The Time-Varying Price of Financial Intermediation in the Mortgage Market*

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Abstract: The U.S. mortgage market links homeowners in the U.S. with savers all over the world. In this paper, we focus on the intermediaries who facilitate those transactions and ask how much of the flow of money from savers to borrowers actually goes to these intermediaries. We develop a new methodology and use a new administrative dataset to answer the question. We find that the price of intermediation, measured as a fraction of the loan amount at origination, is large — 142 basis points on average over the period 2008-2014. At daily frequencies, intermediaries pass on price changes in the secondary market to borrowers in the primary market almost completely. At lower frequencies, the price of intermediation fluctuates significantly. It is highly sensitive to volume: a one standard deviation increase in applications for new mortgages leads to a 30-35 basis point increase in the price of intermediation. Additionally, over 2008-2014, the price of intermediation increased about 30 basis points per year, potentially reflecting increased costs of mortgage servicing and an increased legal and regulatory burden. Finally, increases in volume associated with "quantitative easing" (QE) led to substantial increases in the price of intermediation, which attenuated the benefits of QE to borrowers.

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1 Introduction

Mortgage lending is one of the main activities of the US financial intermediation sector and a principal driver of its growth in recent decades (Greenwood and Scharfstein, 2013). In recent years, the intermediary in most cases directly connects borrowers with capital market investors (through the market for mortgage-backed securities, or MBS), rather than funding loans from deposits or other funding sources.[1] So *a priori* one might expect that the price of this service should be fairly low and stable. We instead show that over the period 2008 to 2014, it was highly volatile. We then explore the drivers of this variation and study its implications for the passthrough of monetary policy, specifically the Federal Reserve's large-scale asset purchase programs, colloquially known as "quantitative easing" (QE).

Our first contribution is to develop a new methodology to measure the price of intermediation, which we define as the payment made to the intermediary for the service of linking the borrower and the ultimate supplier of funds for the loan. This payment covers costs associated with originating, underwriting and servicing the loan and also may include profits. One way one can think of the role of the intermediary in mortgage origination is as a dealer who buys a loan (meaning the right to future coupon and principal payments) from the borrower (in the "primary" market), and sells it in the "secondary" (MBS) market to investors from around the world. The intermediary's dollar margin, or the price of intermediation, is then defined as the difference between the value of the loan in the secondary market and what the intermediary pays to the borrower. This latter payment includes not only the loan amount (or principal), but also an additional upfront transfer known as "rebate" (if positive from the point of view of the borrower) or "discount points" (if negative). The rebate depends on the loan's note rate and typically changes daily for a given note rate.

The two central inputs for our analysis are thus the secondary market value of a mortgage and the rebate paid by the intermediary to the borrower. Measuring the price of a loan in the MBS market is relatively straightforward, though we use two different methods to value the part of the cash flow associated with the servicing of the mortgage.[2] Cleanly measuring rebates is much more challenging, since the "rate sheets" on which they are quoted are in general not publicly disclosed. A key innovation in the paper is that we use a new administrative dataset that documents rebates on a daily basis as a function of the note rate and detailed characteristics of the borrower and the loan. The data come from a company

[1] Over our sample period (2008-2014), about 80% of new mortgage loans are securitized through the "agency" MBS market, where the government-backed agencies Fannie Mae, Freddie Mac and Ginnie Mae insure the timely payment of principal and interest payments to investors.

[2] Our baseline measure values all cash flows based on MBS market prices; an alternative measure relies on "base servicing multiples" from an industry source to assess the value of the 25 basis points annual compensation for the right and obligation to service the mortgage.

called Optimal Blue, an industry-leading provider of real-time data to loan officers.

We use these data for several complementary analyses. To begin, we study the high-frequency (daily) passthrough of MBS price changes to rebates over the period 2008-2014, first focusing on six major monetary policy announcements (mostly QE-related) and then looking across all days in our sample. Next, we study how the price of intermediation evolved at lower (monthly) frequency, explore potential drivers of the variation, and study the implied costs to borrowers. Finally, we clarify the relationship between our price of intermediation and a commonly used measure that instead compares mortgage rates to yields in the MBS market.

Our main findings are the following: The passthrough of MBS price changes to the primary mortgage market following QE announcements was generally large, though appears to be affected by the level of demand for mortgages (measured by daily applications for new loans) at the time of the announcement. At times when demand was strong, such as around the expansion of "QE1" in March 2009, passthrough was relatively weaker and the price of intermediation increased.

More generally, we find that at the daily frequency, rebates move very closely with prices in the MBS market. We find that, on average, 92% of changes in MBS market prices are passed through to the primary market. We also find evidence for asymmetry: while MBS market price decreases are on average completely passed through to the primary market, MBS price increases yield a smaller passthrough of about 0.8. The latter coefficient also varies with the level of demand: when demand for new loans is higher, intermediaries pass through less of MBS price increases to the primary market.

Despite the strong daily passthrough, we show that the price of intermediation is highly variable over time. In particular, it strongly increases with current mortgage application volume: at monthly frequency, a one standard deviation increase in new mortgage applications is associated with a 30-35 basis point increase in the price of intermediation relative to an average price in our sample of 142 basis points. We view this as evidence consistent with significant capacity constraints in the mortgage industry, for which we also present direct evidence based on the processing time of new loan applications.

We also document a significant upward trend in the price of intermediation over the period from 2009 to 2014; using our baseline specification, this amounts to 30 basis points per year. This trend is not explained by a change in interest rate volatility (a driver of hedging costs of intermediaries) or a change in market concentration. It is partly explained by an increase in per-worker labor costs in the real estate credit sector, though of course it is difficult to know which way the causality goes. Even after controlling for labor costs, however, a positive trend remains, bearing out anecdotal evidence of an increased legal and regulatory burden leading to increased costs over this period. Consistent with this interpretation, we show that an important part of the upward trend appears to be due to a decrease in lenders' valuation of mortgage servicing rights (relative to the value of the cash flows in the MBS market), which may reflect increased costs of servicing loans and the changed treatment of servicing rights under revised capital regulations.

We find that the variation and the upward trend in the price of intermediation has had substantial costs to mortgage borrowers. Specifically, over 2009-2014, had the price of intermediation been insensitive to application volume and had there not been an upward trend, US borrowers collectively would have received roughly an additional $140 billion (in present value terms), holding the volume and timing of originations constant. Another exercise we can do is to translate the increase in the price of intermediation into its effect on interest rates for borrowers, holding the upfront cost to the borrower constant. We find that over extended times during our sample period, mortgage rates would have been 30-40 basis points lower under the counterfactual described above.

Our work relates to various strands of existing research. Most broadly, we contribute to the voluminous literature studying the effects of monetary policy and financial market conditions on the real economy through the credit channel (e.g. Bernanke, Gertler, and Gilchrist, 1999; Bernanke and Gertler, 1995; Kashyap and Stein, 2000). Specifically, we focus on the link between financial markets (which in turn may be affected by monetary policy) and borrowing rates faced by households. Recent contributions with a similar focus include Gertler and Karadi (2015) and Gilchrist, López-Salido, and Zakrajšek (2015). While other work has emphasized time-varying risk-premia, for instance in corporate bonds (Gilchrist and Zakrajsek, 2012), we focus specifically on changes in rates due to time-varying margins of intermediaries. Evidence suggests that rates in turn affect the real economy; for instance, Walentin (2014) finds that mortgage spreads have significant explanatory power for several macro variables.[3]

Related to our sample period and event studies, a growing literature has studied the effects of QE on lending rates and quantities. Most directly, this paper builds on Fuster and Willen (2010) who looked at QE1 announcements in more detail, based on an earlier version of the rate sheet data we use here. Hancock and Passmore (2011, 2015) also study the impact of unconventional monetary policy on primary mortgage rates, while Stroebel and Taylor (2012), Krishnamurthy and Vissing-Jorgensen (2011, 2013) and Boyarchenko, Fuster, and Lucca (2015) focus primarily on MBS market spreads. The effects of QE announcements on the quantity of mortgage originations (especially refinancings) are studied by Fuster and

[3]Walentin defines mortgage spreads as the gap between headline mortgage rates and long-term government bond yields.

Willen (2010), Beraja et al. (2015) and Di Maggio, Kermani, and Palmer (2016), focusing on heterogeneity across borrower types, regions, and market segments, respectively.

In the banking literature, Hannan and Berger (1991), Neumark and Sharpe (1992) and Drechsler, Savov, and Schnabl (2015), among others, have studied the adjustment of deposit rates to shocks, and link it to market power. In the mortgage market, Scharfstein and Sunderam (2013) study heterogeneity across counties in the sensitivity of rates and refinancing to changes in MBS yields over 1994-2011, finding less passthrough in more concentrated markets. We study whether changes in concentration could explain the increase in intermediation prices that we document, but since mortgage lending concentration fell substantially over 2010-2014, this does not appear to be a promising explanation of the patterns in our data.

Related to our focus on capacity constraints in the mortgage market, Sharpe and Sherlund (2016) present evidence consistent with limited capacity affecting the types of loans that lenders choose to originate. Fuster et al. (2013), who focus on longer-term trends in intermediary margins (and did not use the high-quality daily rate sheet data used here) also highlight capacity constraints as a potentially important explanation of temporarily high margins. Other work has focused on the capacity constraints of mortgage servicers (who may be the same entity as the originators we study) and how these constraints have affected modification activity during the crisis (e.g. Cordell et al., 2009; Maturana, 2015).

Finally, studying the market for financial intermediation in mortgages is also interesting from an industrial organization perspective. Our analysis parallels others studying how product prices react to changes in input prices—for instance, how the price of gasoline reacts to the price of crude oil (Borenstein, Cameron, and Gilbert, 1997; Bachmeier and Griffin, 2003). We do find some asymmetry in the passthrough, with positive MBS price changes being reflected in YSPs more slowly than negative changes, in line with existing findings of similar asymmetries in many markets (e.g. Peltzman, 2000; Driscoll and Judson, 2013).

The remainder of the paper proceeds as follows: in Section 2, we discuss the market for financial intermediation and our concepts of interest through a simple model. We then turn to the question of how to measure the theoretical concepts in the data in Section 3. Section 4 presents our event study of major monetary policy announcements. In Section 5, we study the daily passthrough over the entire sample period, while in Section 6, we focus on long-term variation in the price of intermediation. We then explore the implications of our estimated models in Section 7, while Section 8 concludes.

2 Financial Intermediation in the Mortgage Market

In this section we provide a brief overview of intermediation in the mortgage market through the lens of a simple model; see e.g. Fuster et al. (2013) for a more extensive discussion of the institutional details.

2.1 A Simple Model

Consider a simple model of the market for financial intermediation in mortgages, where we define financial intermediation as the service of matching a borrower in the primary market with an investor in the secondary market. We start with a lender who makes a loan to a borrower with a fixed interest rate r^n. Following industry parlance, we refer to r^n as the "note rate" of the loan. A central feature of the mortgage market is that, in addition to providing the borrower with the principal on the loan, the intermediary also either receives an additional upfront payment from the borrower, referred to as the borrower "paying (discount) points," or pays a "rebate" to the borrower to cover closing costs and other expenses. This upfront payment, which goes by many different names (Yield Spread Premium, Service Release Premium, (negative) discount points) plays a central role in all mortgage transactions but is often not explicitly disclosed to the borrower who just sees the points/rebate in the form of changed closing costs.

The size of that rebate, which we denote $YSP(r^n)$, depends on the note rate — a higher note rate is more valuable (since it generates higher future cash flows) and thus commands a higher YSP.[4] One useful way to think about this transaction is that in originating a mortgage, the intermediary *buys* the mortgage from the borrower by paying the principal plus the rebate. That is, the price paid for a mortgage with \$100 principal and note rate r^n is:

$$p^n_{YSP} = 100 + YSP(r^n).$$

After the intermediary buys the loans from the borrower, it turns around and sells it to investors. In general, intermediaries can sell loans to many different types of investors but over the period we study, about 80% of new mortgage lending was funded through "agency" MBS guaranteed by the government-sponsored enterprises (GSEs) Fannie Mae and Freddie Mac or the government agency Ginnie Mae; only about 20% of loans were kept on bank balance sheets.[5] Our discussion will focus on a loan sold through a Fannie Mae MBS; the mechanics for Freddie Mac or Ginnie Mae are very similar.

[4] If the borrower pays discount points, this corresponds to the intermediary paying a negative rebate, $YSP(r^n) < 0$.

[5] See e.g. p.8 of http://www.urban.org/UploadedPDF/2000150-Housing-Finance-At-A-Glance.pdf.

To sell loans in the secondary market, the intermediary typically starts by putting together a pool of loans and then exchanges the pool with Fannie Mae for an MBS backed by those loans.[6] The intermediary pays a monthly premium called a guarantee fee (g-fee) and a one-time upfront fee called the "Loan-Level Price Adjustment" (LLPA) to Fannie Mae, in exchange for which Fannie Mae creates the security and ensures timely payment of principal and interest. After the swap with Fannie Mae, the intermediary holds a tradeable MBS that will pay cash flows to its holder based on the payments from the underlying mortgages. It can then sell the MBS to an investor (such as a pension fund or a central bank) in the secondary market.

The process of closing, packaging the loan into an MBS and delivering it to an investor takes several weeks but, fortunately for the intermediary, there is a highly liquid forward market, the so-called "To Be Announced" or TBA market, for GSE MBS. More or less immediately after agreeing to terms, or "locking," the loan with the borrower, the intermediary can sell the loan forward in the TBA market. We define

$$p^n_{TBA}$$

to be the price of a loan in the TBA market (per \$100 principal) net of anticipated payments to Fannie Mae associated with the sale, securitization and insurance of the loan. Since we study the market for intermediation, and not the market for mortgages *per se*, we take p^n_{TBA} as exogenously given.

We then define the market price of intermediation ϕ^n of a loan with note rate r^n as:

$$\phi^n \equiv p^n_{TBA} - p^n_{YSP} \tag{1}$$

Our empirical analysis will investigate how the price of intermediation changes over time, and how it is affected by the level of demand. To get some intuition, consider a profit-maximizing and, for simplicity, price-taking intermediary who originates mortgages. We assume that they make q^n loans of note rate r^n:

$$\max_{q_n} \ \phi^n \cdot q^n - C(q^n)$$

where $C(\cdot)$ includes the costs to the intermediary of underwriting, originating and servicing loans (as discussed in the next subsection) and delivering the resulting MBS to an investor.

[6] It is also possible to sell individual loans to a GSE directly through their "Cash Window." The GSEs pool these loans themselves, and then market the issued MBS.

Trivially, the first-order condition is

$$C'(q^n) = \phi^n \tag{2}$$

Equation (2) implies the usual condition that price equals marginal cost which would, in a perfectly competitive market with free entry, imply zero economic profit in equilibrium. It is important to stress that this does not mean that we should not observe profits in the mortgage market or that an increase in demand for intermediation will not increase returns for intermediaries. In particular, marginal cost includes payments to all factors of production. If we think of intermediaries as owning capital, either physical like computer systems or non-physical like human or reputation capital, then an increase in demand for intermediation will lead to increases in profits for intermediaries as measured by accountants.

Figure 1 graphically shows the equilibrium in the market for intermediation. In the standard supply-and-demand representation of a market, the quantity q on the x-axis is the number of mortgages originated and the price ϕ on the y-axis is the price of intermediation. If we assume increasing marginal costs, equation (2) implies that supply is upward sloping in q. Looking at the demand side, households demand fewer mortgages as ϕ goes up. To see why, note that holding p^n_{TBA} constant, any increase in ϕ reduces the rebate paid to the borrower for a given note rate r^n.

One goal of this paper is to understand how changes in the secondary market price translate into the the primary market. Figure 1 shows that the effect of a change in p_{TBA} on ϕ and q depends on the shape of the supply curve, which in turn depends on intermediaries' marginal costs. As depicted in the top panel, if the marginal cost of originating mortgages is increasing, then an increase in p_{TBA} will lead to an increase in ϕ, and thus passthrough to primary market prices (p_{YSP}) will be incomplete. As shown in the bottom panel, if instead the marginal cost is constant, the supply curve is flat and changes in TBA prices will completely pass through to YSPs (ϕ remains constant). Also, the loan quantity response to a change in TBA prices is larger in that case. Of course one can imagine intermediate cases, such as kinked supply curve that is flat up to some "normal capacity" level and then starts to slope upwards. Then, passthrough would be complete at relatively low levels of q, but diminish once q is to the right of the kink.

Our discussion here has for simplicity considered a single note rate. In reality, intermediaries typically offer loans with many different note rates, $n = 1, ..., N$, which in turn differ in their secondary and primary market values. Then, the first-order condition (2) will hold for all n. If the marginal costs of producing different note rates are equal, this would in turn imply that ϕ^n should be the same for all n.

Also, we emphasize that ϕ is not equivalent to the origination-related transaction costs and fees the borrower has to pay. In particular, as we will discuss below, a borrower typically works with a loan officer or broker that either gets paid out of the YSP or requires a separate payment. Also, there are additional fees, for instance for an appraisal or title search, that are outside the transaction that we focus on.

2.2 The Intermediary Cost Function $C(q^n)$

What are the costs to the intermediary? The intermediary plays two functions in the life of the loan, underwriting/originating the loan, and then servicing the loan once it has been made.[7] We discuss each in turn.

The first component of origination costs are the direct costs associated with the process of underwriting the loan. An intermediary must employ loan officers to work with borrowers, underwriters to review loan applications, a compliance department to make sure that the loan officers and underwriters are fulfilling their legal and contractual obligations, and so on. Additional costs include rent, information technology expenses, advertising and other administrative costs.

The second component of origination costs involve various forms of risk management. In particular, mortgage originators actively engage in "pipeline hedging," meaning that they hedge financial risks between the time a borrower "locks" a rate/YSP combination and the time the loan closes and is delivered to an MBS investor, which typically takes somewhere between 30 and 90 days. The main risk is that the fraction of loans that are actually originated is lower than expected.[8] This tends to occur primarily when rates fall between the time of lock and origination, since many borrowers may either try to renegotiate or go to a different intermediary altogether. Such an outcome is costly for originators if they forward-sold the loan in the MBS market, since an inability to meet that commitment will require them to buy back part of their committed volume at a higher price (since rates fell).[9] To hedge this risk, originators typically either use "mortgage options" (options on TBA contracts) or swaptions. The cost of the hedge will be higher when the implied interest

[7]In practice, the entity servicing the loan is not always the same as the one that originated the loan. However, since the intermediary that originally owns the "mortgage servicing right" (MSR) gets compensated when transferring it (there is a relatively active market in which MSRs are traded), this does not affect our discussion.

[8]There is also the risk that a higher-than-expected fraction of loans end up being originated. In expectation, a positive fraction of loans "fall out" due to idiosyncratic events, such as the property appraisal not coming in sufficiently high or the borrower being unable to produce required documentation.

[9]This risk could be avoided by not selling the loan forward until it has been originated. However, this creates an alternative risk, namely that prices in the MBS market move between the time of the rate lock and the time of the sale. This risk, like the risk of fallout, is primarily due to interest rate movements.

rate volatility is higher, and in our empirical analysis we will proxy for this with an index of implied Treasury option volatility.

Another risk management cost is due to the possibility that the intermediary will be forced to buy back a loan that the guaranteeing agency determines to be in violation of its underwriting guidelines. The volume of such "putbacks" became very large for the loan vintages that performed worst during the crisis. However, for new loans, it can be mitigated through careful underwriting. Also related in part to putback risk, there is a cost of capital, since intermediaries that want to sell loans to the guaranteeing agencies are required to maintain a certain net worth (as a cushion against future liabilities).

In addition to underwriting the loan, the second main task of the intermediary is to service the loan, which consists of collecting payments from the borrowers after the loan is made, and in case the borrower becomes delinquent, working out a loss mitigation strategy and/or initiate foreclosure. Servicing generates costs but can also generate income. Servicers receive "float income" (coming from a delay between when payments are received from borrowers and when they are passed on to investors). In addition, the servicer also gains an opportunity to cross-sell financial products and has the inside track to refinance the loan.

Formally, we can decompose the cost of intermediation into one-time origination costs, C_o, and per-period servicing costs, C_s. The present value (PV) of the costs of intermediation is then:

$$C(q^n) = C_o(q^n) + PV(C_s(q^n)). \tag{3}$$

In addition to the timing, there is also a fundamental difference in the aggregate cost function for underwriting versus servicing. As we discuss in detail later, the demand for underwriting fluctuates enormously. A drop in interest rates can lead to massive waves of new loan applications which can tax the limited resources of the industry. A similar problem does not occur with servicing since refinancing typically has no effect on the aggregate number of loans being serviced. As a result, we would expect C_o' to be upward sloping but we would not expect C_s' to be. Thus, if we assume that the per-period cost of servicing a loan is a constant c_s, we can then write the marginal cost of producing and servicing a loan as[10]

$$C'(q^n) = C_o'(q^n) + PV(c_s). \tag{4}$$

[10]Note that c_s can change across loans originated at different times, as our empirical analysis will suggest that it has. The assumption here is only that the marginal cost is independent of the quantity of originations at a given time.

2.2.1 The Valuation of Servicing

One important institutional detail in GSE MBS is how the servicer gets compensated. For as long as a loan is open, a servicer receives a monthly payment equal to 25 basis points (annual) of the mortgage amount. This payment is taken out of the borrower's monthly payment (and is thus part of the note rate). As discussed above, the servicer additionally receives other income (or potential benefits), but also incurs costs. Our baseline calculation of ϕ does not separately measure these additional costs/benefits to the servicer, and simply values the 25 basis points of servicing based on the value of the cash flow in the MBS market. We can write (using the superscript "$n - 0.25$" to mean a note rate of $r^n - 0.25$):

$$\begin{aligned}
\phi^n &\equiv p^n_{TBA} - p^n_{YSP} \\
&= p^{n-0.25}_{TBA} + (p^n_{TBA} - p^{n-0.25}_{TBA}) - p^n_{YSP} \\
&= p^{n-0.25}_{TBA} + 0.25 \cdot \frac{p^n_{TBA} - p^{n-0.25}_{TBA}}{0.25} - p^n_{YSP} \\
&= p^{n-0.25}_{TBA} + 0.25 \cdot mult^n_{MBS} - p^n_{YSP} \qquad (5)
\end{aligned}$$

where $mult^n_{MBS}$ is a valuation multiple that transforms an interest rate strip (here, worth 25 basis points) into a present value.

In the case above, this valuation multiple is based on MBS prices for different note rates. However, in our empirical analysis, we will also make use of an alternative multiple to value base servicing, provided by a firm called MIAC (Mortgage Industry Advisory Corporation) that specializes in the valuation of and market-making for mortgage servicing rights. These multiples will lead to an alternative measure of intermediary margins, π^n:

$$\pi^n = p^{n-0.25}_{TBA} + 0.25 \cdot mult^n_{MIAC} - p^n_{YSP} \qquad (6)$$

π is different from ϕ in that it incorporates the additional benefits from servicing, but also the per-period costs. Thus, based on equations (2) and (4) we should have that ϕ equals $C'_o(q^n) + PV(c_s)$ (where c_s is the net per-period cost of servicing) while π equals $C'_o(q^n)$ (the origination costs and profits).[11] The difference between the ϕ and π is thus equal to the present value of the net cost of servicing.

[11] π is close to the measure of "originator profits and unmeasured costs" (or OPUC) of Fuster et al. (2013), with the difference that here we will not explicitly calculate the "best execution" MBS coupon, and that we do not include origination points in the calculation. On the other hand, our measurement below uses better quality and higher frequency data than Fuster et al. (2013).

3 Measurement

In this section, we describe our approach to calculating the components of the price of intermediation ϕ, defined in equation (1). First, we discuss how to measure p^n_{YSP}, including how we choose r^n, the note rate of the mortgage. We then turn to the question of how to measure p^n_{TBA}, the price of a given mortgage in the secondary market.

3.1 Measuring the Primary Market Price

Lenders publish daily rate sheets which are, essentially, a menu of combinations of note rates and associated yield spread premia (YSPs). The YSP is a payment made by the lender which is shared by the borrower and the loan officer; it can also be negative, meaning the borrower has to "pay points." Figure 2 shows an example of a rate sheet. The upper left panel shows that if the borrower commits to close a 30-year fixed-rate mortgage within 30 days with a note rate of 4.625%, the lender will pay the borrower 70 cents per hundred dollars of principal. If instead the borrower chooses a 4.25% rate, she will have to pay the lender 130 cents. The rest of the rate sheet covers other products (like adjustable-rate mortgages) and "adjustments" which are changes in the YSP to reflect the fact that, for example, the property is a condominium or the borrower has a low credit score.

Some background on the structure of the mortgage market helps here. Following industry convention, we refer to the individual who works directly with the borrower as a *loan officer* or LO. The party we called "intermediary" in our discussion above, i.e. the entity that provides the funds to the borrower and then sells the loan in the secondary market, is (somewhat confusingly) referred to as the *investor.* The main breakdown of the market is between retail or single-investor LOs and wholesale or multi-investor LOs. Multi-investor LOs can be further broken down into correspondent LOs who underwrite and fund the loan before selling it to the investor and broker LOs who link the borrower to the investor who then underwrites and funds the loan.[12]

Our rate sheet data come from a company called Optimal Blue (formerly known as LoanSifter) which provides data on rates and YSPs to multi-investor LOs. Optimal Blue either digitizes rate sheets like the one in Figure 2 or accesses investor websites to create an online database of rates and YSPs. Optimal Blue then provides LOs with a search engine that allows the LO to enter the characteristics of the loan such as the loan-to-value (LTV) ratio, FICO, and loan amount. Importantly, the offers in Optimal Blue are essentially

[12]The use of multi-investor LOs has fluctuated over time, falling from a peak of over 60 percent in 2006 to 40 percent in 2014. See "Mortgage Brokers See Slight Gain in Market Share During 4Q14; Retail Lost Some Ground in 2014," *Inside Mortgage Finance*, February 27, 2015.

binding on the investor. If the borrower selects an offer and the LO delivers a loan with the specified characteristics, the investor has an obligation to fund it at the chosen rate/YSP combination (assuming the borrower fulfills the underwriting guidelines). Investors typically issue the first rate sheet of the day around 10am and then frequently revise it over the course of the day.[13] Our data only includes a single snapshot taken at the end of the day, meaning we have the last rate sheet issued on any given day.

Each LO has access to a subset of lenders with which the LO has an agreement, and offers for an identical loan may differ across loan officers for a given lender. We obtain offers either for a generic LO that was set up specifically for us (for data from October 2008 - September 2009) or for five different representative loan officers (since September 2009).[14,15]Further information about the Optimal Blue dataset can be found in Table 1. The number of lenders over which Optimal Blue searches fluctuates in our sample. Part of this reflects the entry and exit of lenders from the multi-investor market; for example, Bank of America exited in 2011.[16] In addition, since our searches since 2009 are based on the profiles of actual loan officers, any change in the set of investors with whom a specific loan officer has a relationship may lead to a change in the number of offers in our sample. We do not know the identities of individual lenders, but know that essentially all the largest lenders are in the Optimal Blue data.[17]

Our baseline scenario involves a fixed-rate mortgage on an owner-occupied property located in Los Angeles, CA, a borrower with a FICO of 750, a term of 30 years, a loan amount of $300,000, a loan-to-value ratio of 80, no prepayment penalty and a 30-day lock period. We consider alternative scenarios as well.

3.1.1 Tracking a mortgage note rate over time

In principle, we could choose a single note rate and follow that note rate over our entire sample period. Unfortunately, in reality, the set of quoted note rates at a point in time is quite narrow and changes often as interest rates evolve, since there is no market for loans with either very high or very low YSPs (high YSPs are unattractive to lenders due to the prepayment option; low YSPs are unattractive to borrowers because they require high upfront payments). As shown in Table 1, our data from Optimal Blue is consistent with

[13] Investors generally adjust their rate sheets on at least a daily level. Of the 35.4k rate sheets captured in our sample, only 2.3k (about 6.5%) show no change from the previous day.

[14] For the period since September 2009, we average a given lender's offers across the LOs the lender has a relationship with.

[15] Over the entire sample period of more than six years, there are 49 days missing, either due to missing backups/queries or due to obviously inconsistent data.

[16] "BofA to exit correspondent mortgage business," Reuters, Aug 31, 2011.

[17] We do have numeric identifiers for individual lenders, but do not make use of those in our analysis.

these facts – the mean points across ratesheets for our entire sample is approximately 101, with a within-day standard deviation of 1.8. The within-day range of rates offered is also reasonably narrow and is typically contained within a range of two percentage points.

To address the problem of time-varying sets of note rates, we derive a constant-YSP note rate, which we argue provides a reasonable index of mortgage rates for our analysis. Our main analysis uses "Rate101", the note rate that yields a YSP of +1 (or $p_{YSP} = 101$), which is anecdotally a typical YSP that borrowers choose. We construct Rate101 for each rate sheet by interpolating between different offers and then use the daily median value across our sample of rate sheets as our baseline.[18]

The top panel of Figure 3 shows the evolution of Rate101 over our sample. Rate101 started above 6 percent in 2008, prior to the monetary policy actions that started in late November of that year, and reached its low point near the end of 2012 at close to 3 percent. The bottom panel shows how Rate101 compares to two alternative choices, Rate100 (for a YSP of 0) and Rate102 (for a YSP of +2), and also to the widely-quoted Freddie Mac Primary Mortgage Market Survey rate. The figure shows that over 2010-2014, the rate change per 1 point in YSP was quite stable around 20 basis points, and that the Freddie Mac rate was on average quite close to our Rate101 (thereby validating our choice of +1 as a "typical" YSP). Earlier in our sample, however, the effect on the note rate of a change in YSP was much larger: at times, a borrower could get a 100 basis point lower mortgage rate by accepting a 1-point lower rebate.[19] This in turn made it attractive to borrowers to get relatively lower YSPs (i.e. 0 instead of +1); this is reflected in the Freddie Mac survey rate, which is closer to Rate100 over this early period.

Rate101 changes from one day to the next, but to study daily passthrough we will want to hold the note rate constant over time. Thus, we introduce the notation

$$p_{YSP}^{Rate101,t}(s),$$

which means the time-s primary market price of a loan with a note rate of time-t Rate101. By definition, $p_{YSP}^{Rate101,t}(t) = 101$. We define $p_{TBA}^{Rate101,t}(s)$ similarly.

[18]The interpolation is required because, as Figure 2 shows, YSPs are quoted in decimals but note rates are generally quoted in 1/8 of a percentage point. In this example (for the 30-day lock), we would linearly interpolate between 4.625 and 4.750 to produce a precise rate that corresponds to a YSP of 1 (in this case 4.641).

[19]This was due to a narrowing of MBS price differences across coupons, as also discussed in Fuster and Willen (2010).

3.2 Measuring the Value of a Mortgage in the Secondary Market

The main secondary market for mortgages is called the To-Be-Announced or TBA market. The TBA market is a forward market for mortgage-backed securities (MBS) guaranteed by Fannie Mae, Freddie Mac and Ginnie Mae, and is one of the largest fixed income markets in the world (Vickery and Wright, 2013). In this market, buyers promise to buy a pool of mortgages meeting certain specified characteristics at a specific date in the future. The majority of newly produced agency MBS pools are traded in this market.[20] Agency MBS are typically only traded in coupon increments of 50 basis points (e.g. 3.5%, 4%, etc.)

As already mentioned earlier, the guaranteeing agency, in our case Fannie Mae, charges an ongoing insurance premium or guarantee fee ("g-fee") as well as an upfront premium depending on loan characteristics, known as "loan level price adjustment" (LLPA). The exact values of g-fees are not disclosed, but we know that they vary over our sample. Up to 2008, the typical g-fee was roughly 22 bps, meaning that Fannie charged an annualized fee of 0.22 percent of the unpaid principal balance of a loan every month.[21] In 2012, two 10 basis point increases were announced, on January 1 (to 32 bps) and on September 1 (to 42 bps). Through the rest of our sample period, the ongoing g-fee is still assumed to be at 42 bps. The upfront LLPA for the base-case loan characteristics only changes once over our sample period, from 25 bps prior to December 23, 2010 to 50 bps.[22]

In our baseline calculation for ϕ, we assume that the value of a mortgage with note rate $Rate101$ in the secondary market is simply given by the interpolated TBA market price of an MBS with coupon $Rate101 - gfee$, and subtracting the upfront LLPA. For instance, if $Rate101 = 4.56$, $gfee = 0.32$, and $LLPA = 0.25$, then our the secondary market value equals:

$$p_{TBA}^{Rate101}(s) = p_{TBA}^{4}(s) + (24/50) * (p_{TBA}^{4.5}(s) - p_{TBA}^{4}(s)) - 0.25,$$

that is, we interpolate between the prices of the 4 and 4.5% coupons. Our calculation above implicitly presumes that a loan always gets securitized in a coupon below $Rate101 - gfee$, whereas in reality originators have the option to securitize a loan in any coupon rate at or below $Rate101 - 0.25$. Fuster et al. (2013) provide a detailed discussion of the decision into which coupon to pool; what is important for us here is that the differences across these

[20]The remainder are pools that either don't meet the criteria for the TBA market or are so-called "spec pools," groups of loans with certain characteristics that are desirable to investors (for example, an investor might want low credit score loans because of their more attractive prepayment properties.)

[21]The value of 22 bps is obtained from Fannie Mae 10Ks; we take an average of the average guarantee fee over 2005-2008.

[22]This value includes the 25 bps "adverse market delivery charge" that the GSEs started charging in March 2008; see the announcement at https://www.fanniemae.com/content/announcement/0721.pdf. Fannie Mae's current LLPA matrix is available at https://www.fanniemae.com/content/pricing/llpa-matrix.pdf.

options are typically small.[23]

3.3 Data Sources

The MBS price data is from J.P. Morgan and, for simplicity, we assume that all loans are sold to Fannie Mae. For our baseline analysis, we normalize all prices to be 45-days-to-settlement using a weighted combination of the 1-, 2-, and 3- months-out contracts.[24] This is the relevant metric if the time between rate lock (prior to loan origination) and delivery in an MBS trade is 45 days, which is close to the approximate average lag from application to origination in the HMDA data. Different normalizations do not materially affect our results since the gaps between the prices are generally stable.

To measure time-series variation in demand, we use new loan applications from the confidential Home Mortgage Disclosure Act (HMDA) dataset. The HMDA dataset captures a large share (roughly 90%) of mortgage applications and originations. The confidential version of the data contains exact application and action (i.e. accept or reject) dates, which allows us to count applications on a daily level. We include all first-lien, single-family loans in our measure, including applications for refinancing and purchase loans. The available data covers 2008 through October 2014.[25] In our lower-frequency analysis in Section 6, we use total monthly originations, normalized by the number of business days in a given month.[26]

We also use the HMDA data to measure lender concentration, by calculating the market share of the top four lenders (following Scharfstein and Sunderam, 2013) at a monthly frequency. This measure is specific to the MSA in question, which is Los Angeles in our baseline case.

As a measure of labor costs, we use real estate credit payrolls, divided by real estate credit employment. Both series are from the Bureau of Labor Statistics and available at a monthly frequency. To measure the volatility of interest rates, which may affect originators' hedging costs, we use the monthly average Merrill Lynch Option Volatility Expectations

[23] We choose to ignore the pooling decision because it would require us to make assumptions about "buy down" multiples set by Fannie Mae that are not publicly disclosed.

[24] These contracts are sometimes referred to, respectively, as "front", "back", and "back2". The following illustrates our weighting: on "notification day" in the TBA market, the front-month time-to-notification is 0 days, the back month is approximately 30 days, and the 3-month-out ("back2") is approximately 60 days. In this case we use $1/2 * p_{back} + 1/2 * p_{back2}$. The following day, the front-month time-to-notification is approximately 30 days, back is 60 days, and back2 is 90 days. In this case we use $1/2 * p_{front} + 1/2 * p_{back}$. This methodology ensures that there are no spurious jumps in MBS prices on the monthly notification days.

[25] To be included in the HMDA data for a given year, an application needs to be processed within that year. Applications submitted towards the end of year t are thus frequently included in the HMDA file for year $t + 1$ only. Since we do not have the 2015 HMDA data yet, including October-December 2014 would lead us to understate application volumes for these months.

[26] Our results do not change significantly if we use the Mortgage Bankers Association's (MBA) Weekly Application Survey, which is widely used but has less granular detail and lower coverage.

(MOVE) index, an index of the normalized implied volatility on 1-month Treasury options, weighted on the 2, 5, 10, and 30 year contracts.

Finally, as discussed in Section 2.2.1, for our alternative measure of intermediary margins π we use base servicing valuation multiples provided to us by the Mortgage Industry Advisory Corporation (MIAC). We have monthly data from the start of our data in October 2008 until September 2014; we assume that the value in October 2014 is the same as September 2014. For the valuation of the remaining interest strip (after g-fee and base servicing are deducted from the coupon), we interpolate between the TBA prices of the surrounding coupons, as we do in our baseline calculation.

4 Event Studies: QE Announcements

In this section, we use the concepts derived above to explore the effect of announcements about the Federal Reserve's large-scale asset purchase program (and one other unconventional monetary policy measure, date-based forward guidance) over the period 2008 to 2013. We do this first because the results are of inherent interest: an explicit purpose of asset purchases (or quantitative easing, QE) was to drive down the cost of mortgage credit for consumers. But, more broadly, the monetary policy announcements provide a sort of laboratory to understand the transmission of shocks in the secondary mortgage market to primary market. The six events we focus on are:

1. **"QE1"**: November 25, 2008. Announcement that Fed would purchase up to $600B in agency MBS and agency debt.

2. **QE1 Expansion**: March 18, 2009. FOMC announced the program would be expanded: purchases of agency MBS and agency debt increased by $750B; purchases of Treasury securities increased by $300B.

3. **Forward Guidance**: August 9, 2011. FOMC changed statement language to "exceptionally low levels for the federal funds rate at least through mid-2013," from "exceptionally low levels for the federal funds rate for an extended period."

4. **"QE3"**: September 13, 2012. Open-ended commitment to purchase $40B agency MBS per month until labor market improved "substantially."

5. **Taper Tantrum**: June 19, 2013. Then-Fed Chairman Bernanke's press conference: "If the incoming data are broadly consistent with this forecast, the committee currently anticipates that it would be appropriate to moderate the monthly pace of purchases later this year."

6. **Non Taper**: September 18, 2013. Contrary to market expectations, FOMC opts *not* to start reducing MBS purchases.

Our choice of events is, by its nature, somewhat arbitrary but our goal was to find news that surprised markets and led to significant shifts in the bond market, as all of these did.[27] As an example of a date that did *not* meet our criteria, the announcement of "QE2" on November 3, 2010 had little effect on bond markets because anticipation of QE2 had led to a substantial rally over the previous three months. The Taper Tantrum is the only event with an MBS price decrease among the six events that we study.

Figure 4 shows the evolution of key variables for each event. We start our discussion with the announcement of QE3 in September 2012 (the bottom left panel). On September 12, 2012, Rate101, the median note rate on a mortgage with a one percent rebate, was 3.375 percent. We calculate that p_{TBA}, the secondary market price, of the Rate101 loan on September 12 was 102.7 meaning that after funding the loan and paying the 1 percent rebate, the intermediary margin was 1.7 dollars per hundred dollars of principal. The announcement of QE3 the following day led to an increase in p_{TBA} to 103.8. Had intermediaries kept rebates the same, the margin on the loan with a note rate of 3.375 would have gone up to 2.8 dollars per hundred dollars of principal. However, we calculate that the rebate on that loan also went up after the announcement, from 1 percent to 1.6 percent. Overall, the secondary market price p_{TBA} went up by 1.1 percent and the primary market prices p_{YSP} went up by 0.6 percent meaning that about 55 percent of the price increase was passed through to borrowers. The bottom left panel of Figure 4 shows that p_{TBA} drifted down over the next few days but p_{YSP} stayed more or less the same so effective passthrough was somewhat higher at longer horizons.

Looking across the six events now, several features of the data are worth noting.[28] First, the high frequency relationship between p_{TBA} and p_{YSP} is quite close. Almost everywhere, increases in the secondary market price lead to increases in the primary market price. This occurs even when the changes in prices are very small. It is important to stress that there is nothing mechanical about this relationship in the data as the two time series come from completely different data sources: p_{TBA} is generated from data from global financial markets and p_{YSP} comes from offers to loan officers working with individual borrowers.

The second notable feature of Figure 4 is that passthrough appears to vary significantly across the different events. Borrowers received less than 50 percent of the effects of the QE1

[27] To enter our sample, the date had to be among either the 25 days in our sample with the biggest increases or among the 25 days with the biggest decreases in the yield on the current coupon MBS (from J.P. Morgan) *and* coincide with a major announcement regarding Federal Reserve policy.

[28] For the first two events, we use Rate100 instead of Rate101 because Rate100 was more representative of the note rates borrowers were choosing at that time (see earlier discussion of Figure 3).

Expansion announcement in March 2009 and, at some horizons, much less. In contrast, the effects of the initial announcement of QE in November 2008, the Taper Tantrum in June 2013 and the Non-Taper in September 2013 were passed on to borrowers almost entirely. What can explain these differences? In Section 2.1 above, we argued that the degree of passthrough depends on the shape of the supply curve. Recall that an increase in prices in the secondary market, all else equal, leads to an increase in the demand for intermediation and that a higher slope of the cost curve implies lower passthrough, as depicted in Figure 1. To explore this effect, we add the daily volume of new loan applications to each figure. As noted already, passthrough was very high for the initial QE1 announcement but much lower for the QE1 Expansion four months later. Consistent with the idea that volume matters, we see a large difference in volume around the announcement. Indeed, at 37,000 applications per day, volume on November 24, 2008 was at a historically low level, so there was likely some capacity slack that allowed for passthrough of increased MBS prices to borrowers. In contrast, the day before the announcement of the QE1 Expansion, there were 63,000 applications and that number spiked to over 100,000 following the announcement; consistent with the idea of intermediaries facing convex costs in quantity, passthrough was lower. June and September of 2013 are also instructive. In the former case, bond prices fell dramatically and, not surprisingly, demand did not increase and passthrough was high. In September of 2013, bond prices rose but from a low level induced by the original taper tantrum, meaning that even after the increase, refinancing was not that appealing to borrowers.

A third feature of Figure 4 is that the price of intermediation ϕ appears to rise over time. If we compare the original announcement of QE with the Non-Taper, passthrough was higher in the latter, as already noted, but the gap between intermediaries' revenue (p_{TBA}) and what they pay the borrower for the loan (p_{YSP}) is much higher in the latter. This increase in ϕ could, according to the theory, result from higher volume, but the data appears to reject that — application volume in September 2013 was very similar to application volume before the QE1 announcement, but ϕ was much higher.

In the next two sections, we will consider questions raised here econometrically. How big is passthrough? Does volume systematically affect passthrough? Is passthrough higher for decreases in prices versus increases? Did the price of intermediation increase over time? What accounts for that increase?

5 High-Frequency Passthrough

The first question we are interested in is to what extent changes in MBS prices from one day to the next are reflected in YSPs offered on ratesheets. To investigate this, we regress the daily change in the YSP for a given rate on the change in the MBS market value of a mortgage with this note rate.

Specifically, we start with the Rate101 for date t. We calculate $p_{TBA}^{Rate101_t}(t)$ for that day, while $p_{YSP}^{Rate101_t}(t) = 101$ by definition. We then move one day forward and calculate $p_{TBA}^{Rate101_t}(t+1)$ and $p_{YSP}^{Rate101_t}(t+1)$ which no longer necessarily equals 101. To illustrate, consider the following example:

		3/31/2010	4/01/2010	
Primary	$Rate101_{3/31/2010}$	5.11	5.11	
Market	$p_{YSP}^{Rate101_{3/31/2010}}$	101.00	100.69	$y_t = -0.31$
Secondary				
Market	$p_{TBA}^{Rate101_{3/31/2010}}$	101.97	101.66	$x_t = -0.33$

In this case, the passthrough is almost complete (0.31/0.33, or 93.9%).

The top panel of Figure 5 shows a scatter plot of daily changes in the primary market value of a Rate101 loan against the change in its secondary market value. From the figure, it is clear that there is a very strong relationship between price changes in the primary and secondary market, though the passthrough appears slightly stronger for negative changes than positive changes.

Table 2 shows the results from simple linear regressions to quantify the amount of passthrough. In column (1), we see that the average passthrough coefficient is 0.92, and that 88% of the variation in YSP changes is explained by variation in MBS price changes. We find that the passthrough of price decreases appears to be stronger than the passthrough of price increases (column (2)). Notably, the asymmetry of passthrough is statistically and economically significant, with price decreases being passed through approximately 100% within this one-day window. Price increases, in contrast, are only passed through about 80% on the first day.[29] In column (3), we add the price change from the previous day, and find that there is some additional passthrough of lagged positive (but not negative) changes, so that over two days, approximately 87% of MBS price increases are reflected in primary market YSPs. (In untabulated results, we find that the effects for further lagged MBS price changes are statistically indistinguishable from zero.)

While the daily passthrough is very strong on average, in the remaining two columns we explore a potential driver of time variation in this passthrough, namely the level of demand

[29] Figure 5 suggests potential non-linearity in the relation between secondary and primary price changes. In untabulated regressions, we find that adding quadratic MBS price changes results in a significant negative (but relatively small) coefficient for price declines, and an insignificant positive coefficient for price increases. None of the other results in this section are qualitatively altered by adding squared price changes to the regressions.

following the discussion in Section 2. Specifically, we interact the changes in the MBS value with the standardized level of new applications from HMDA, so that the coefficient on the interaction term corresponds to the effect on daily passthrough of a one-standard deviation increase in (one-day-lagged) application volume. Column (4) shows that indeed, a higher level of applications lowers the passthrough of MBS price increases to YSPs. For instance, the coefficients imply that if applications are two standard deviations above average, only 66% ($= 0.791 - 2 * 0.064$) of a price increase are passed through. The final column shows that this interaction effect remains unchanged if we add the lagged price change as well.

The bottom panel of Figure 5 graphically illustrates how differences in application volume at a lower frequency are related to variation over time in the passthrough coefficients. It plots the coefficients from regression (2) from Table 2, but estimated separately year-by-year (except that we pool the 2.5 months of data from 2008 with 2009). The figure shows that for MBS price increases, the estimated passthrough was lowest in 2012, when applications were at their highest levels. Passthrough then increased over the following two years, as application volumes dropped; in 2014, the year with the lowest mortgage demand in our sample, passthrough of positive price changes exceeds 0.9. The passthrough of price decreases (the upper line) is fairly stable and close to 1, except in 2013 when it goes up to 1.1.

The take-away from these regressions is that at high frequencies, primary market prices strongly respond to the secondary market. In a sense, this should not be surprising given that lenders issue new rate sheets every day and sometimes more than once a day. But it is in contrast with findings of infrequent adjustments in other consumer finance markets, where rates offered to consumers only react slowly to changes in monetary policy and market rates (e.g. Driscoll and Judson, 2013).

Although these high-frequency regressions suggest a direct and strong link from MBS prices to the primary market, the result that increases in price result in incomplete passthrough leaves open the possibility of lower frequency movements in the price of intermediation, which we turn to next.

6 Evolution of the Price of Intermediation Over Time

Figure 6 shows the evolution of our baseline estimate of the price of intermediation at the daily frequency. This cost is calculated as the secondary market value of the Rate101 loan $p_{TBA}^{Rate101}$ (net of payments to Fannie Mae) less the primary market value $p_{YSP}^{Rate101}$ which is, by definition, 101:

$$\phi(t) = p_{TBA}^{Rate101,t}(t) - p_{YSP}^{Rate101,t}(t) = p_{TBA}^{Rate101,t}(t) - 101 \tag{7}$$

We estimate that over the whole sample, the price of intermediation averaged 142 basis points. The standard deviation was large (61 basis points), as evidenced by the fact that our estimated values range from 0 to 300 basis points.

As explained earlier, we also calculate an alternative measure of intermediation margins π, where the 25 basis points of servicing cash flow are valued using a separate multiplier (from MIAC) that takes into account other costs/benefits of servicing (while our calculation of ϕ implicitly values the servicing as if it was just a 25 bp interest strip).

Figure 6 shows that the time series of π displays a somewhat less pronounced upward trend than ϕ. There are two main reasons for this: first, MIAC servicing multiples did not fall in early 2009, unlike the market-implied value of a 25 bp interest strip. Second, toward the end of the sample, servicing multiples fell relative to MBS-price-implied valuations. Following our discussion in Section 2.2.1, this implies that the present value of net servicing costs increased over our sample period, something we will come back to later.

6.1 Determinants of Variation in the Price of Intermediation

We now turn to potential drivers of the variation in the price of intermediation. Figure 6 plots four key variables that proxy for either the costs of intermediaries or their ability to earn excess profits:

1. New application counts from the confidential HMDA data;
2. Interest rate volatility as measured by the Merrill Lynch MOVE index;
3. The payroll per employee in real estate credit, from the BLS;
4. Market concentration, as measured by the market share of the top 4 lenders in the Los Angeles MSA in the HMDA data.

Applications proxy for potentially increasing marginal costs, or increased pricing power due to limited origination capacity, as discussed earlier. Indeed, we observe a strong positive correlation between ϕ and application volume. Higher interest rate volatility increases the cost of hedging the origination pipeline, so we would expect it to correlate positively with ϕ. However, the chart shows that the main variation in rate volatility was due to a decrease following the height of the crisis; since then, the MOVE has remained relatively flat and does not seem to be a main driver of the evolution of ϕ. Employee payroll is likewise an important component of origination costs, and indeed has seen an upward trend over this period, consistent with the increase in ϕ. Finally, market concentration has decreased over this time, suggesting that, at least when measured based on market shares in the HMDA data, changes in concentration cannot explain the rise in ϕ.

To analyze this more formally, we regress ϕ or π on these variables, at the monthly frequency, both in levels (Table 3) and changes (Table 4). In the levels regressions, we also add a linear time trend, to test whether there appears to be an increase in the price of intermediation that is not accounted for by our explanatory variables. All explanatory variables are normalized to have a mean of zero and a standard deviation of one.

Table 3 shows that in levels, an increase in new application volume is strongly positively associated with higher costs, whether these are measured as ϕ or π and whether or not other explanatory variables are included. In fact, adding the linear time trend substantially increases the coefficient on applications in column (2), and the time trend and applications jointly explain 85 percent of the variation in ϕ (while the time trend alone would explain 52 percent). The tight fit is illustrated by the chart below the table. In terms of magnitude of the effect, a one-standard deviation increase in applications is associated with a 36 basis point increase in ϕ. The corresponding coefficients when using π as dependent variable are even slightly larger. Table 4 confirms these findings when running the regression in monthly changes; the coefficients decline slightly relative to the version in levels but the explanatory power of changes in applications for changes in ϕ or π remains high.

Interest rate volatility is negatively associated with ϕ but positively with π. The latter finding is consistent with originators increasing their margins when their costs increase; however, the estimated coefficients are smaller and not very precisely estimated when using monthly changes. Taken together, these results suggest that either hedging costs were not a major driver of time-variation in intermediation prices over this period, or that our proxy for them is too crude.

In levels, both ϕ and π are strongly positively related to our measure of payroll per employee in the real estate credit sector, which trended upward over the sample period. Thus, an increase in the labor cost involved in the origination process could be an important part of the upward trend in ϕ and π. (Once payroll is added to the regression, the time trend becomes statistically indistinguishable from zero for π; for ϕ it remains positive and significant though is only half as large as in specifications without payroll.) In monthly changes, payroll is not significantly related to ϕ or π, but month-to-month changes likely contain significant noise.

Finally, there is no evidence that changes in market concentration affected intermediation prices over this period—which is not surprising, given that concentration trended down over this time (so regressing ϕ or π on concentration alone actually yields a negative and significant coefficient).

Figure 7 shows that our measure of ϕ evolves similarly if we change the assumed note rate (to Rate100 or Rate102), the assumed FICO score (to 680 instead of 750), the MSA (New York instead of Los Angeles) or the loan size ($150,000 instead of $300,000). As a consequence, regressions with ϕ or π series based on these alternative assumptions yield results very similar to those shown in Tables 3 and 4. These findings provide "robustness checks" with respect to our assumptions on loan characteristics, but below we will also discuss what they mean for the interpretation of the results.

6.2 Additional Evidence and Interpretation

We view the strong positive correlation between ϕ and application volume documented above as highly suggestive of limited capacity in mortgage originations. To the extent that ϕ (or π) includes profits (or high rents for the factors of production), why does capacity not expand so that profits get competed away? Lenders may be reluctant to add additional capacity if they think the increase in volume is relatively short-lived, as is often the case with refinancing booms. Furthermore, new entry into the mortgage intermediation business is far from costless; for instance, an intermediary has to fulfill a number of requirements (such as a minimum net worth) to be able to securitize mortgages through the GSEs.

To further support our interpretation, we present evidence based on processing times of mortgage applications according to the HMDA data. The second panel in Figure 6 shows, at the monthly frequency, the number of new mortgage applications plotted against the median processing time of applications submitted in that month (i.e. the number of days between the application date and the "action" date, when either the loan closes, or the application is denied or withdrawn).

The figure shows that when the number of new mortgage applications increases, it takes longer to process additional applications. The correlation between the two series in levels is 0.38; in changes it is 0.64. The variation in processing times can be substantial: for instance, it jumps from below 25 days to about 40 days following the November 2008 Fed announcement. This evidence suggests that indeed, the capacity of mortgage originators to process applications is limited. A regression analysis, shown in Table 5, confirms the significance of this relation: a one-standard deviation increase in monthly applications is associated with about a 3-day increase in processing time. It also shows that conditional on application volume, there was a significant upward trend in processing time over this time period.[30] This is consistent with evidence from industry surveys that indicates that the labor

[30] Calendar months are also important in explaining variation in processing time; in particular, processing times (for given application volume) tend to increase in December. The last column in the table shows that once we add indicators for December and January to the regression in changes, the adjusted R^2 increases

intensity of underwriting has increased substantially since 2008.[31]

This leads to the question of how to interpret the positive time trend in ϕ. An important component of this trend comes from the relative decrease in the effective value of servicing rights based on the MIAC multiples relative to their MBS-price-implied value—which is what is driving the difference between ϕ and π. In other words, net servicing costs seem to have increased over 2008-2014. This is consistent with evidence on an increase in the direct costs of servicing over this period (see for instance Figure 1 in Goodman 2016) and also the increased regulatory cost of holding mortgage servicing rights for banks under Basel III (see Hendricks et al. 2016 for a thorough discussion).

But even after accounting for the effect of servicing valuations, there remains a positive time trend in π as long as we do not control for payroll (see columns (7) and (8) of Table 3). This could be due to the increased labor intensity of underwriting noted above, or the need for more qualified people doing it—an explanation consistent with the positive correlation with payroll (though an alternative interpretation could be that employees in the real estate credit sector simply earn higher rents when the profitability of originations increases).

There are a number of potential explanations that seem less consistent with our evidence. One such explanation is that the time variation and/or the positive trend in ϕ is due to changes in the expected life span of the originated loans. If there is a constant per-period cost of an open loan (e.g. due to the liability/putback risk, discussed below), variation in the expected life span would translate into differences in ϕ (as originators want to be compensated upfront if expected lifetime costs increase).

It is difficult to obtain a good measure of the expected time a new loan will remain open, but we can use two proxies obtained from the J.P. Morgan MBS model (consisting of a prepayment model and an interest rate model). One is the "Weighted Average Life" (WAL), which is the expected average time until the mortgage principal is repaid (either by scheduled amortization or by unscheduled prepayments). This is calculated under a single assumed mortgage rate path, which is a shortcoming because the desired measure would take into account that rates vary in the future, which in turn affects prepayments. A measure that does take this into account is the "Option-Adjusted Duration" (OAD), which is the weighted average time until mortgage cash flows are received (both coupon payments and principal payments). This is again not a perfect measure for us, since we are not interested in the coupon payments for our purpose, but changes in OAD should be a good proxy for changes in expected lifespan of a new loan.

We obtain time series of WAL and OAD corresponding to Rate101 based on coupon-level

dramatically and the constant becomes significant (indicative of the positive time trend).

[31] See https://www.mba.org/Documents/Research/ChartoftheWeek%2007102015.pdf.

measures from J.P. Morgan.[32] These are plotted in Figure 8, against ϕ. The chart suggests two things: first, the spikes in the price of intermediation do not seem to be associated with spikes in the expected lifespan of new loans; if anything, the opposite relationship holds. Second, there is no upward trend in WAL or OAD since early 2010, while ϕ has drifted upward over that time.

Other evidence also does not point toward an important role for anticipated per-period costs (other than those already captured in the servicing valuation) in the increase in ϕ. One such cost is related to potential legal liabilities. In the wake of the crisis, the GSEs have aggressively enforced "representations and warranties," forcing many entities that had sold mortgages to them to buy back (mostly delinquent) mortgages where some flaw in the underwriting or documentation was found. This "putback risk" has commonly been cited as a reason behind the tighter lending standards in recent years, since lenders what to avoid this risk on new loans going forward.[33]

If increased expected putback costs were priced in directly by intermediaries, we would expect that ϕ would have increased more on some types of loans than others. In particular, this theory would suggest that riskier loans should have seen a larger increase in ϕ (since they are more likely to lead to a delinquency followed by a repurchase and a credit loss). Furthermore, loans with a longer expected life span should have seen a larger increase in ϕ, since they will remain a potential liability for longer. However, as shown in Figure 7, ϕ did not increase more for FICO 680 loans than for FICO 750 (if anything, the contrary), even though the former have higher delinquency risk. Also, there is no evidence that smaller loan sizes (150k vs. 300k), which are associated with slower prepayment speeds, command a higher ϕ for the same note rate. There is some divergence across ϕ for note rates Rate102 vs. Rate100 in 2012, with ϕ being higher for lower note rates (with longer expected life). But the difference remains relatively small compared to the overall increase in ϕ over the sample period, and reverts back to zero in 2013/early 2014. That said, it is plausible that the increased aversion to putbacks was a significant driver of the upward trend in origination costs (for instance due to the need for more qualified underwriting personnel, and more time spent on each loan, as discussed above).

Finally, as noted above, our measure of ϕ is almost unchanged if instead of Los Angeles,

[32]To do so, we take the note rate that J.P. Morgan assumes for each MBS coupon, and directly interpolate between these rates and corresponding WALs/OADs to where our Rate101 would be.

[33]For instance, the Federal Reserve's Senior Loan Officer Opinion Survey in April 2013 found that "Three-fourths of banks also cited the risk of putback of delinquent mortgages by the GSEs as an important factor restraining their current ability or willingness to approve home-purchase loans, and (...) a large fraction of banks reported an increase in the importance of this factor over the past year." See http://www.federalreserve.gov/boarddocs/snloansurvey/201305/default.htm. Goodman and Zhu (2013) provide additional discussion of putback patterns in recent years.

we use New York as the MSA in our rate sheet search. This is the case even though market concentration (as measured in HMDA) was somewhat higher in LA over 2008-2009 but then fell quite steeply and has been lower than in New York since 2012. This again means that we do not find evidence suggesting that market concentration (or changes therein) explains the pattern in intermediation costs that we document.[34] However, our findings are not necessarily inconsistent with those of Scharfstein and Sunderam (2013) — they simply mean that at least over the period since 2008, the effects of concentration did not occur at the level we study (i.e. intermediary rate sheets) but could instead occur through the split of the rebate between LO and borrower.

7 Economic Implications

In this section, we first clarify the relationship between our measure of the price of intermediation and a commonly used alternative measure, the spread between primary market rates and secondary market yields. We then explore the relevance of our calculations to households by using our estimates of the price of intermediation to measure how much households spent on intermediation during the period we study. This calculation has particular policy relevance since, as already discussed, the mortgage market was a key element in the transmission of monetary policy. We then do several counterfactual exercises to decompose household expenditures.

7.1 The Primary-Secondary Spread

Traditionally, market analysts have measured the price of intermediation by computing the difference between rates paid by borrowers and the yields on mortgage-backed securities. In contrast, we look at the difference between the price of a mortgage with a given note rate r^n in the secondary market and the funds provided to the borrower, including any rebate. To understand the difference between the two approaches, consider an intermediary similar to that in Section 2.1 that makes a loan with note rate r^n and pays the borrower p^n_{YSP}. However, rather than selling the loan directly, the intermediary raises p^n_{YSP} in the secondary market by issuing debt tied to the payments on the mortgage. Define y^n to be the implied

[34] Similarly, at the national level, concentration in mortgage lending has been decreasing over our sample period. According to data from Inside Mortgage Finance, the market share of the top 10 lenders in the US overall was 75.7% in 2010 before declining to 63% in 2012 and 45.4% in 2014. Also, the weighted-average county-level "Top 4" share shown in Figure 1 of Scharfstein and Sunderam (2013) fell from over 0.38 in 2010 to below 0.3 in 2013 and 2014, and is thus close to its longer-term average for the period since 1994.

coupon on this debt defined by:

$$p^n_{YSP} = PV(\text{principalpayments(n)}) + y^n \text{mult}^n_{MBS} \tag{8}$$

where mult^n_{MBS} is a valuation multiple similar to the one defined in Section 2.2.1. Similarly, we can write that

$$p^n_{TBA} = PV(\text{principalpayments(n)}) + r^n \text{mult}^n_{MBS} \tag{9}$$

Equations (8) and (9) generate a relationship between the price of intermediation measured as the difference in prices and as the spread between rates in the primary market and implied coupon in the secondary market.

$$\phi^n = p^n_{TBA} - p^n_{YSP} = (r^n - y^n)\text{mult}^n_{MBS} \tag{10}$$

In other words, the one-time payment to the intermediary, ϕ^n equals the present value of an interest strip that pays the difference between what the borrower pays to the intermediary (r^n) and what the intermediary pays to investors (y^n).

$r^n - y^n$ is similar to what market participants normally refer to as the "primary-secondary spread."[35] Rearranging equation (10) as

$$r^n - y^n = \frac{\phi^n}{\text{mult}^n_{MBS}} \tag{11}$$

and taking differences over time shows that changes in rates reflect three factors:

$$r^n(t') - r^n(t) = \underbrace{y^n(t') - y^n(t)}_{\substack{\text{(1) }\Delta\text{Secondary} \\ \text{Market Cost of} \\ \text{Funds}}} + \underbrace{\frac{\phi^n(t') - \phi^n(t)}{\text{mult}^n_{MBS}(t')}}_{\substack{\text{(2) }\Delta\text{Price of} \\ \text{Intermediation}}} - \underbrace{(r^n(t) - y^n(t))\frac{\text{mult}^n_{MBS}(t') - \text{mult}^n_{MBS}(t)}{\text{mult}^n_{MBS}(t')}}_{\text{(3) }\Delta\text{MBS Multiplier}} \tag{12}$$

[35] Analysts typically define the primary-secondary spread as the difference between an index of primary market rates like the 30-year fixed rate index from the Freddie Mac Primary Mortgage Market Survey and compare it with the yield on an MBS trading at par. This measure would only be equivalent to ours if the rebate on the Freddie Mac loans was 0 which is typically note the case. Since the rebates are usually positive, the primary-secondary spread overstates the rate spread. Even if intermediation were free, a positive rebate would imply a positive spread between the note rate and yield on a loan trading at par.

In contrast, changes in the primary market price only reflect two factors:

$$p^n_{YSP}(t') - p^n_{YSP}(t) = \underbrace{p^n_{TBA}(t') - p^n_{TBA}(t)}_{\substack{\text{(1) }\Delta\text{Secondary} \\ \text{Market Price}}} - \underbrace{\big(\phi(t') - \phi(t)\big)}_{\substack{\text{(2) }\Delta\text{Price of} \\ \text{Intermediation}}} \tag{13}$$

Comparing equations (12) and (13) illustrates the challenge of using rates to measure changes in the price of intermediation. Changes in the value of the interest strip can change rates even when there is no change in the price of intermediation. Intuitively, suppose that market expectations of prepayments go down, leading the MBS multiplier to go up. Equation (12) illustrates that even if the cost of funds and the price of intermediation stay the same (meaning terms (1) and (2) are zero), the primary market rate will fall, leading one to conclude, incorrectly, that the price of intermediation has fallen. The reason for the fall in rates is simply that the price of intermediation is now spread out over a longer period.

The top left panel of Figure 10 illustrates the relationship between the rate spread, $r - y$ and the price of intermediation, ϕ. At some points in our sample, the rate spread and ϕ tell similar stories. For example, in 2012, both ϕ and the rate spread almost double, a fact that is not surprising given that the multiplier, shown in the bottom part of the panel, is relatively stable. But at other points, rate spread and ϕ give different accounts. For example, in late 2008 and early 2009, the rate spread spikes and then drops dramatically. The decline does not show up in ϕ, which remains within a relatively narrow band. The difference, of course, is the multiplier which rises from one at the end of 2008 to nearly six at the beginning of 2010. Intuitively, as the multiplier went up, the rate spread required to maintain a stable price of intermediation fell roughly by a factor of six. It is important to point out that the strong time trend we documented in Section 6.1 does not show up in the rate spread. The difference between the trends in the two series is, of course, explained by the multiplier. The rising multiplier ensured that the increase in the price of intermediation translated into a much smaller increase in rates. Put differently, if the multiplier had remained constant over this period, the rate spread would have widened much more dramatically than it did.

In the other three panels of Figure 10, we revisit three of the QE-related event studies described in Section 4 to see if the rate spread and ϕ yield different interpretations of the data. The top left panel shows the time around the initial announcement of QE in November of 2008. The lines labelled p_{TBA}, p_{YSP} and price passthrough are identical to the corresponding lines in Figure 4. However, the bottom part of the panel now shows Rate101 (r^n) and the implied coupon (y^n) and a corresponding measure of passthrough in rates. To understand the differences, focus on the announcement of QE3 in September of 2012 (the bottom left panel in Figure 10). On the day prior to the announcement, a loan paying a one percent rebate offered a rate of 3.47 percent – in other words, $Rate101 = 3.47$. We then calculate the cost of funds in the TBA market to be $y^n = 3.08$ percent meaning that the primary-secondary spread is 41 basis points. What happens to the primary secondary-spread after the announcement? According to the Optimal Blue data, Rate101 falls by 10 basis points to 3.37 percent but the secondary market price of the Rate101 loan falls by 23 basis points to 2.85 percent. In other words, passthrough is 10/23 or 43 percent. In contrast, the one-day price changes imply 55 percent passthrough. What accounts for the difference? As equation (12) shows, it must be that the interest strip multiplier went down. The point here is that the big shock to the level of prices in the secondary market also affects relative prices in the secondary market and those relative prices determine the interest strip multiplier. Indeed, at the time, many commentators looked at the rate spread and conclused that passthrough was exceptionally low.[36] Our measure shows much higher levels of passthrough and, in fact, the gap between the two measures widened significantly over the next few days before narrowing. The other two events in Figure 10 show much smaller divergence between the two measures.

7.2 Expenditure on Intermediation

Over the 73 month period we cover in the paper, American households refinanced 6.5 trillion dollars of mortgages and used 3.8 trillion dollars of new mortgage debt to purchase homes.[37] According to our estimates, households implicitly paid 155 billion dollars to financial intermediaries for their services in these transactions (99 billion dollars for the refinances and 56 billion dollars for the purchase mortgages), or about 25 billion per year on average. We arrive at this estimate by using our monthly average estimates of ϕ from Section 6.1 and multiplying them by the dollar amount of monthly originations.[38] One obvious question is how large a number this is. To give some perspective, note that according the Bureau of Economic Analysis, the cumulative reduction in household mortgage interest payments over the relevant period was around 760 billion dollars.[39] As another comparison, Hurst et al. (2016) find that the GSE policy of uniform mortgage rates across locations (rather than letting rates vary with credit risk) implied a redistribution across US regions of 14.5 billion

[36]See, for instance, "Banks reap profits on mortgages after QE3," *Financial Times*, October 1, 2012.

[37]These figures are based on HMDA data, and may thus slightly understate the actual total, since about 10% of loans are not covered in HMDA.

[38]This therefore assumes that other types of mortgages, such as FHA loans or loans held on bank balance sheets, incur the same price of intermediation.

[39]See "Mortgage Interest Paid, Owner- and Tenant-Occupied Residential Housing" at `http://www.bea.gov/national/supplementary.htm`. The 760 billion dollar figure equals the difference between the sum of all interest paid from 2009-2014 if interest payments were fixed at the 2008Q4 level and actual interest payments. This number includes reductions in interest payments due to lower interest rates (due to refinancing of fixed-rate mortgages and automatic adjustments of adjustable-rate mortgages) and reductions in payments due to lower outstanding principal resulting from foreclosures and other debt reduction.

dollars (in NPV terms) over the 2007-9 period, or roughly 5 billion per year.

The top panel of Figure 9 shows our estimate of the time series of monthly expenditures, which range from less than one billion dollars in some months to between five and six billion per month at the peak in the summer and fall of 2012. To understand the evolution of costs, we consider some counterfactual experiments. As we showed in Section 6.1, two variables, application volume and at time trend, account for most of the variation in the price of intermediation, ϕ, and so one important question is how much of the variation in intermediation expenditures is explained by these two factors. In the bottom panel of Figure 9, we use our regression estimates to calculate predicted values of ϕ under three sets of assumptions: (1) ϕ does not react to applications; (2) the time trend was zero; and (3) the combination of (1) and (2). In each case, we assume that the level of ϕ at the beginning of our sample period was at its actual level. We then use those estimates to calculate counterfactual expenditures on intermediation displayed in the top panel, holding the volume of new loan originations fixed at its actual level.

The line labeled "No effect of apps" shows that if ϕ had not responded to application volume, this would have lowered expenditure on intermediation by about 50 billion dollars to 106 billion. If, on the other hand, we let ϕ vary with applications as it did but there was no increasing time trend, expenditures would have fallen by over 90 billion dollars. And finally, the combination of the two counterfactual assumptions would have wiped out most of the expenditure, reducing it to only 13 billion over the 73 months of our sample.

The economic interpretation of these numbers is somewhat nuanced. As mentioned above, 99 billion dollars or two-thirds of the expenditure on intermediation involved refinances of existing mortgages. This is important because one of the channels through which the Federal Reserve QE policies transmits to households was by allowing them to refinance into lower interest rate mortgages. Although the benefits to households obviously outweighed the costs, our results show that these costs were substantial. One can interpret the 99 billion figure as one of the costs of having a mortgage market that is dominated by fixed-rate mortgages, since mortgagors need to refinance to benefit from lower rates. In an economy where most borrowers have adjustable-rate mortgages instead, the transmission of interest rates to household cash flow requires no action by financial intermediaries.

Interpretation of the other counterfactuals is less stark but interesting nevertheless. In particular, our results show that the upward trend in the price of intermediation documented in Section 6.1 resulted in a nearly three-fold increase in expenditure on intermediation during this period. Capacity constraints also led to substantial increases in expenditures on intermediation, highlighting the limits of the sector as a channel for policy.

A natural question is whether it is reasonable to assume in our counterfactuals that ϕ in

October 2008 is a reasonable "reference level," given that it is substantially lower than what we observe over the rest of our sample period. While we do not have the Optimal Blue data going back further, it turns out that a similar calculation based on the Freddie Mac survey rate implies that ϕ was roughly constant at this low level over 2006-2008 — see Chart 2 in Fuster et al. (2013).[40] Thus, it is not the case that the starting point of our ϕ series is "unusual" relative to historical values.

It is important to stress that we are not making any welfare statements here. What the numbers above reflect is a transfer of the surplus generated by lower rates (higher MBS prices) from households to intermediaries, taking the volume of loan originations as fixed. This is not to say that the high price of intermediation could not have welfare effects. In particular, had ϕ remained at its lower original level, this would have led to additional mortgage originations that would have generated surplus for both borrowers and intermediaries.[41] Thus, if for instance post-crisis regulations led to the positive time trend in ϕ, then one can argue that there was in fact a deadweight loss. That said, these regulations may of course also have offsetting benefits, such as fewer mortgage defaults, that would have to be weighed in a full welfare analysis.

7.3 Counterfactual Mortgage Rates with Alternative ϕ

In the previous section, we studied how expenditures on intermediation would have differed under various counterfactual assumptions about the evolution of ϕ. In this section, using the above insights, we transform these counterfactual ϕ into counterfactual Rate101 series. This provides an alternative (and perhaps more easily interpretable) way of assessing the effect that the increased ϕ had on borrowers over our sample period.

These counterfactual Rate101 series are shown in the bottom panel of Figure 9. The figure shows that the costs of intermediation did have a significant effect on the interest rates faced by borrowers. Our experiment of setting the sensitivity of the price of intermediation to applications to zero would have reduced rates by 10 basis points on average and as much as 88 basis points in January 2009. Eliminating the time trend would have reduced Rate101 by 16 basis points on average and by 29 basis points by the end of the sample. The combination of the two counterfactual experiments would have implied a decrease in Rate101 of 30-40 basis points over an extended period in 2012-13.

[40] There is a difference in levels between the chart in Fuster et al. (2013) and our ϕ because here we subtract 101 from p_{TBA} while there it was only 100. There are also small differences in assumed g-fees between the two calculations, but these only have minor effects on the evolution of the series.

[41] A full discussion of the strength of this channel requires a model of borrower behavior and is beyond the scope of this paper.

8 Conclusion

Over the period 2000-2014, residential mortgage originations in the US have averaged about 2.2 trillion dollars per year.[42] Given the size of the market, even relatively small changes in the price of intermediation, defined as the difference between the value of a mortgage's cash flows to investors in the MBS market and what a borrower receives, add up to significant changes in implicit borrower expenditures. In this paper, we have systematically studied how the price of intermediation has evolved over 2008-2014, a period during which monetary policy and other macroeconomic and financial factors led to record low interest rates.

We find a significant upward trend in this price that appears driven by increased net costs of mortgage servicing and potentially the increased labor intensity of mortgage underwriting due to new regulations and lenders being more averse to liability risk. In addition, there are substantial fluctuations around this trend that are closely related to the level of demand for new mortgages; this is strongly suggestive of capacity constraints in mortgage originations. We estimate that the upward trend and the sensitivity to demand together increased expenditures on intermediation by about 140 billion dollars over the 73 months in our sample, holding origination volumes constant.

Capacity constraints have affected the passthrough of monetary policy. Even though we show that offers to borrowers in the primary mortgage market generally respond very quickly to MBS price changes, we also find that the passthrough of MBS price increases is subdued when application volumes are high. This implies that policy actions that increase MBS prices, for instance an announcement of increased asset purchases, will pass through less strongly if demand for mortgages was already strong. Put differently, in such a situation, intermediaries may absorb a large chunk of the increase in MBS values, rather than passing it on to borrowers. Thus, intermediation frictions are important for policy makers to consider when designing policy actions that primarily target the mortgage market.

Finally, it is important to emphasize that expenditures on intermediation in the mortgage market could potentially be much lower under a different institutional setup. Most of the variation in mortgage demand, and in the price of intermediation, in recent years was due to the refinancing of fixed-rate mortgages. Refinancing in most cases requires a full re-underwriting of the mortgage even though the reduction in the monthly payment will generally lead to a reduced credit risk relative to the outstanding loan.[43] Making the process more streamlined would not only save borrowers time, but potentially also substantial amounts of money.

[42] Source: Inside Mortgage Finance, Mortgage Market Statistical Annual.

[43] Credit risk may not be lower if the borrower withdraws equity in a cash-out refinance.

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Loan-level characteristics for baseline scenario			
Variable	**Base case**	**Variable**	**Base case**
Loan amount	300,000	Prepayment penalty	None
Loan-to-value ratio (LTV)	80	Lock period	30 days
FICO	750	Owner-occupied or investment	Owner-occupied
Program	Conforming	State	CA
Loan type	Fixed	MSA	Los Angeles
Term	30 year		

Rate sheet information					
unique lenders	63				
	mean	**SD**	**p10**	**p50**	**p90**
lenders per day	21.7	5.6	13	21	28
offers per ratesheet	22.9	18.5	9	16	48
Points and rates					
Within day					
	mean	**SD**	**p10**	**p50**	**p90**
points offered	101.2	1.8	98.5	101.5	103.3
rates offered	4.54	0.41	3.99	4.54	5.09
Across days					
	mean	**SD**	**p10**	**p50**	**p90**
points offered	101.2	1	99.9	101.3	102.4
rates offered	4.53	0.57	3.78	4.52	5.25
Pooled					
	mean	**SD**	**p10**	**p50**	**p90**
points offered	101.2	2.2	98.2	101.5	103.7
rates offered	4.55	0.71	3.63	4.50	5.50

Table 1: Characteristics of the proprietary lender ratesheet data from Optimal Blue used for our analysis. The rate/point offers depend on borrower- and loan-level characteristics, such as the FICO score and loan type. Our base case is listed above. The second part of the table shows descriptive statistics on the rates and points on ratesheets, both within day (across lenders), across days (taking the mean of lenders for any given day), and pooled (across both lenders and days).

	(1)	(2)	(3)	(4)	(5)
$\Delta p_{TBA,t}$	0.916***				
	(0.014)				
$\Delta p^{+}_{TBA,t}$		0.794***	0.789***	0.791***	0.787***
		(0.024)	(0.024)	(0.023)	(0.023)
$\Delta p^{-}_{TBA,t}$		1.023***	1.028***	1.023***	1.027***
		(0.022)	(0.022)	(0.022)	(0.022)
$\Delta p^{+}_{TBA,t-1}$			0.077***		0.080***
			(0.020)		(0.019)
$\Delta p^{-}_{TBA,t-1}$			0.011		0.007
			(0.023)		(0.023)
$\Delta p^{+}_{TBA} \times$ Applications				-0.064***	-0.069***
				(0.019)	(0.023)
$\Delta p^{-}_{TBA} \times$ Applications				0.008	0.014
				(0.017)	(0.021)
$\Delta p^{+}_{TBA,t-1} \times$ Applications					-0.023
					(0.017)
$\Delta p^{-}_{TBA,t-1} \times$ Applications					-0.039*
					(0.021)
Constant	-0.001	0.022***	0.016***	0.022***	0.015***
	(0.002)	(0.004)	(0.005)	(0.004)	(0.005)
Adj. R^2	0.88	0.89	0.89	0.89	0.89
Observations	1412	1412	1412	1412	1412

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Regressions of $\Delta p^{Rate101}_{YSP}$ on $\Delta p^{Rate101}_{TBA}$ at daily frequency. "Applications" is the daily HMDA application volume from the previous day. Δp^{+}_{TBA} indicates the magnitude of the day-over-day change in TBA price for positive changes only, and Δp^{-}_{TBA} corresponds to the negative changes. Columns 4 and 5 also include a price change lagged by one business day. All prices are normalized to the same rate ("Rate101").

Regression Results

	ϕ					π				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Applications	0.205*	0.361***	0.355***	0.313***	0.340***	0.342***	0.404***	0.438***	0.376***	0.402***
	(0.110)	(0.042)	(0.040)	(0.034)	(0.048)	(0.070)	(0.061)	(0.056)	(0.047)	(0.073)
Time trend		0.025***	0.024***	0.012***	0.017**		0.010***	0.020***	0.003	0.008
		(0.002)	(0.003)	(0.003)	(0.008)		(0.003)	(0.003)	(0.004)	(0.009)
Volatility			-0.050	-0.133**	-0.093			0.252***	0.130*	0.167**
			(0.066)	(0.059)	(0.077)			(0.079)	(0.067)	(0.079)
R.E. payroll				0.202***	0.190***				0.295***	0.284***
				(0.052)	(0.060)				(0.062)	(0.067)
Lender conc.					0.071					0.067
					(0.080)					(0.101)
Constant	1.396***	-14.427***	-13.210***	-6.006***	-9.158*	1.130***	-5.188***	-11.330***	-0.801	-3.788
	(0.123)	(1.317)	(1.742)	(2.170)	(4.727)	(0.079)	(1.784)	(2.017)	(2.478)	(5.565)
Adj. R^2	0.10	0.85	0.85	0.87	0.88	0.43	0.59	0.67	0.74	0.74
Observations	73	73	73	73	73	73	73	73	73	73

Newey-West standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Predicted vs. Actual, Specification (2)

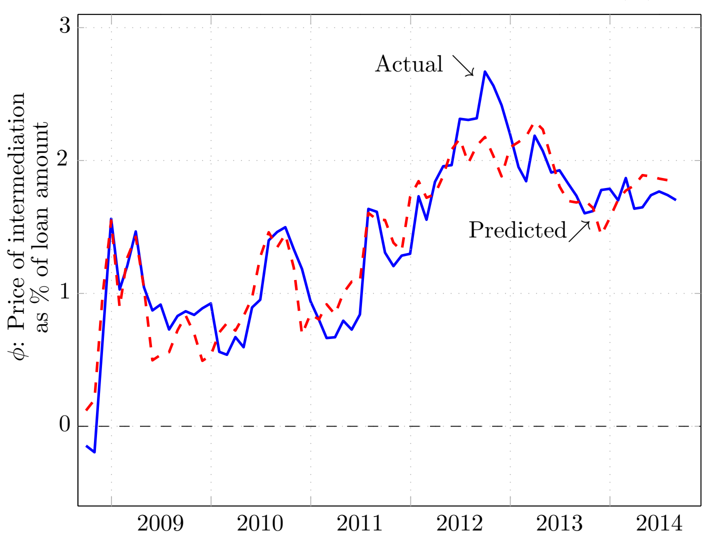


Table 3: Understanding time-variation in the price of intermediation – regression in levels. The definition of ϕ and π, as well as the explanatory variables, can be found in Section 3. All explanatory variables except for the time trend (where the unit is calendar month) have been standardized over the relevant sample, so that the coefficients can be interpreted as the effect of one standard deviation of the relevant variable on the price of intermediation.

	$\Delta\phi$				$\Delta\pi$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Applications	0.260***	0.258***	0.258***	0.251***	0.298***	0.337***	0.337***	0.332***
	(0.049)	(0.057)	(0.057)	(0.062)	(0.069)	(0.075)	(0.074)	(0.083)
Δ Volatility		-0.009	-0.011	-0.011		0.132	0.127	0.128
		(0.104)	(0.105)	(0.107)		(0.088)	(0.086)	(0.086)
Δ R.E. payroll			0.020	0.025			0.052	0.056
			(0.055)	(0.055)			(0.068)	(0.071)
Δ Lender conc.				-0.047				-0.039
				(0.082)				(0.098)
Constant	0.027	0.026	0.025	0.024	0.010	0.018	0.016	0.015
	(0.023)	(0.024)	(0.025)	(0.026)	(0.026)	(0.027)	(0.027)	(0.028)
Adj. R^2	0.41	0.40	0.39	0.38	0.41	0.42	0.42	0.42
Observations	72	72	72	72	72	72	72	72

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Understanding time-variation in the price of intermediation – regression in monthly changes. Regressors are standardized for the relevant sample before monthly differences are taken, so that the coefficients can be interpreted as the impact of a change in a given variable by one standard deviation.

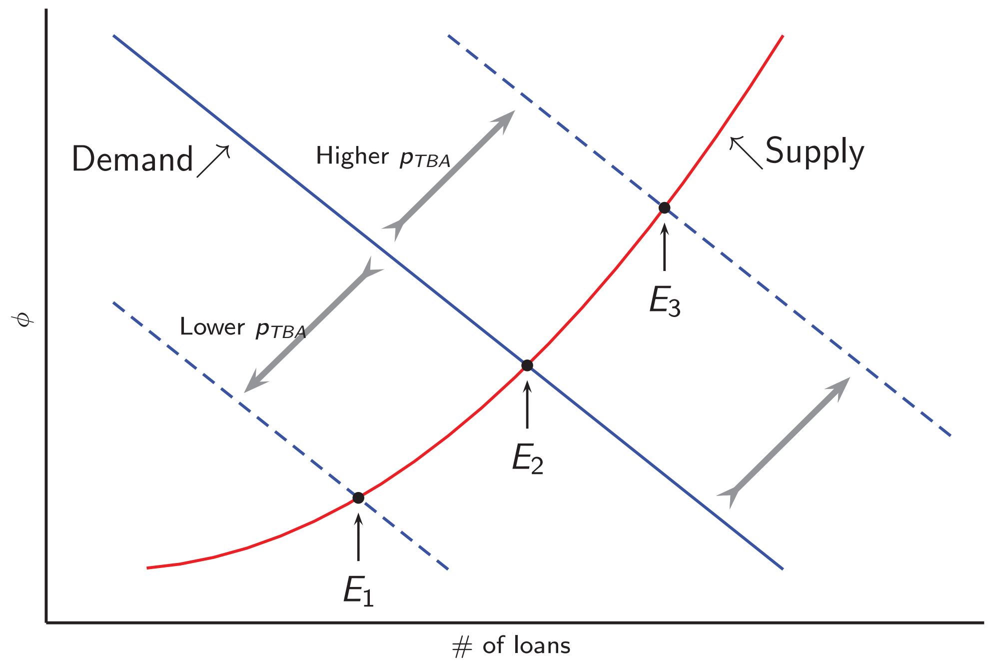
	(1) Delay	(2) Delay	(3) Δ Delay	(4) Δ Delay
Std. New Applications	3.242***	3.543***		
	(0.782)	(0.730)		
Time Trend	0.139***	0.141***		
	(0.0412)	(0.0395)		
Δ Std. New Applications			2.385***	2.955***
			(0.470)	(0.325)
Dec. Indicator				1.810**
				(0.714)
Jan. Indicator				-3.659***
				(1.050)
Constant	-49.14*	-51.83**	0.180	0.344**
	(25.73)	(25.02)	(0.205)	(0.148)
Month FEs	no	yes	no	no
Adj. R^2	0.45	0.44	0.39	0.60
Observations	81	81	80	80

Standard errors shown in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Regression of HMDA processing delays on the loan demand. The dependent variable, delay, is defined as the number of days between loan application and action (accept, withdraw, or deny). We measure loan demand using the count of loan applications from HMDA. Monthly regression using data from January 2008 to September 2014. Applications normalized per business day, then standardized. Newey-West robust standard errors shown for Columns (1) and (2); robust standard errors shown for Columns (3) and (4). Column (2) contains calendar-month fixed effects to control for potential seasonality.

Supply and Demand for Intermediation



Perfectly Elastic Supply

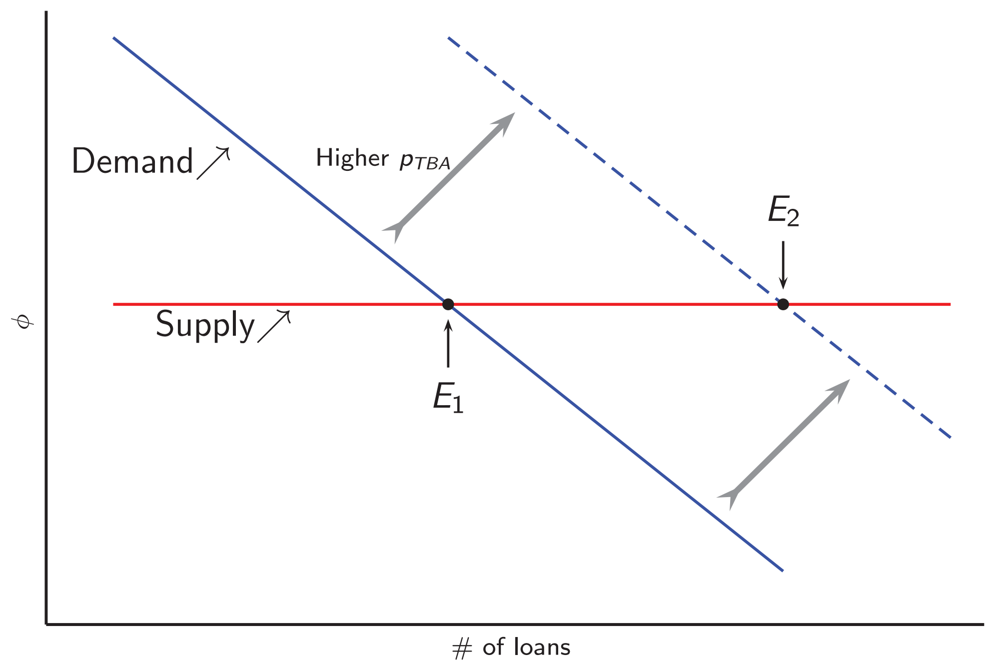


Figure 1: The Market for Financial Intermediation

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To Register and Lock Rates Online:
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Contact Your 5/3 Account Executive to gain access.

Group 7 State(s): IL

FIFTH THIRD MORTGAGE

Wholesale Rate Sheet For Broker Use Only
Traditional and Table Fund
Rate Sheet Number: 2010-1619
Effective @8:30 AM EST of: 6/7/2010

Maximum Combined Broker Compensation (YSP and Broker Fees)
Loan Amount <= $417,000 = 3.5% of Total Loan Amount
Loan Amounts > $417,000 = 2.5% of Total Loan Amount

Off Sheet Pricing available: Contact your Account Executive for information
FREDDIE MAC OPEN ACCESS NOW AVAILABLE - SEE PAGE 5 FOR PRICING ADJUSTMENTS

Conforming Fixed Products - Upto FHLMC Limit

21-30 Yr. Fixed (FX30)			
	15 day	30 day	60 day
5.375	(4.700)	(4.575)	(4.450)
5.250	(3.950)	(3.825)	(3.700)
5.125	(3.325)	(3.200)	(2.950)
5.000	(2.825)	(2.700)	(2.450)
4.875	(2.325)	(2.200)	(1.950)
4.750	(1.575)	(1.450)	(1.200)
4.625	(0.825)	(0.700)	(0.450)
4.500	(0.325)	(0.200)	0.050
4.375	0.300	0.425	0.675
4.250	1.175	1.300	1.550
4.125	2.675	2.800	3.175
4.000	3.425	3.550	3.800
3.875	4.050	4.175	4.550
3.750	4.925	5.050	5.300

16-20 Yr. Fixed (FX20)			
	15 day	30 day	60 day
5.375	(4.820)	(4.695)	(4.445)
5.250	(4.195)	(4.070)	(3.820)
5.125	(3.820)	(3.695)	(3.445)
5.000	(3.445)	(3.320)	(3.070)
4.875	(2.945)	(2.820)	(2.695)
4.750	(2.320)	(2.195)	(2.070)
4.625	(1.820)	(1.695)	(1.570)
4.500	(1.445)	(1.320)	(1.070)
4.375	(0.945)	(0.820)	(0.570)
4.250	(0.320)	(0.195)	0.055
4.126	3.680	3.805	4.055
4.000	4.180	4.305	4.680
3.875	4.805	4.930	5.180
3.750	5.430	5.555	5.805

10-15 Yr. Fixed (FX15)			
	15 day	30 day	60 day
5.125	(4.520)	(4.395)	(4.270)
5.000	(4.270)	(4.145)	(3.895)
4.876	(3.895)	(3.770)	(3.645)
4.750	(3.395)	(3.270)	(3.145)
4.625	(2.895)	(2.770)	(2.520)
4.500	(2.520)	(2.395)	(2.270)
4.375	(2.145)	(2.020)	(1.895)
4.250	(1.645)	(1.520)	(1.395)
4.125	(0.770)	(0.645)	(0.395)
4.000	(0.395)	(0.270)	(0.020)
3.875	0.105	0.230	0.480
3.750	0.730	0.855	0.980
3.625	1.855	1.980	2.230
3.500	2.480	2.805	2.730

AGENCY JUMBO LOANS

PRICE ADJUSTMENTS- FOR APPROVED MSA's ONLY

		LTV %		
Product	Purpose	<=75	>75 & <=80	>80
Fixed P/I	Purchase R/T Refi	0.750	0.750	0.750
	Cash Out Refi	1.750	N/A	N/A
*Fixed I/O	Purchase R/T Refi	0.750	0.750	0.750
	Cash Out Refi	1.750	N/A	N/A
*ARM I/O	Purchase R/T Refi	1.500	2.250	2.250
	Cash Out Refi	2.500	N/A	N/A

All pricing bumps per Conforming products such as Credit Score/LTV, Cash Out, Escrow Waiver & others apply in addition to above adjustments
*I/O Only available for apps prior to 5/17/10. Must Close by 6/13/10

Non-Agency Jumbo Fixed Products - Max Loan Amount $1MM

Jumbo 16-30 Yr. Fixed (FJ30)			
	15 day	30 day	60 day
6.125	(3.255)	(3.130)	(2.880)
6.000	(3.130)	(3.005)	(2.755)
5.875	(3.005)	(2.880)	(2.630)
5.750	(2.505)	(2.380)	(2.130)
5.625	(2.005)	(1.880)	(1.630)
5.600	(1.505)	(1.380)	(1.130)
5.375	(1.130)	(1.005)	(0.755)
6.250	(0.505)	(0.380)	(0.130)
5.125	0.120	0.245	0.495
5.000	0.745	0.870	1.120
4.875	1.370	1.495	1.745
4.750	2.120	2.245	2.495

Jumbo 10-15 Yr. Fixed (FJ15)			
	15 day	30 day	60 day
5.625	(2.020)	(1.895)	(1.645)
5.500	(1.895)	(1.770)	(1.520)
5.375	(1.145)	(1.020)	(0.770)
5.250	(0.895)	(0.770)	(0.520)
5.125	(0.645)	(0.520)	(0.270)
5.000	(0.270)	(0.145)	(0.020)
4.875	0.355	0.480	0.605
4.750	0.730	0.855	0.980
4.625	1.105	1.230	1.480
4.500	1.480	1.605	1.855
4.375	2.230	2.355	2.480
4.250	2.730	2.855	2.980

ALL ADJUSTMENTS BELOW ARE TO PRICE EXCEPT IF NOTED OTHERWISE

Figure 2: An example of a rate sheet

Rate101

Rate Comparisons

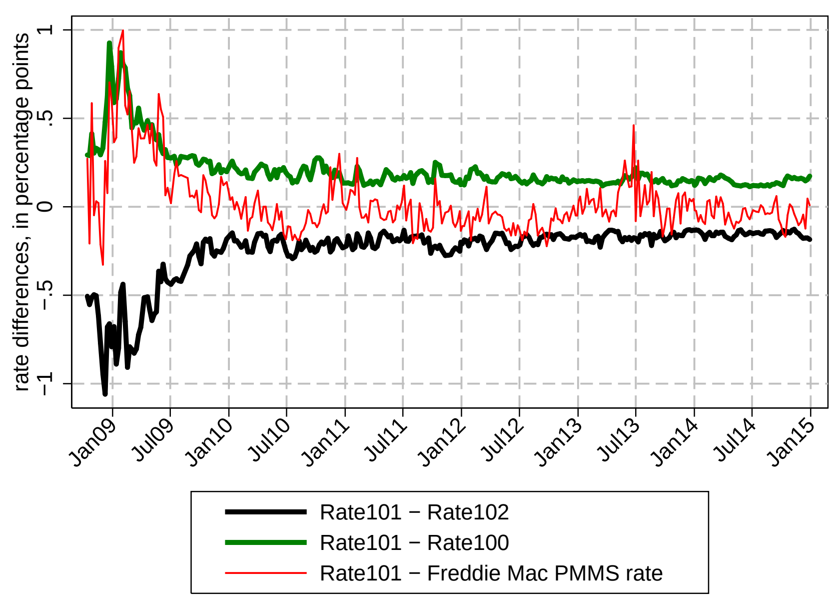


Figure 3: Rate101 (top) and the differences against Rate102, Rate100, and the Freddie Mac Primary Mortgage Market Survey series for 30-year fixed-rate mortgages (bottom), all weekly averages. As discussed in the text, Rate100, Rate101, and Rate102 refer to the ratesheet-derived mortgage rate normalized to a loan with YSP 100, 101, or 102. The normalization is performed using linear interpolation with the closest coupons surrounding the relevant YSP for any given lender-day, and the graph and subsequent analysis use medians within day across lenders. For the Rate101-Freddie series, the Rate101 series is restricted to the days that are reported in the weekly Freddie Mac series.

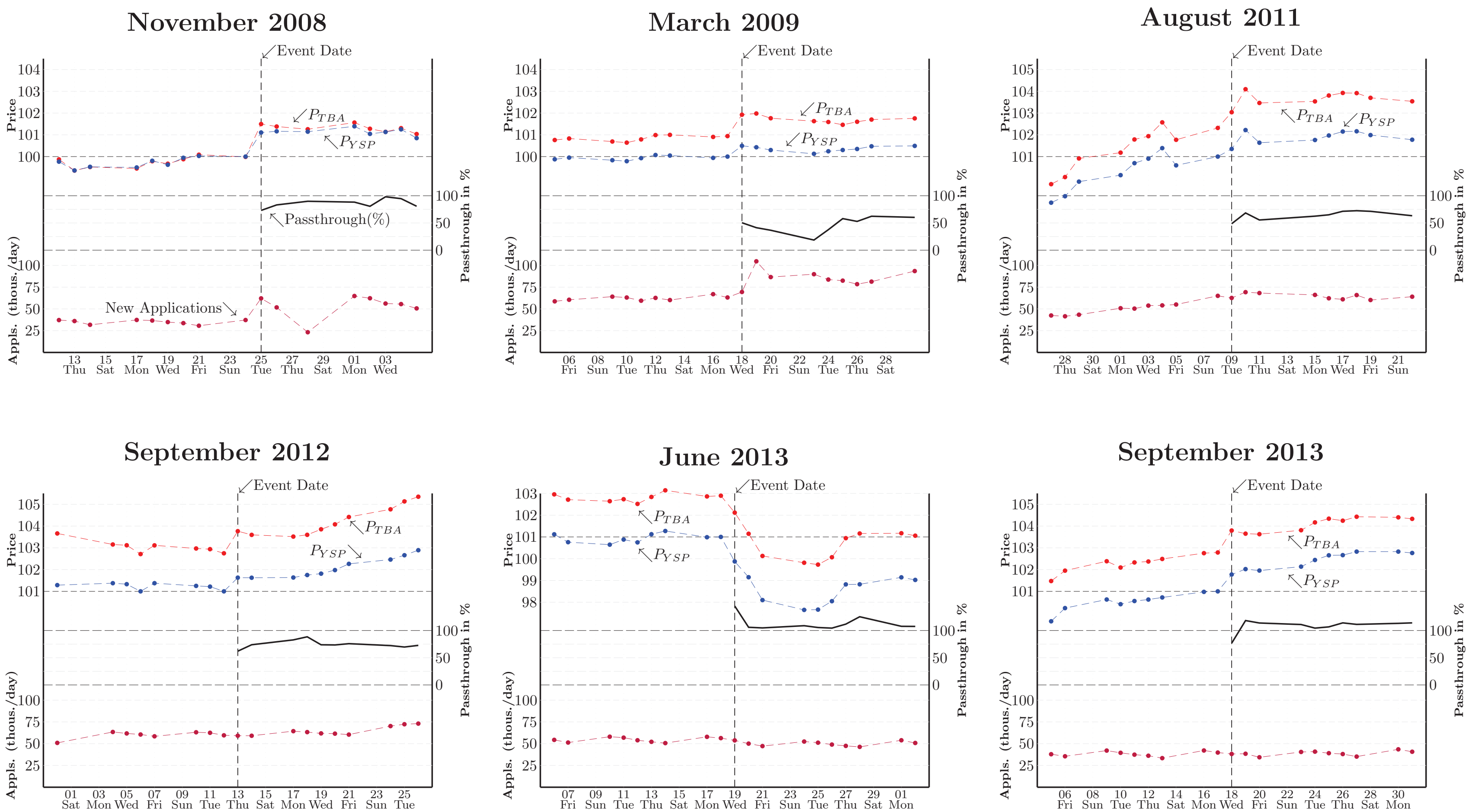


Figure 4: Event studies of major monetary policy (QE) announcements over our sample period. Top lines show the TBA and YSP prices holding the rate fixed at Rate101 (Rate100 in 2008-2009) of the day prior to the announcement. Middle line shows the passthrough of the TBA price change to YSP. Bottom line shows daily application counts as measured by HMDA.

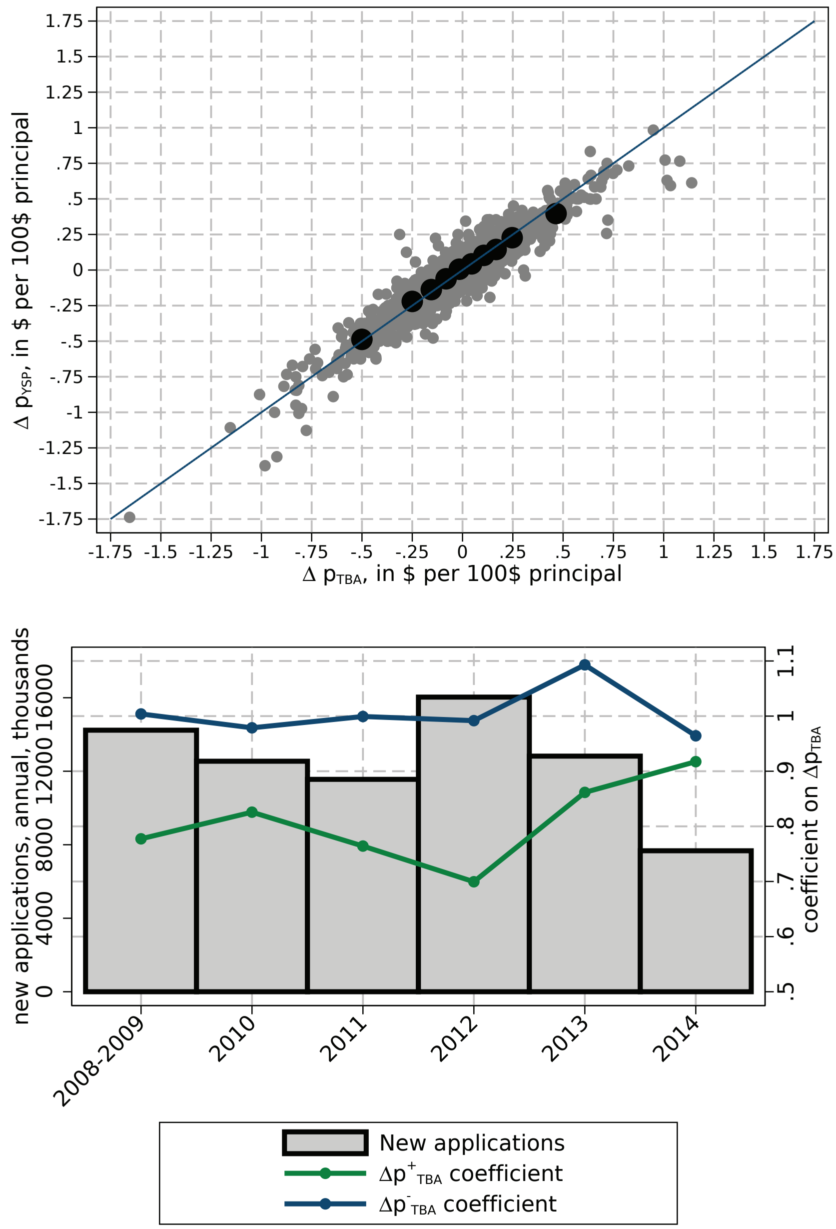


Figure 5: Top panel shows scatterplot of daily first differences of YSPs and MBS prices. Grey dots show every data point (for the full sample period, October 2008 - October 2014) while black dots show averages by deciles of p_{TBA} ("binscatter"). Diagonal line is the 45-degree line, where points would lie with perfect passthrough. Both the YSP and MBS series are for Rate101, as discussed in Section 5. These data underlie the regressions in Table 2. Bottom panel shows coefficients of first difference regression by year: $\Delta YSP = \beta_0 + \beta_+ \Delta p^+_{TBA} + \beta_- \Delta p^-_{TBA}$ is run by year, and the coefficients are plotted on the graph alongside bars that indicate the annual new mortgage applications as calculated using the HMDA data. Source: Optimal Blue; J.P. Morgan Markets; HMDA; authors' calculations

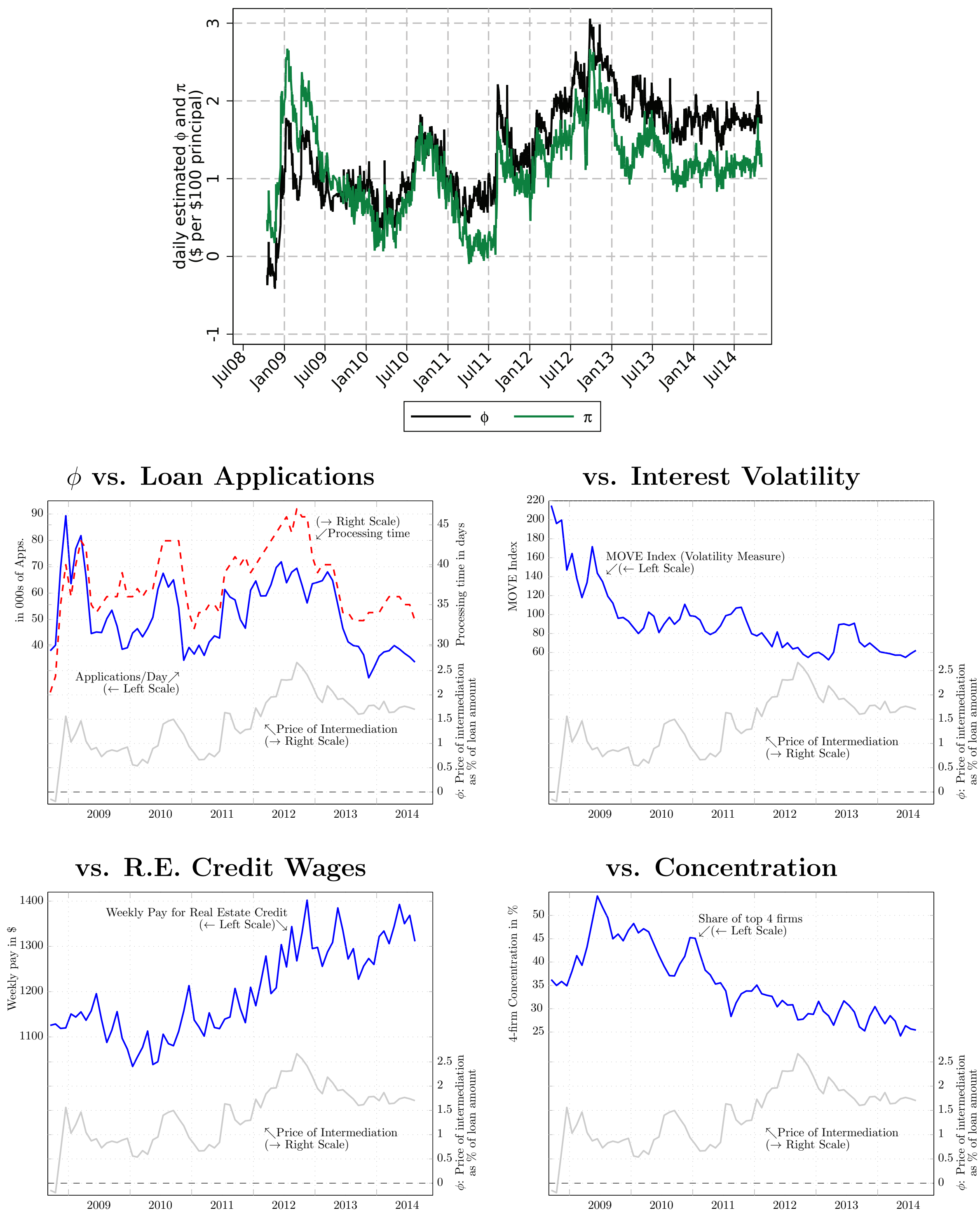
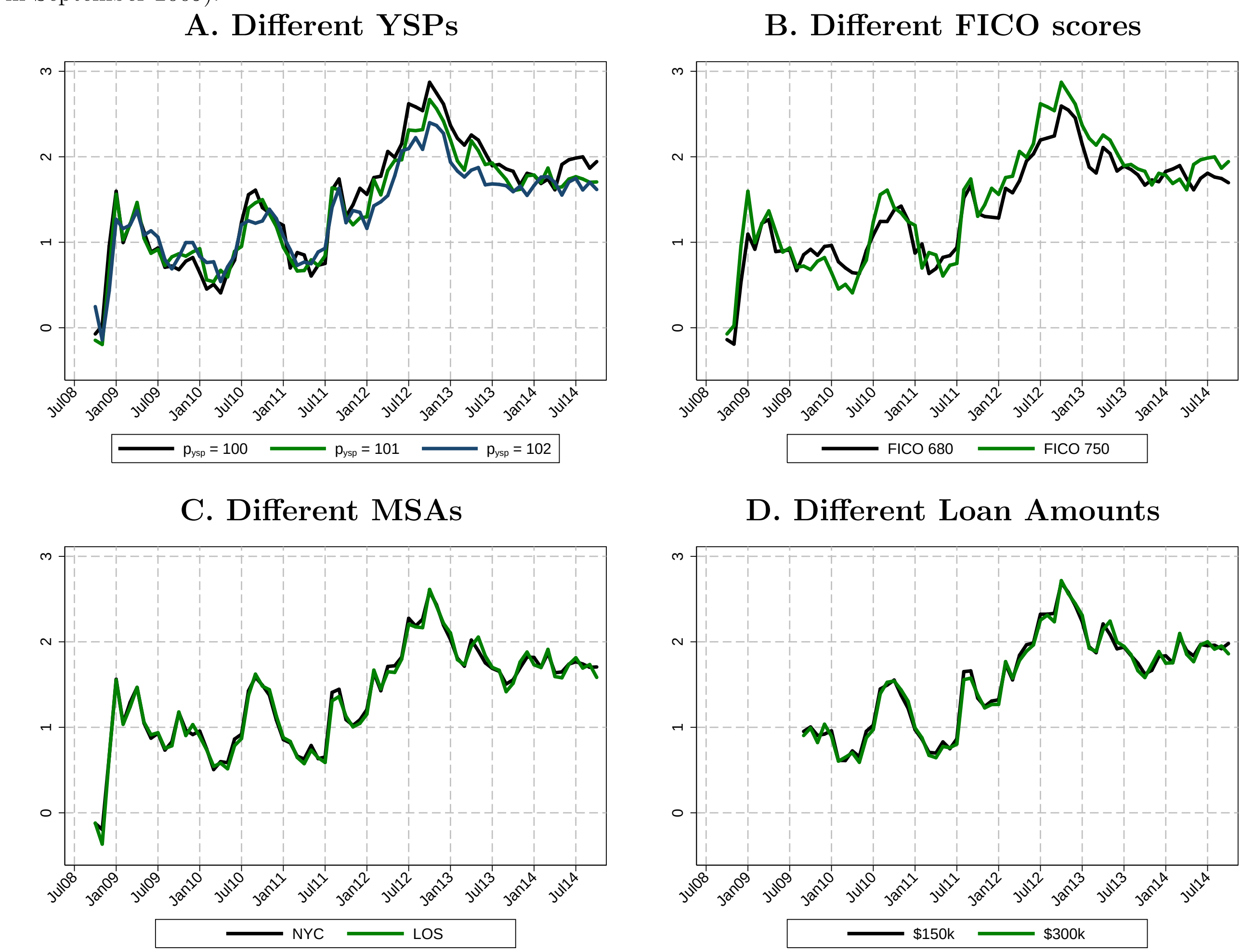


Figure 6: Estimated ϕ and π, and covariates.

As explained in Section 6, ϕ is our baseline estimate of the price of intermediation and π is our alternative measure of intermediary margins where the 25 basis points of servicing cash flow are valued by a separate multiplier, rather than implicitly by MBS prices. Lower panels show monthly average ϕ plotted against applications per business day and average processing time (from HMDA); implied interest rate volatility (MOVE); payroll per employee in real estate credit (from the BLS); and mortgage market concentration (from HMDA).

Figure 7: Estimated ϕ for different assumptions

Panels show ϕ under different assumptions about the loan. Panel A compares ϕ for three different mortgage note rates (our baseline assumption is $p_{YSP} = 101$). Panel B compares ϕ for a FICO credit score of 750 (baseline) with ϕ for FICO of 680. (This is done at $p_{YSP} = 100$, since only few lenders offered 101 to FICO 680 borrowers in the early parts of our sample.) Panel C compares a loan in Los Angeles (baseline) to one in New York City. Panel D compares a loan for $300,000 (baseline) to one for $150,000 (offers for the latter are only available to us starting in September 2009).



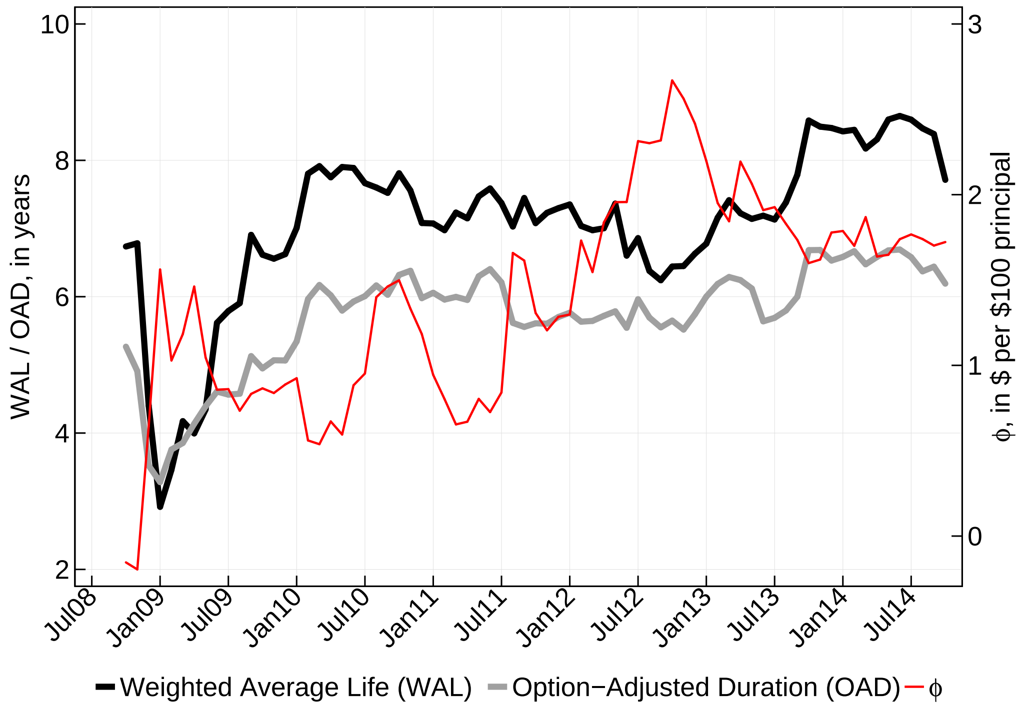


Figure 8: Expected life span of new mortgages and the price of intermediation. See text in Section 6.2 for discussion.

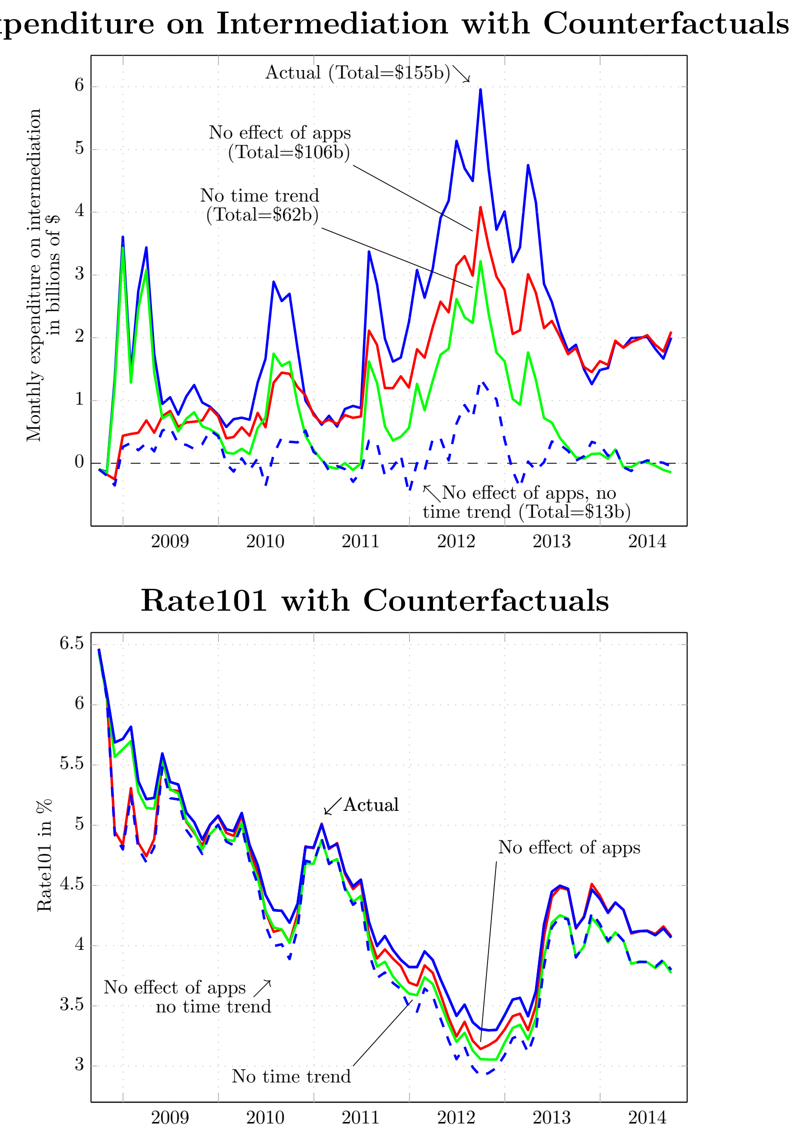


Figure 9: Expenditure on intermediation and Rate101 under different assumptions. See Section 7.2 and 7.3 for relevant discussion.

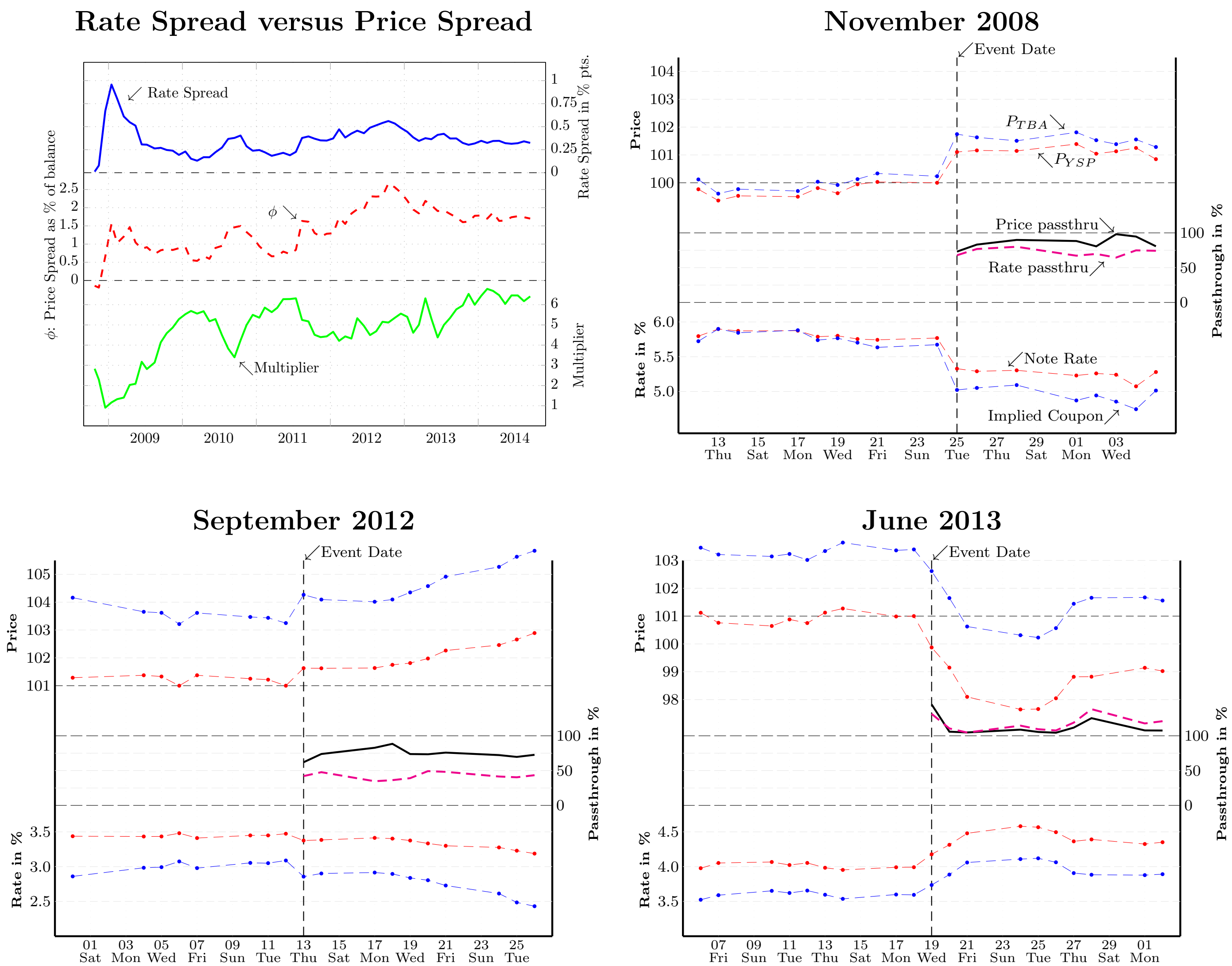


Figure 10: Primary-secondary spread and QE passthrough analysis. See Section 7.1.