70
75	1.75	0	1.47	0.10	1.20	0.50	0.93	2.30
90	2.25	0	1.98	0	1.70	0	1.43	0.10

Notes: Quarterly data from Q1 1985 to Q1 2016. The fixed-rate mortgage rates and COFIs used in deriving mean values are +/-10 percent from each percentile. Probabilities estimates based on normally distributed quarterly changes in 1-year Treasury yields with mean = 0 and MLE standard deviation estimator = .471.

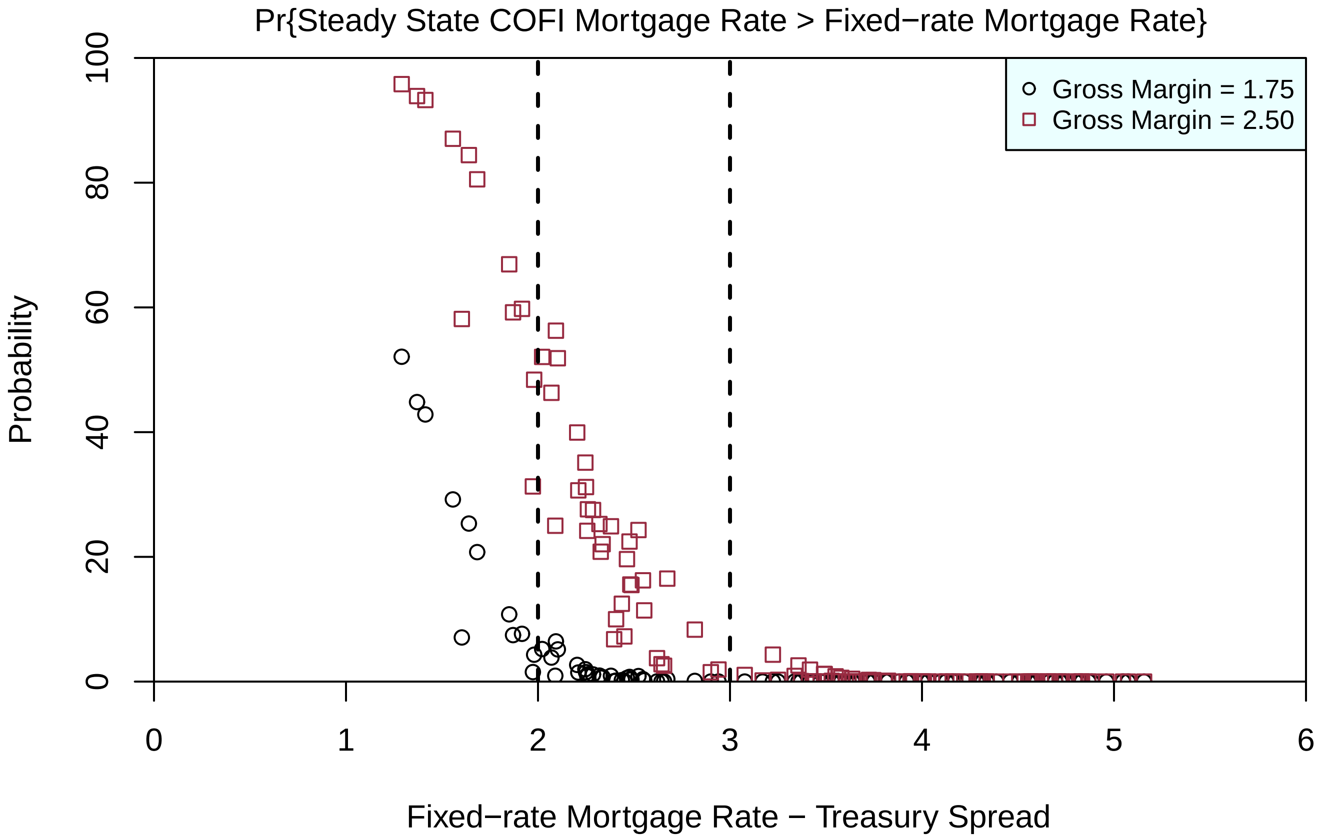
Data sources: Cost of Funds Index (constructed from quarterly Federal Financial Institutions Examination Council Call Report data available at https://cdr.ffiec.gov/public/); Estimated COFI-Cat Mortgage Gross Margins (Hancock and Passmore forthcoming); and Fixed-rate Mortgage Rates (Freddie Mac Primary Mortgage Market Survey data available at http://www.freddiemac.com/pmms/pmms_archives.html, quarterly averages of weekly values); and 1-year Treasury Yields (US Treasury available at https://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yield, quarterly averages of daily values).

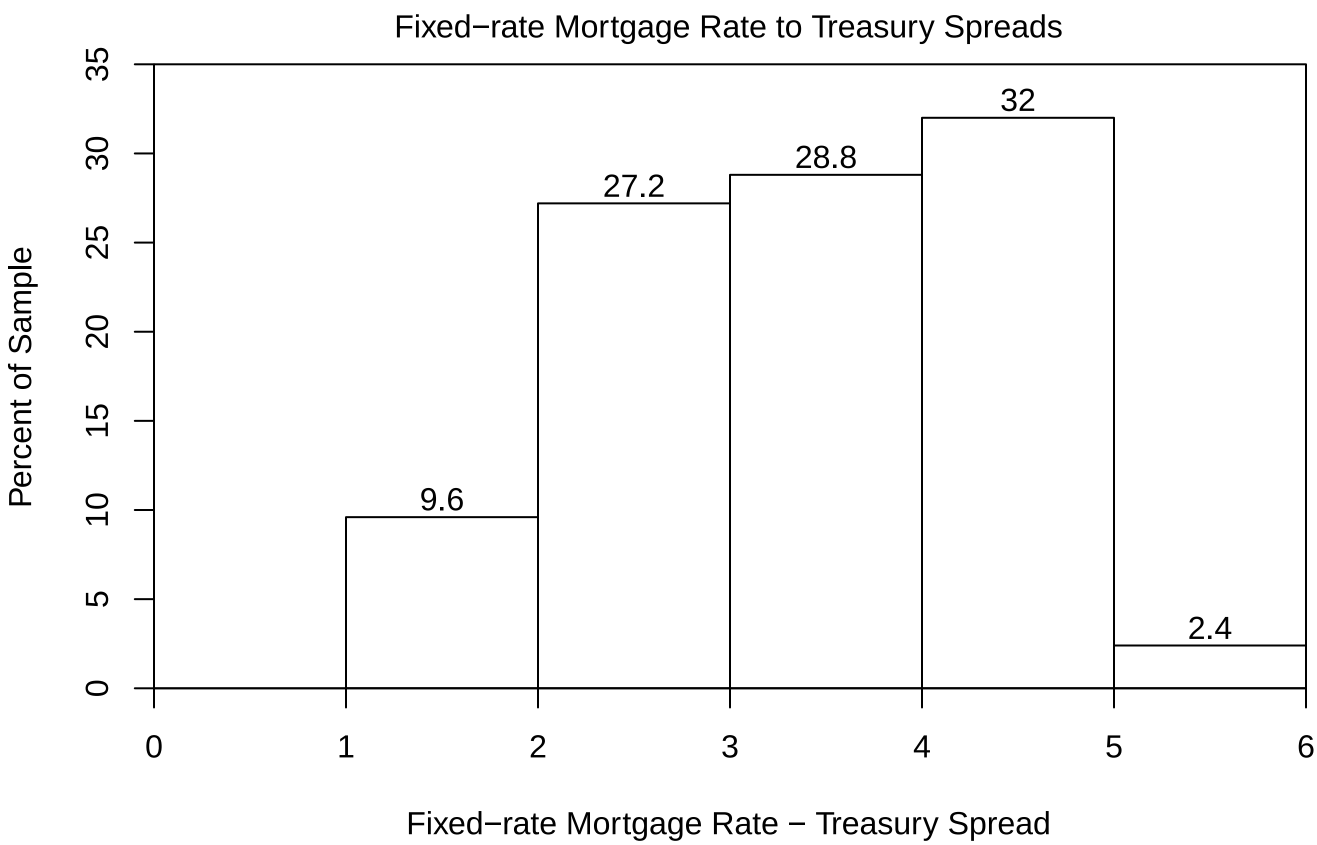
Hlavac, Marek (2015). stargazer: Well-Formatted Regression and Summary Statistics Tables. http://CRAN.R-project.org/package=stargazer.

Created: 2016-10-04.

Figure 7

Fixed−rate Mortgage Rate − Treasury Spread



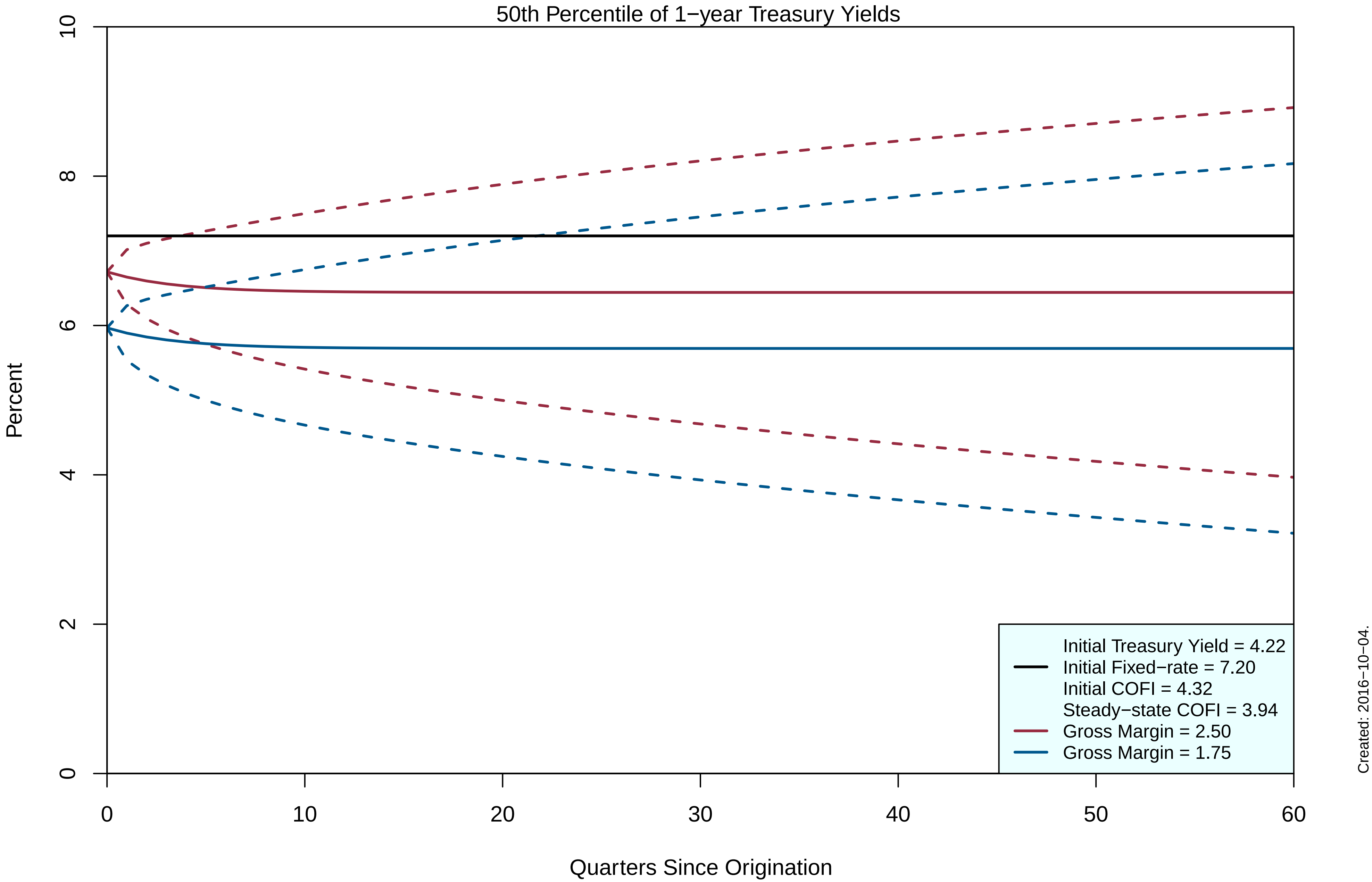


Created: 2016−10−04.

Data sources: Estimated COFI−Cat Mortgage Gross Margins (Hancock and Passmore forthcoming); Fixed−rate Mortgage Rates (Freddie Mac Primary Mortgage Market Survey data available at http://www.freddiemac.com/pmms/pmms_archives.html, quarterly averages of weekly values) and 1−year Treasury Yield (US Treasury available at https://www.treasury.gov/resource−center/data−chart−center/interest−rates/Pages/TextView.aspx?data=yield, quarterly averages of daily values).

Figure 8

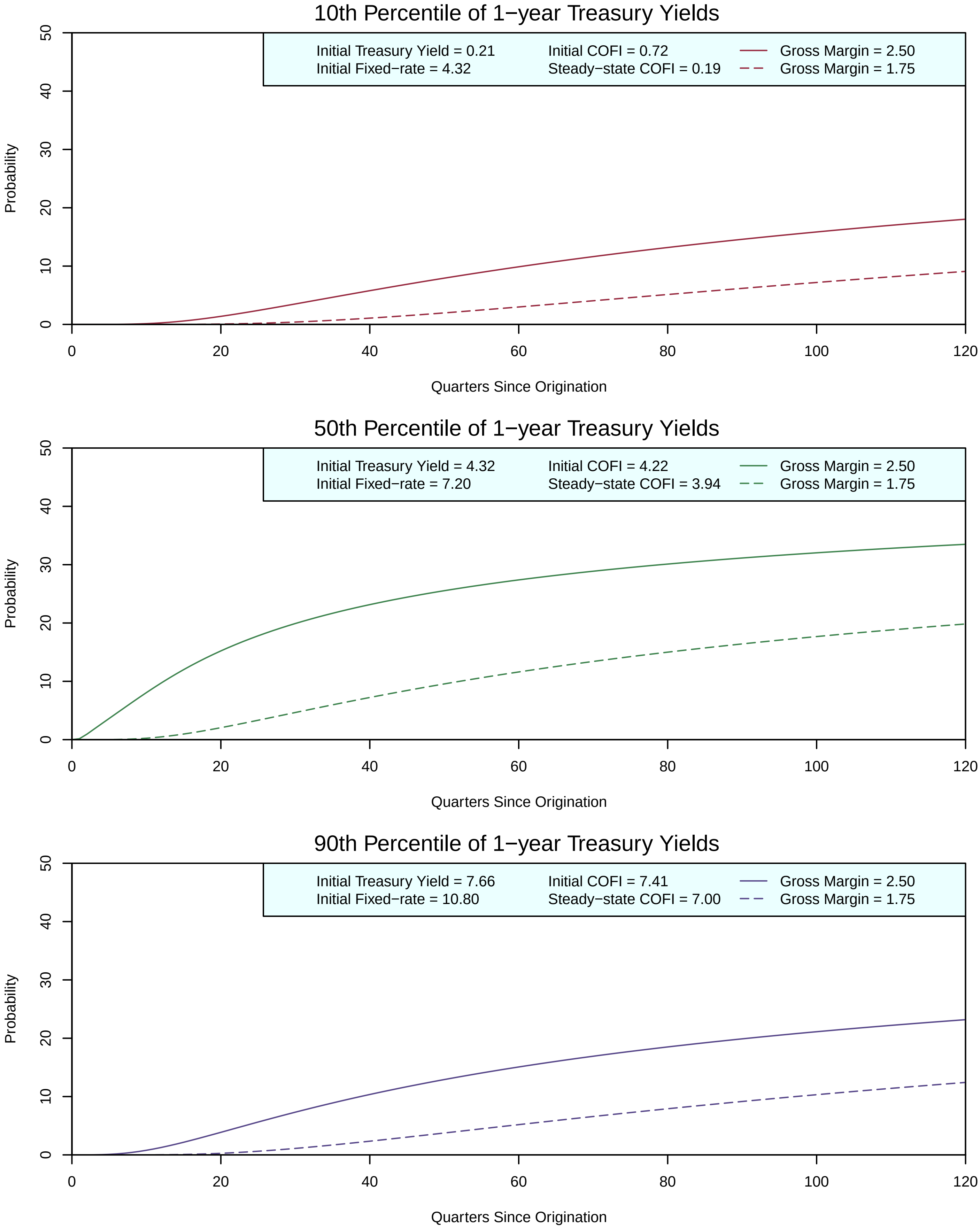
Expected COFI Mortgage Rates with 95% Confidence Interval



Data sources: Cost of Funds Index (constructed from quarterly Federal Financial Institutions Examination Council Call Report data available at https://cdr.ffiec.gov/public/); Estimated COFI−Cat Mortgage Gross Margins (Hancock and Passmore forthcoming); Fixed−rate Mortgage Rates (Freddie Mac Primary Mortgage Market Survey data available at http://www.freddiemac.com/pmms/pmms_archives.html, monthly averages of weekly values) and 1−year Treasury Yield (US Treasury available at https://www.treasury.gov/resource−center/data−chart−center/interest−rates/Pages/TextView.aspx?data=yield).

Figure 9

Probability of COFI Mortgage Rates Greater than Fixed−rate Mortgage Rates

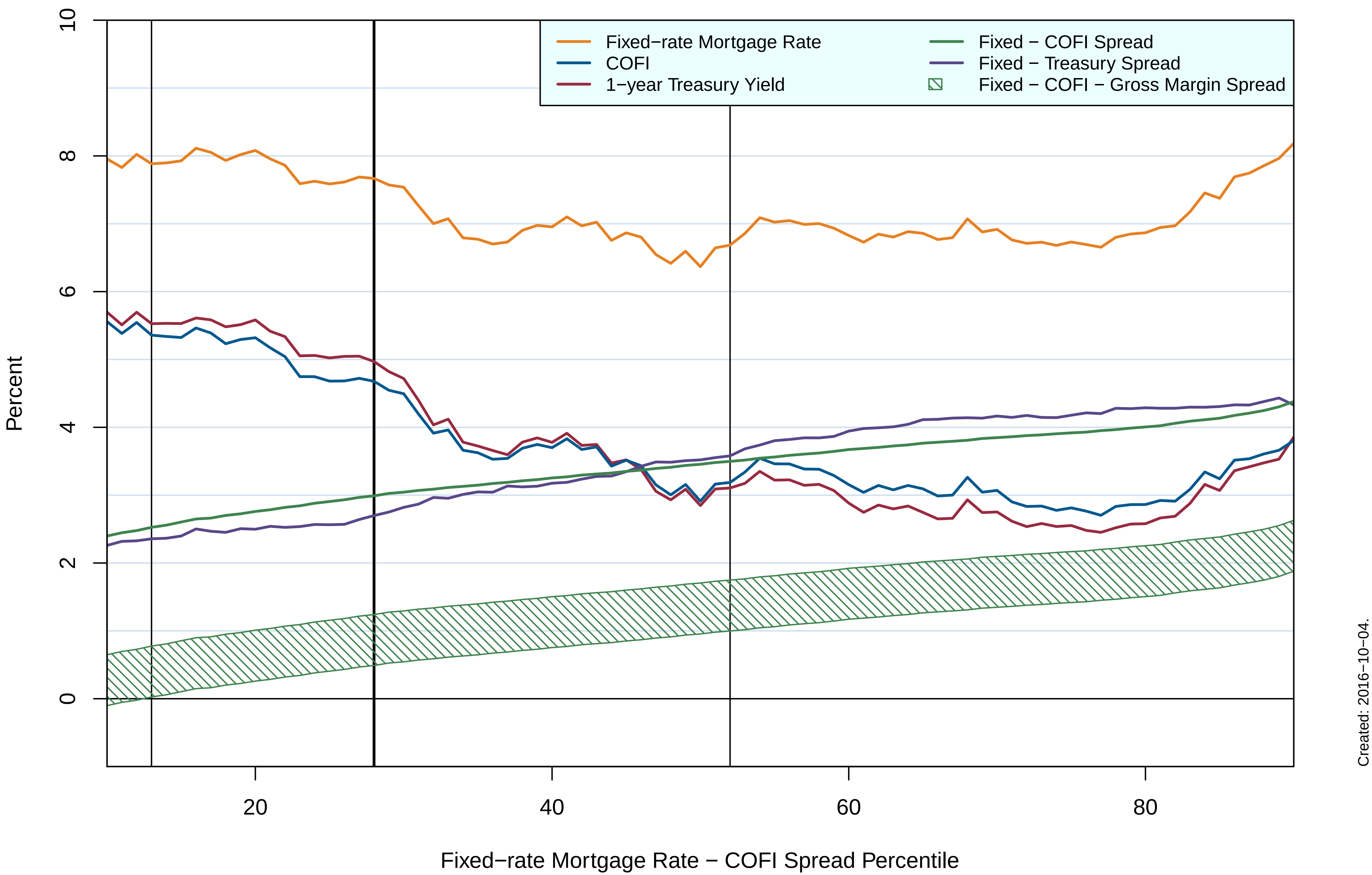


Created: 2016−10−04.

Data sources: Cost of Funds Index (constructed from quarterly Federal Financial Institutions Examination Council Call Report data available at https://cdr.ffiec.gov/public/); Estimated COFI−Cat Mortgage Gross Margins (Hancock and Passmore forthcoming); Fixed−rate Mortgage Rates (Freddie Mac Primary Mortgage Market Survey data available at http://www.freddiemac.com/pmms/pmms_archives.html, monthly averages of weekly values) and 1−year Treasury Yield (US Treasury available at https://www.treasury.gov/resource−center/data−chart−center/interest−rates/Pages/TextView.aspx?data=yield).

Figure 10

Simulation Initial Conditions

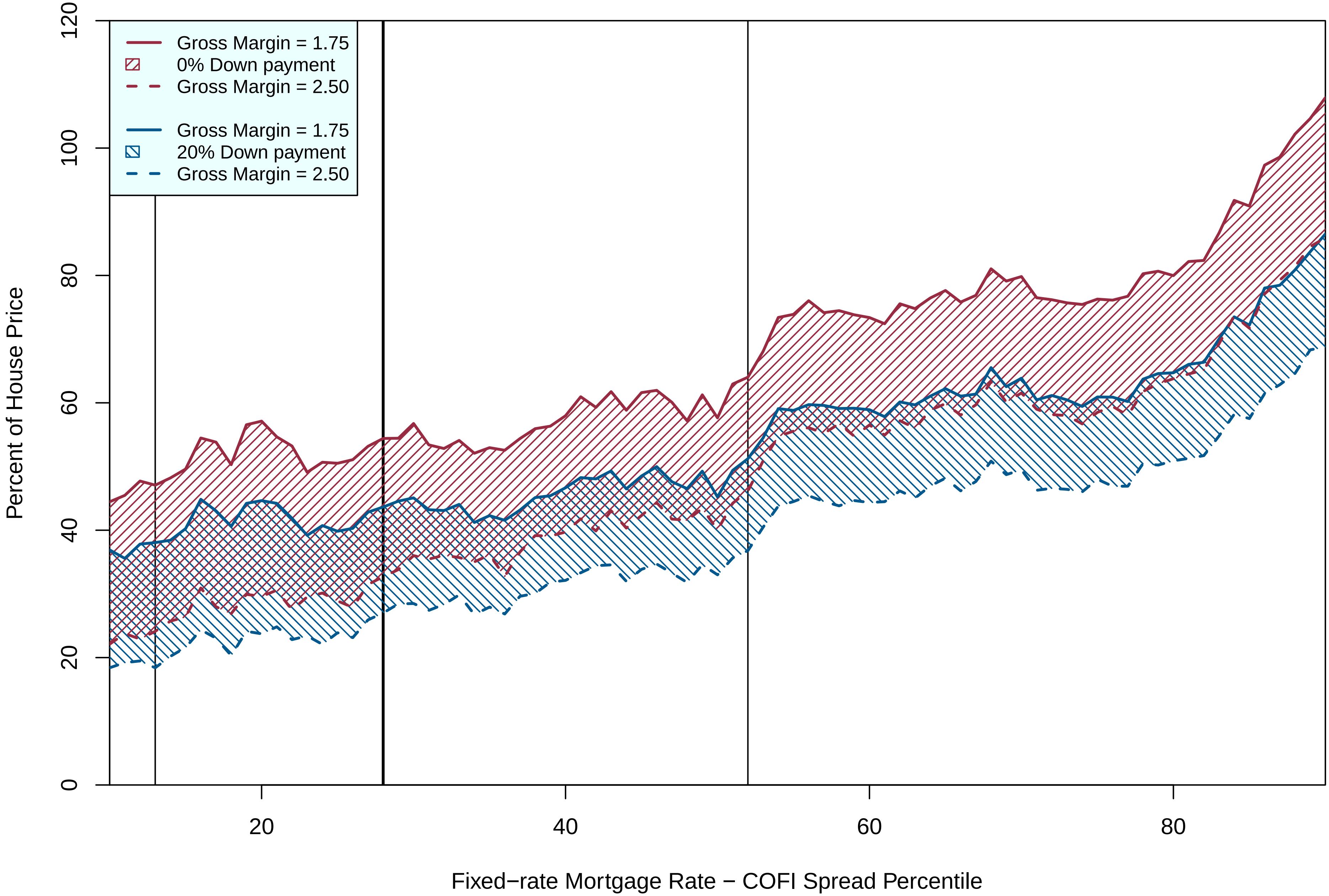


Notes: 1−year Treasury Yield, COFI and Fixed−rate mortgage rate values are means computed from a +/−10 percent spread around each spread percentile. Vertical black lines indicate Fixed − COFI spreads of 2.5, 3.0, and 3.5 percent, respectively.

Data sources: Cost of Funds Index (constructed from quarterly FFIEC Call Report data available at https://cdr.ffiec.gov/public/); Fixed−rate Mortgage Rates (Freddie Mac Primary Mortgage Market Survey data available at http://www.freddiemac.com/pmms/pmms_archives.html, quarterly averages of weekly values); and 1−year Treasury Yield (US Treasury available at https://www.treasury.gov/resource−center/data−chart−center/interest−rates/Pages/TextView.aspx?data=yield, quarterly averages of daily values).

Figure 11

Simulation Results: Interest Savings

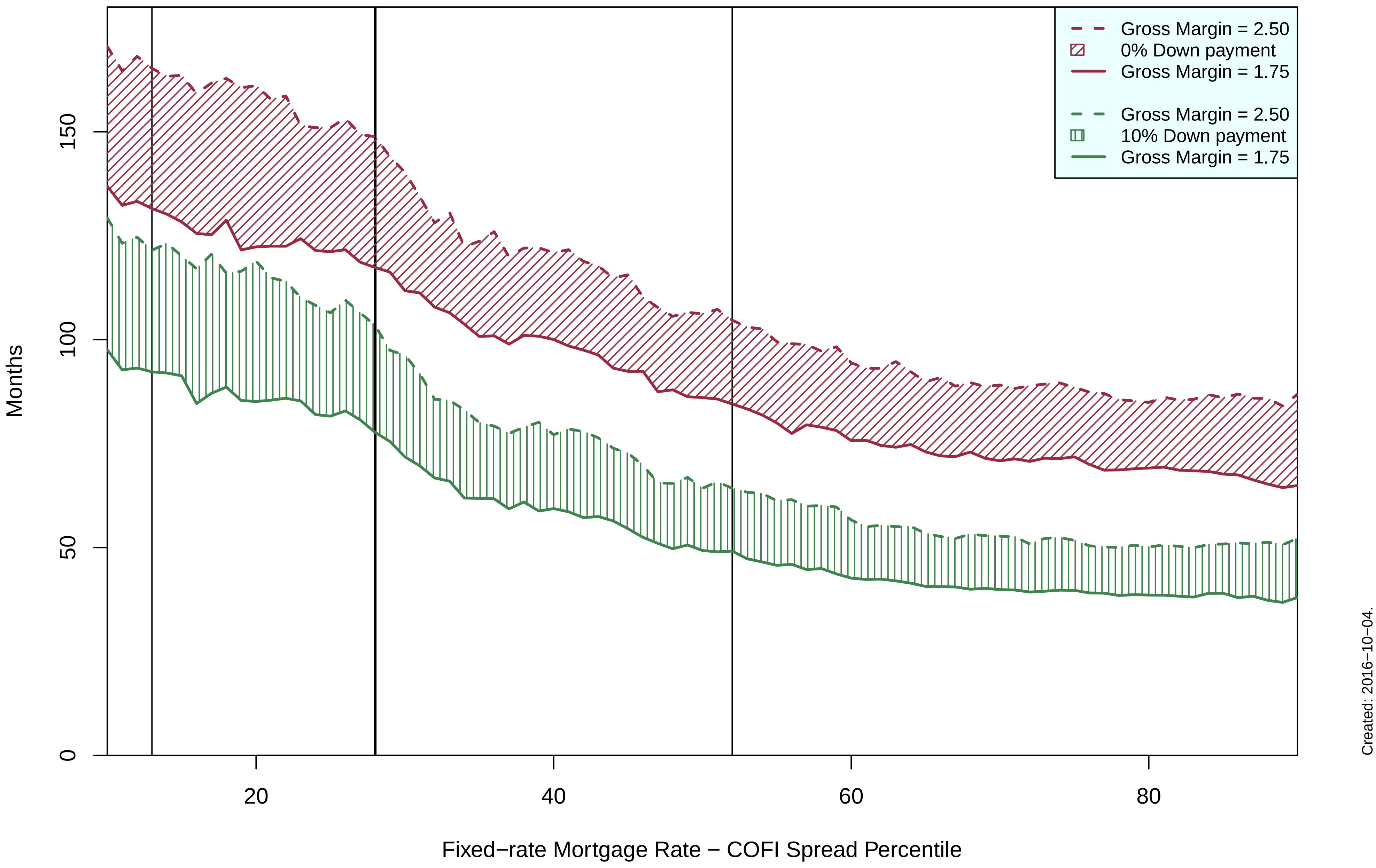


Notes: Compared to fixed−rate mortgages without refinancing. Simulations terminated after 70 years. 10000 simulations per set of initial conditions. Vertical black lines indicate Fixed − COFI spreads of 2.5, 3.0, and 3.5 percent, respectively.

Created: 2016−10−04.

Figure 12

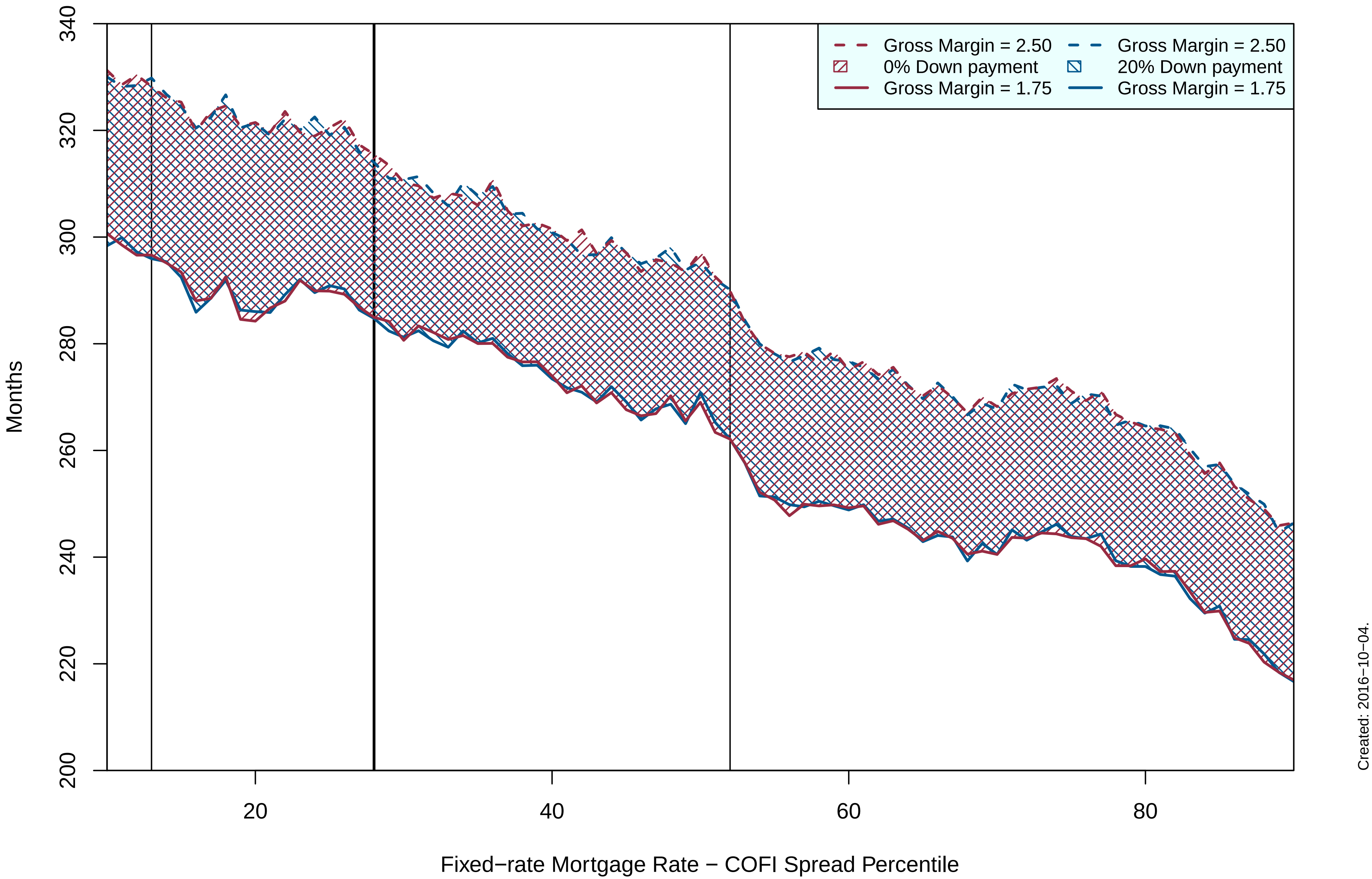
Simulation Results: Average Months Until 20% Equity Accrued



Notes: 10000 simulations per set of initial conditions. Vertical black lines indicate Fixed − COFI Spreads of 2.5, 3.0, and 3.5 percent, respectively.

Figure 13

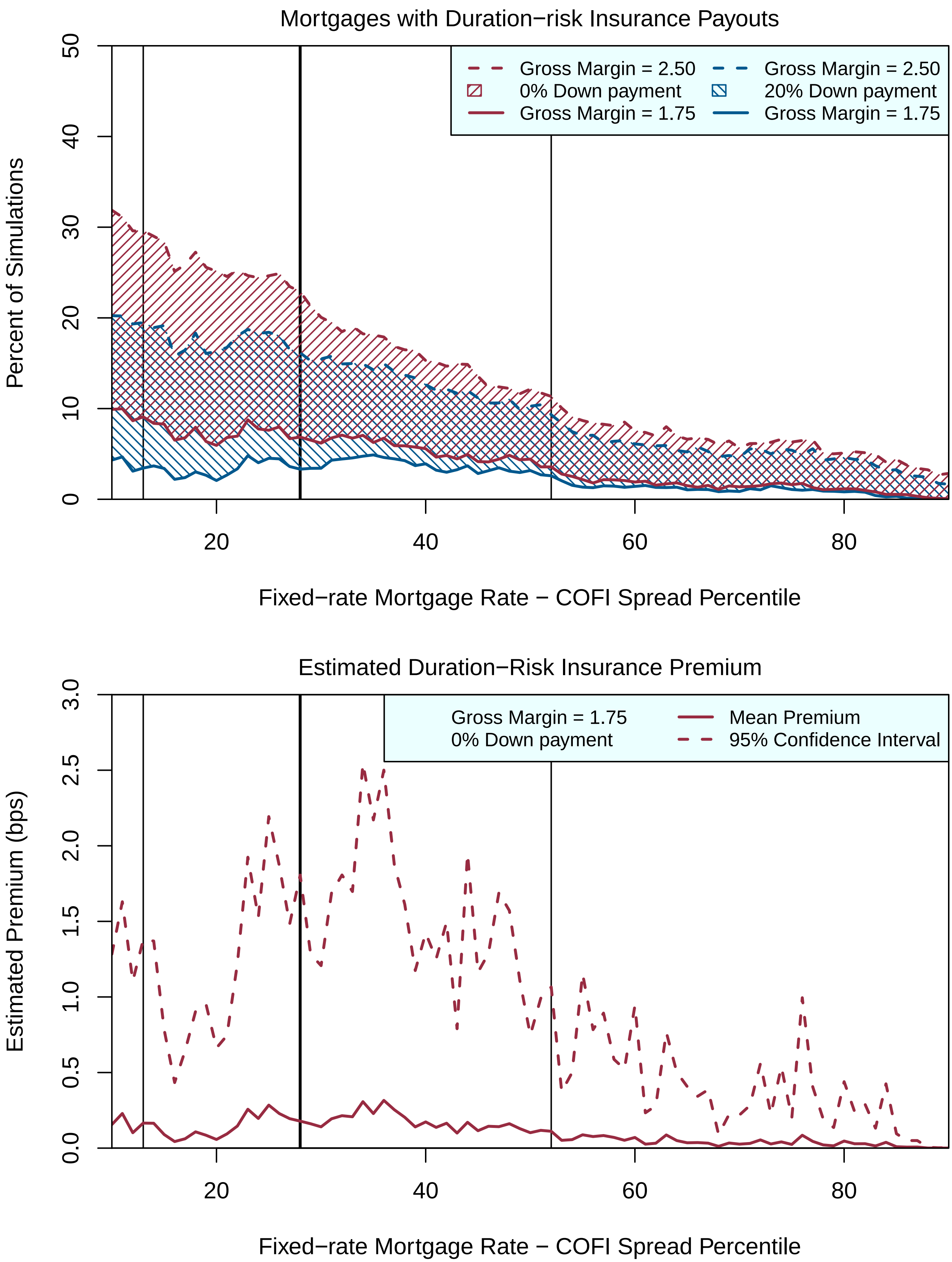
Simulation Results: Average Length of Mortgages



Simulations terminated after 70 years. 10000 simulations per set of initial conditions. Vertical black lines indicate Fixed − COFI Spreads of 2.5, 3.0, and 3.5 percent, respectively.

Figure 14

Simulation Results: Duration−risk Insurance Payouts

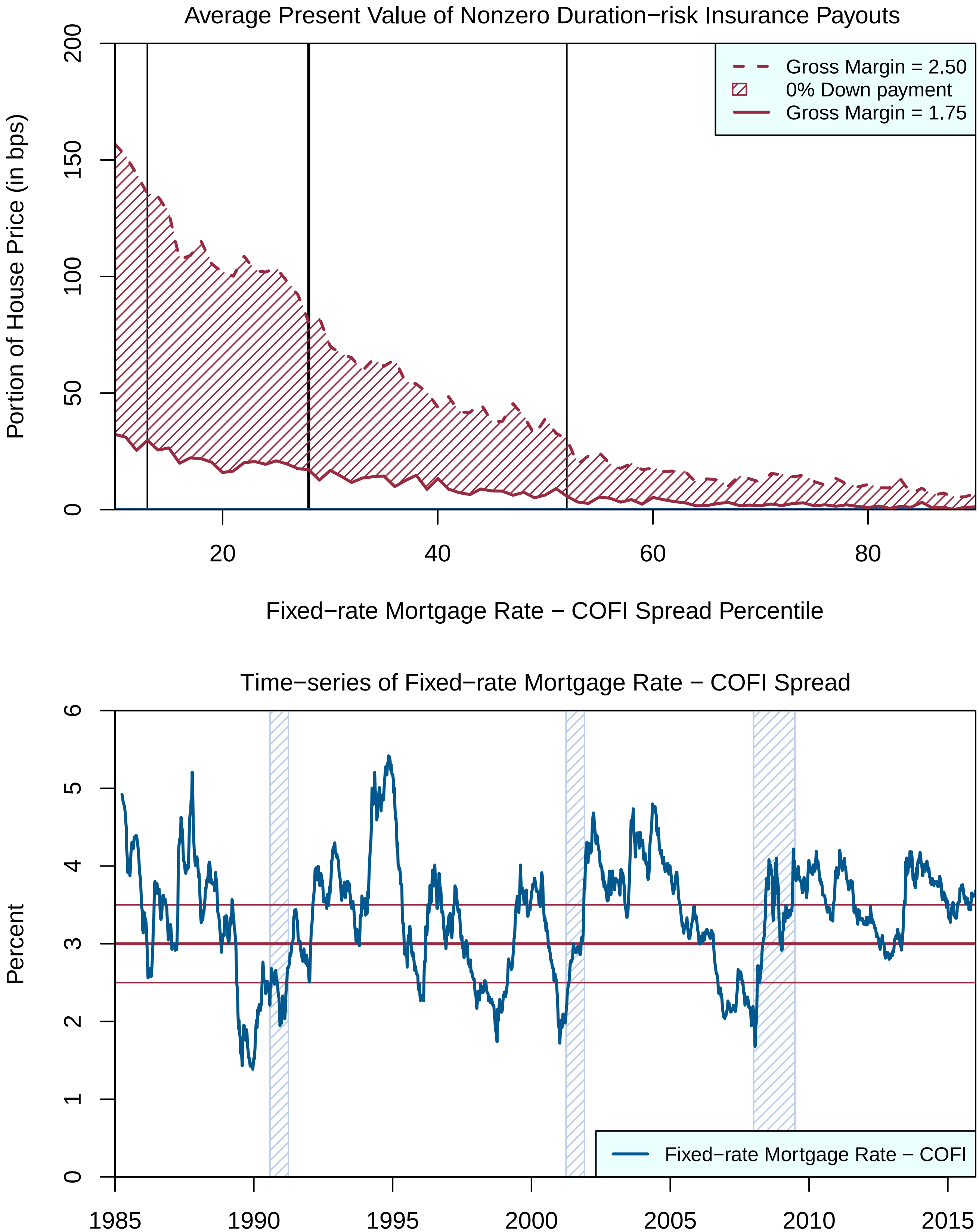


Created: 2016−10−04.

10000 simulations per set of initial conditions. Vertical black lines indicate Fixed − COFI Spreads of 2.5, 3.0, and 3.5 percent, respectively. Present values are discount by Treasury rates.

Figure 15

Simulation Results: Insurance Payouts and Spreads



10000 simulations per set of initial conditions. Vertical black lines indicate Fixed − COFI Spreads of 2.5, 3.0, and 3.5 percent, respectively. Present values are discount by Treasury rates.