Monetary Transmission through Shadow Banks*

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Abstract

I find that shadow bank money creation significantly expands during monetary tightening. This "shadow money channel" offsets the reductions in commercial bank deposits and dampens the impact of monetary policy. Using a structural model of bank competition, I show that heterogeneous depositor clientèle quantitatively explains the difference in monetary transmission between commercial and shadow banks. Facing more yield-sensitive clientèle, shadow banks pass through more rate hikes to depositors, thereby attract more deposits when the Fed raises rates. My results suggest that monetary tightening may unintentionally drive deposits into the uninsured shadow banking sector, amplifying the risk of bank runs.

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1. Introduction

The U.S. banking system has experienced significant structural changes over the past thirty years. A group of non-bank financial intermediaries, collectively known as the *shadow banking system*, has grown outside of the traditional commercial banking sector. Important components of the shadow banking system include money market funds (MMFs), securitization vehicles, broker-dealers, and mortgage companies. Shadow banks compete with commercial banks in many traditional banking businesses. For example, MMFs compete in the deposit market by creating liquid claims which, in many ways, are similar to commercial bank deposits, yet provide higher yields. In recent years, more than 30% of deposits have been created by shadow banks.

The rapid growth of shadow banks has raised concerns for policy makers on the effectiveness of monetary policy.[1] Traditionally, commercial banks have played an important role in transmitting monetary policy to the real economy. Over the years however, an increasing share of deposits has been created outside of the commercial banking sector. Despite the importance of shadow banks in current economy,it is unclear how deposit competition from shadow banks affects the transmission of monetary policy.

Unlike commercial banks, which combine deposit creation and loan origination under one roof, the shadow banking system separates the intermediation process into different entities. This paper focuses on MMFs which are shadow banks in the deposit market. MMFs provide depository services for households and businesses and then pass the proceeds to other shadow banks that specialize in loan origination. The liquid claims created by MMFs constitute the main component of aggregate money supply from the shadow banking system.[2]

[1]For instance, in July 2014, the then-Federal Reserve Board Chair, Janet Yellen said, "We won't be able to detect them (shadow banks), and if we can, we won't have adequate regulatory tools. That is a huge challenge to which I don't have a great answer."

[2]Other types of shadow banking liabilities, such as repos and asset-backed commercial paper, are generally not included in the aggregate money supply because first, they are less liquid than MMF shares, and second, they are generally held within the shadow banking system rather than being held by households and businesses. Including these short-term shadow banking liabilities in money supply would double count the amount of funds that go into the shadow banking system.

I first document a new transmission channel of monetary policy in the shadow banking system—the shadow money channel. Standard theories of monetary transmission predict that high interest rates are associated with low deposit creation (Bernanke and Blinder 1988; Drechsler, Savov, and Schnabl 2017).[3] This prediction has been verified empirically by previous literature in the commercial banking sector (Kashyap and Stein 1995, 2000; Drechsler et al. 2017). However, using aggregate U.S. money supply data from 1987 to 2012, I find the *opposite* of what happens in commercial banks happens in shadow banks.[4] When the Federal Reserve wants to reduce deposits by raising interest rates, shadow bank deposits expand dramatically, and as a result, dampen the impact of monetary policy. The contrast between shadow and commercial banks can easily be seen in a time-series plot of deposit growth rates as shown in Figure 1. This finding contradicts conventional wisdom that high interest rates are contractionary for deposit creation. It suggests that the monetary transmission channel in the shadow banking sector is different from the traditional channels in the commercial banking sector. Moreover, this finding shows that monetary policy not only affects the *total amount* of bank deposits but also the *relative shares* between the shadow and commercial banking sectors. Because shadow bank deposits are outside of government safety nets such as deposit insurance and the discount window, shifts in the relative shares of deposits have important implications for financial stability. To the best of my knowledge, the present study is one of the first to document this counterintuitive pattern of shadow bank deposit creation.

In order to understand the underlying mechanism, I develop a structural model of bank

[3]The shared idea of these two theories is that a high interest rate policy increases the opportunity cost of holding liquid deposits, which reduces the amount of bank deposits in the economy. The difference between these two theories is how a high interest rate policy increases the opportunity cost of holding liquid deposits. Bernanke and Blinder (1988) suggest reserve requirements of commercial banks as an important channel, while Drechsler et al. (2017) show that the market power of commercial banks can also play a role.

[4]In this paper, I use "MZM" (money zero maturity) as the measure of money supply in the economy. This measure is a modification of M2 after the usefulness of previous measures became compromised in the 1990s. This measure includes currency, traveler's checks of non-bank issuers, demand deposits, other checkable deposits, savings deposits, retail MMF shares, and institutional MMF shares. However, choosing a specific definition of money aggregate is not important, because my question is about each component of the money aggregates rather than the sum.

competition. The prior literature on monetary transmission often assumes homogeneous banks and depositors. I introduce product differentiation for bank deposits and heterogeneous preference for depositors following the industrial organization literature (Berry 1994, Berry, Levinsohn, and Pakes 1995, and Nevo 2001). Because of product differentiation, competition is imperfect and banks make a trade-off between deposit volumes and rates. Such trade-off differs for shadow and commercial banks because of their different depositor clientèle. In equilibrium of deposit rate competition, monetary policy drives the spreads between shadow and commercial deposit rates, which results in deposit flows between the two banking sectors.

In my model, banks are differentiated by their respective degrees of transaction convenience and yields. Shadow banks offer lower transaction convenience compared to commercial banks because the lack of bank charters prohibits them from operating branch networks and payment systems. Instead, they differentiate themselves by competing on yields. Product differentiation between shadow and commercial banks results in different clientèle for each banking sector. Commercial banks attract a group of transaction-oriented depositors who value transaction services but are insensitive to yields. Typical examples of transaction-oriented depositors include small and unsophisticated depositors who choose banks mainly based on geographical proximity rather than yields. In contrast, shadow banks attract a group of yield-oriented depositors such as wealthy individuals and corporate treasurers. These yield-oriented depositors are not primarily concerned with transaction convenience, but instead, are very sensitive to yields.

Depending on their depositor clientèle, commercial and shadow banks strategically set their deposit rates to maximize profits. When the Fed Funds rates are low, both types of banks offer similar rates. This is because commercial banks cannot offer rates much lower than zero given the competition from cash while shadow banks cannot offer rates much higher than zero given the low returns on assets. However, when the Fed raises interest rates, deposit rates of the two banking sectors start to diverge. Commercial banks keep

paying low deposit rates because their main clientèle, the transaction-oriented depositors, are attached to their transaction services. In contrast, shadow banks raise deposit rates to keep their yield-sensitive depositors from switching to bonds. As a result, monetary tightening widens the spread between shadow and commercial bank deposit rates, inducing some of the depositors from commercial banks switch to shadow banks.[5] This gives rise to the shadow money channel in which shadow bank deposits expand when the Fed tightens monetary policy.

The key institutional feature that generates the shadow money channel is the differences in depositor clientèle. However, there are many other institutional differences that may generate predictions in the same direction and it is challenging to quantify their relative contribution using a reduced-form method. This challenge lends itself to a structural estimation approach in which competing channels are evaluated by altering the corresponding structural parameters. Specifically, I incorporate a bank reserve channel in which reserve requirements lead to a contraction of commercial bank deposits and a substitution to shadow bank deposits in periods of monetary tightening. I also consider a risk channel in which default probabilities of the two banking sectors vary over time. I estimate my model using institution-level data on U.S. commercial banks and MMFs. The estimation shows that different depositor clientèle is the dominant factor in explaining both deposit rates and volumes.

The structural model also allows a set of counterfactual analyses. I simulate a counterfactual economy without shadow banks using the estimated parameters. Comparing the counterfactual economy with the real data, I find that shadow money creation offsets 34 cents of each dollar in commercial bank deposit reductions, significantly dampening the impact of monetary policy on the banking system. This suggests a new explanation for the diminished monetary impact since the 1990s as documented in the macroeconomic literature (Boivin,

[5]Even though commercial banks lose some deposits to shadow banks, commercial banks would not replicate the shadow banks' strategy because passing through more rates would reduce their profit margin. On the other hand, shadow banks cannot copy the commercial banks' strategy as shadow banks cannot offer the same transaction services to keep depositors attached.

Kiley, and Mishkin 2011). Finally, my results suggest monetary tightening may unintentionally drive deposits from the insured commercial banking sector into the uninsured shadow banking sector, and in doing so, heighten the risk of bank runs.

This paper contributes to three strands of literature. The first strand studies monetary transmission mechanisms in the banking system. Traditionally, this literature has focused on commercial banks (Bernanke and Blinder 1988; Kashyap and Stein 1995, Kashyap and Stein 2000; Drechsler et al. 2017). This paper brings shadow banks to the forefront of the theoretical and empirical analysis of monetary policy. Theoretically, traditional monetary transmission channels in banks usually assume perfect competition and focus on regulatory constraints such as deposit rate ceilings and reserve requirements (Tobin and Brainard 1963; Bernanke and Blinder 1988). While these regulatory constraints were important historically, they have become less relevant since 1990s because of technological innovation and regulatory reform.[6] In search of alternatives, recent papers such as Duffie and Krishnamurthy (2016), Drechsler et al. (2017), and Scharfstein and Sunderam (2017) point out that imperfect competition in the banking sector may play a role in transmitting monetary policy. Following this line of research, I introduce imperfect competition between differentiated banks following Berry et al. (1995) (BLP) into the Bernanke and Blinder (1988) formulation of the bank lending channel. I further use a structural estimation to quantify the magnitude of this channel. The structural approach complements the previous literature such as Kashyap and Stein (1995, 2000), Scharfstein and Sunderam (2017), and Drechsler et al. (2017), which use reduced-form methods.

The second strand of literature to which this paper contributes concerns the interaction between monetary policy and macro-prudential policies. Prior to the 2008–09 financial crisis, the consensus among policy makers was that monetary authority should focus on price stability and employment (Smets 2013). However, this consensus has been challenged by

[6]The Depository Institutions Deregulation and Monetary Control Act of 1980 abolished most of the interest rate ceilings that had been imposed on deposit accounts since the Banking Act of 1933. The sweep technology developed in the early 1990s allows banks to automatically move funds from checking accounts to saving accounts, which reduces required reserves.

an alternative view that took shape after the financial crisis, which argues that monetary policy should also be used to promote financial stability (Borio and Zhu 2012; Stein 2012; Ajello, Laubach, López-Salido, and Nakata 2015). Proponents of this view contend that by tightening monetary policy, the central bank can curb, among other things, the creation of money-like liabilities by the banking system. On the other hand, the potential complication caused by the shadow banking sector is also mentioned (Stein 2012; Yellen 2014). My findings contribute to this debate by showing empirical evidence that monetary tightening may lead to an unintended consequence of driving deposits to the shadow banking system. Because shadow banks are not protected by deposit insurance, such a policy may actually increase systemic risk. My paper supports the view that "monetary policy is too blunt a tool to address possible financial imbalances" as argued by Bernanke (2011) and Yellen (2014).

This paper also adds to a new and growing body of literature that applies a structural IO approach to financial intermediation topics such as bank runs (Egan, Hortaçsu, and Matvos 2017a), bank value creation (Egan, Lewellen, and Sunderam 2017b), insurance (Koijen and Yogo 2016), and mortgages (Buchak, Matvos, Piskorski, and Seru 2017). This paper is the first attempt to use a structural IO model to study transmission channels of monetary policy. This paper is particularly related to Egan et al. (2017a) which uses a similar structural IO framework to study deposit competition and bank runs. Notably, the demand elasticity of commercial bank deposits estimated in this paper is very close to the value estimated in Egan et al. (2017a).[7] This paper further introduces shadow banks into deposit competition and allows depositors to have heterogeneous preference between yield and convenience. The key new finding of this paper is that shadow banks exhibit much higher demand elasticities than commercial banks due to the difference in depositor clientèle, which leads to different pass-through of monetary policy.

The remainder of this paper is organized as follows. Section 2 presents several new stylized facts on deposit creation in the shadow banking system. Section 3 presents a structural model

[7]The median demand elasticity of commercial banks estimated in this paper is 0.38, while Egan et al. (2017a) estimate an weighted average of 0.35 (0.16 for insured deposits and 0.56 for uninsured deposits).

of bank competition to rationalize the empirical findings. Section 4 presents the estimation procedure and results. Section 5 discusses policy implications, and Section 6 concludes.

2. Deposit Creation by Shadow Banks

In this section, I provide a brief description of the institutional background of the shadow banking system. I then present several new stylized facts about the shadow money channel.

2.1 Institutional Background

The shadow banking system is a collection of financial intermediaries that conduct maturity, credit, and liquidity transformation outside the traditional commercial banking system.[8] Examples of shadow banks include securitization vehicles, asset-backed commercial paper (ABCP) conduits, MMFs, broker-dealers, and mortgage companies. Like commercial banks, shadow banks transform long-term illiquid assets into short-term money-like claims. Since households and businesses have a preference for liquidity, issuing money-like claims allows shadow banks to lower their financing costs.

Figure 3 provides a simplified representation of the U.S. banking system.[9] The upper branch represents the commercial banking sector, while the lower branch represents the shadow banking sector. Unlike commercial banks, which combine deposit creation and loan origination under one roof, the shadow banking system separates the intermediation process into different entities. MMFs constitute the first stage of the shadow banking intermediation process. MMFs take deposits from households and businesses and then pass the proceeds to other shadow banks such as securitization vehicles, mortgage conduits, broker dealers, and mortgage companies that specialize in loan origination. In this process, MMFs create

[8]Former Federal Reserve Chair Ben Bernanke provided a definition of the shadow banking system in April 2012: "Shadow banking, as usually defined, comprises a diverse set of institutions and markets that, collectively, carry out traditional banking functions but do so outside, or in ways only loosely linked to, the traditional system of regulated depository institutions."

[9]A more detailed description of the shadow banking intermediation process can be found in Pozsar, Adrian, Ashcraft, and Boesky (2010).

money-like liabilities—MMF shares—which resemble commercial bank deposits.

MMF shares are widely (though not necessarily accurately) regarded as being as safe as bank deposits while providing a higher yield. Similar to commercial bank deposits, MMFs provide intraday liquidity, and some of them even allow depositors to write checks on their deposits. Due to their similarity to commercial bank deposits, MMF shares are included in official money supply statistics. The amount of MMF shares also provides a good proxy of the quantity of funds flowing into the shadow banking sector.

While shadow bank deposit creation is conducted by MMFs, loan origination is conducted by different shadow banking entities such as funding corporations, finance companies, mortgage companies, captive financial institutions, and broker-dealers. For example, Quicken Loans and PHH are shadow banks that specialize in loan origination in the mortgage market. These "loan-originating shadow banks" do not issue deposits directly to depositors. Instead, they obtain a significant amount of funding from MMFs through issuing money market instruments.

Over the past thirty years, the shadow banking sector has become increasingly important in the economy. Based on the aggregate money supply statistics from the Federal Reserve, the share of shadow bank deposits has increased from around 15% in the 1980s to around 40% in 2007, while the share of commercial bank deposits is on a downward trend.

2.2 Data Sources

The first main database used in this paper is iMoneyNet. This data set provides monthly share-class level data for U.S. MMFs dating back to 1985. After a cross-check with the aggregate money supply statistics from the Federal Reserve Board, I find that this database covers essentially all the MMFs after 1987. The data contain detailed information on fund characteristics such as deposit amounts, charged expense ratios, yields, management costs, and other costs. Portfolio holding information became available in 1998 and includes average portfolio maturity and portfolio weights by asset class. As data on shadow banks are

generally very scarce, this data set provides a rare glimpse into the inner workings of the shadow banking system.

The second main data set is the Consolidated Report of Condition and Income, generally referred to as the Call Report. This data set provides quarterly bank-level data for every U.S. insured commercial bank, including detailed accounting information such as deposit amounts, interest income, salary expenses, and fixed-asset expenses. I complement the Call Report with the FDIC Summary of Deposits, which provides branch-level information on deposit amounts annually since 1994. Following the literature, deposit rates are imputed from bank financial statements by dividing deposit interest expenses over the total amount of deposits (Dick 2008). In the following analysis, I focus on "liquid deposits" which are defined as the sum of checking and savings deposits.[10] Table 1 provides the summary statistics of the final sample used for the structural estimation.

In addition to the two main data sources above, I also use the Survey of Consumer Finance (SCF) 2013 to obtain depositor-level deposit holdings and demographic information. Finally, I retrieve aggregate time series of the amount of cash held by households and the Fed Funds rates from the Federal Reserve Economic Data (FRED). I retrieve aggregate time series of the amount of Treasury bills held by households from the Financial Accounts of the United States.

2.3 Stylized Facts

In this section, I document a set of new stylized facts on monetary transmission through the shadow banking system. First, I investigate the effect of monetary policy on shadow bank money creation. Specifically, I break down the aggregate money supply into cash, commercial bank deposits, and shadow bank deposits. Commercial bank deposits include demand and savings deposits. Shadow banking deposits include retail MMF shares and institutional

[10] Previous literature has shown that the pricing and quantities of "liquid deposits" are quite different from "illiquid deposits" such as small-time savings deposits (Driscoll and Judson 2009; Drechsler et al. 2017).

MMF shares. Figure 1 plots the Fed Funds rates and the annual deposit growth rates of each banking sector over time. Conventional monetary transmission channels predict that high Fed Funds rates have tightening effects on the money supply (Bernanke and Blinder 1988; Kashyap and Stein 1995, 2000; and Drechsler et al. 2017). This prediction has been verified by prior literature, which I replicate here. The top panel of Figure 1 shows the growth rates of commercial bank deposit rates and the Fed Funds rates. Consistent with conventional wisdom, high Fed Funds rates are associated with low growth rates of commercial bank deposits.

What remains unknown is what happen to shadow bank deposit creation. The bottom panel of Figure 1 plots the deposit growth rates of shadow banks. In contrast to conventional wisdom in the commercial banking sector, high Fed Funds rates are associated with high growth rates of shadow bank deposits. This means that monetary tightening has an expansionary effect on shadow bank money creation. Formally, I regress deposit growth rates of each banking sector on the Fed Funds rates, controlling for a list of macroeconomic variables such as GDP growth rates, inflation, TED spread, and a time trend:

$$Deposit\ Growth\ Rates_t = \alpha + \beta Fed\ Funds\ Rates_t + \gamma X_t + \epsilon_t \tag{1}$$

Table 2 presents the results. Consistent with the graphical observation, monetary policy has opposite effects on these two sectors: a 1% increase in the Fed Funds rates is associated with a 2.29% decrease in the growth rates of commercial bank deposits, but a 4.11% increase in the growth rates of shadow bank deposits. The estimates are both statistically and economically significant. In column 4 of Table 2, I regress the growth rates of the total money supply on the Fed Funds rates. Although the sign of the coefficient is still negative, it is insignificantly different from zero. This is because shadow bank deposit creation partially offsets the reduction of commercial bank deposits and attenuates the impact of monetary tightening on aggregate money supply. To address the concern that unconventional monetary policy post-2008 may drive the result, I repeat the analysis using the post-2008 sample. As

shown in columns 5-8 of Table 2, the result is very similar to the full sample analysis.[11]

Next, I consider the asset side of MMFs. There are four major categories of money market instruments held by MMFs: commercial paper (CP), asset-backed commercial paper (ABCP), repurchase agreements (repo), and floating rates notes (FRNs). By buying these money market instruments, MMFs lend to the "loan-originating shadow banks" such as mortgage companies and finance companies which conduct loan origination but do not issue deposits. As more deposits flow into MMFs, they should increase their lending to these "loan-originating shadow banks". To verify this conjecture, I regress annual growth rates of MMF lending by each type of money market instruments on the Fed Funds rates, controlling for macroeconomic variables, fund characteristics, and fund fixed effects:

$$MMF\ Lending\ Growth\ Rates_{i,t} = \alpha + \beta Fed\ Funds\ Rates_t + \gamma X_{i,t} + \epsilon_{i,t}. \tag{2}$$

Columns 1 to 4 of Table 3 show that MMFs significantly increase their lending as the Fed Fund rates increase. The economic magnitude is significant: a 1% increase in the Fed Fund rates is associated with a 0.17–0.78% increase in lending from MMFs to other shadow banks. In addition to the four types of money market instruments discussed above, MMFs also hold commercial bank obligations, which are issued by commercial banks to obtain short-term funding. Column 6 of Table 3 shows that MMFs also increase the holding of large denomination bank obligations when the Fed raises interest rates. This result reveals an interesting interaction between the shadow and commercial banking system. As the Fed tightens monetary policy, commercial banks borrow more from MMFs to compensate for their loss of the core deposits.[12] This may have implication for financial stability as core deposits are often insured while large denomination bank obligations are not.

Next, I examine the asset growth rates of the "loan-originating shadow banks". I conjecture that with an increase in funding supply from MMFs, the loan-origination shadow

[11] One may also wonder whether the result may differ across retail MMFs and institutional MMFs. In Figure 1 of the Online Appendix, I plot the deposit growth rates of retail and institutional MMFs separately. The cyclical pattern is quite similar for both retail and institutional MMFs while the magnitude is slightly greater for institutional ones.

[12] Choi and Choi (2016) examine commercial bank liability data and reach a similar conclusion.

banks should be able to expand their credit supply. Specifically, I look at five types of shadow banks that rely on MMFs to obtain financing: funding corporations, finance companies, ABCP issuers, captive financial institutions, and broker-dealers. I regress aggregate asset growth rates of these five types of shadow banks on the Fed Funds rates and various macroeconomic controls:

$$Shadow\ Bank\ Asset\ Growth_t = \alpha + \beta Fed\ Funds\ Rates_t + \gamma X_t + \epsilon_t. \tag{3}$$

Table 4 presents the results. When the Fed Funds rates are high, the assets of these shadow banks also grow faster. Taken together, the results show that monetary tightening has a surprising expansionary effect on the quantity of shadow bank deposits and loans.

To understand why monetary tightening has an expansionary effect on shadow banks, I examine interest rates of shadow bank deposits and loans. The upper panel of Figure 2 plots the average deposit rates of commercial banks and MMFs over time. I find that the spread between shadow and commercial bank deposit rates widens when the Fed increases interest rates. The effect is economically significant. For example, in the 2004–2006 tightening cycle, the difference in deposit rates increased from less than 0.5% to nearly 3%. As transaction convenience of bank deposits is relatively stable over time, such big changes in relative yields may significantly affect depositors' choice between these two banking sectors. This seems to be consistent with the fact that the quantity of shadow bank deposits expand in periods of high interest rates.

Now I examine lending rates of shadow banks. The lower panel of Figure 2 plots the average lending rates of 30-year fixed-rate mortgages issued by commercial banks and shadow banks.[13] Unlike deposit rates which diverge significantly over monetary policy cycles, the two types of banks have very similar mortgage lending rates. I also find that lending rates of other types of loans are quite similar between shadow and commercial banks.[14]

This result suggests that the different response of shadow banks originates from the

[13]Shadow banks considered here are mortgage companies specializing in mortgage origination.
[14]The result is reported in Online Appendix Figure 2.

deposit market rather than the loan market. In the following section, I will propose a model of deposit competition to explain why monetary policy has a different impact on shadow bank deposit creation.

3. A Structural Model of Bank Competition

3.1 Intuition

In this section, I develop a structural IO model to rationalize the above empirical findings. There are two key ingredients of the model. First, commercial and shadow bank deposits offer different degrees of transaction convenience. Specifically, commercial bank deposits have higher convenience because of branch networks, ATMs, and payment systems offered by commercial banks.[15] In contrast, shadow bank deposits have lower convenience because they cannot offer some of the transaction services due to charter restrictions.[16] To compensate for the lack of transaction convenience, shadow banks usually compete on yields.

The second key ingredient of the model is that depositors exhibit heterogeneous preference over convenience and yields. There is a group of "transaction-oriented" depositors who care a lot about transaction convenience, but are not very sensitive to yields. For example, "mom and pop" depositors are typical transaction-oriented depositors, who choose banks mainly based on geographical proximity rather than deposit rates paid by banks. There is also a group of "yield-oriented depositors" who are very sensitive to yields but are relatively insensitive to convenience. For example, large corporations and wealthy individuals are typical yield-oriented depositors. They are less concerned about transaction convenience but are very sensitive to yields.

[15] In addition, the deposit insurance on commercial bank deposits may also increase their convenience relative to shadow banks. Deposit insurance is less relevant for very large depositors because the FDIC only insures commercial bank deposits up to a certain amount.

[16] In practice, some MMFs provide check-writing services by working with commercial banks. However, there are restrictions on the minimum dollar amount for each check and the number of checks allowed per month.

These two groups of depositors are likely to self-select into different types of banks. Commercial banks are likely to attract more transaction-oriented depositors because of their superior transaction services, while shadow banks attract more yield-oriented depositors because of high deposit rates. Consistent with this idea, using the Survey of Consumer Finances (SCF) 2013, I find that depositors who are wealthy or more sophisticated (proxied by college education) are more likely to choose shadow banks. The result is reported in Table 5.

Facing different depositor clientèle, shadow and commercial bank deposit rates exhibit different sensitivities to monetary policy. When the Federal Reserve increases interest rates, commercial banks are not pressured to increase their deposit rates because their main depositor clientèle—transaction-oriented depositors—are attached to transaction services offered by commercial banks. This allows commercial banks to keep deposit rates relatively low and earn higher spreads between lending rates and deposit rates. In contrast, shadow banks have to raise their deposit rates with the market interest rates. Otherwise, their yield-oriented clientèle will switch to other higher-yielding liquid assets such as short-term bonds. As a result, when the Fed raises interest rates, the gap between shadow and commercial bank deposit rates widens and some of the marginal depositors will switch from commercial banks to shadow banks. This explains why shadow bank deposits expand while commercial bank deposits shrink during monetary tightening. In the following analysis, I refer to this channel as the "shadow money channel" because the different response of shadow banks to monetary policy originates from the deposit market rather than the loan market.

3.2 Model Setting

Having shown the basic intuition of the shadow money channel, I now proceed with offering a structural model to formalize the idea. I introduce imperfect competition between differentiated banks following Berry et al. (1995) (BLP) into the Bernanke and Blinder (1988) formulation of the bank lending channel. Bernanke and Blinder (1988) argue that since bank

loans and bonds are not perfect substitutes, there is a distinctive transmission channel of monetary policy through banks in addition to the neoclassical channel through bond-market interest rates.[17] This paper introduces shadow banks into the banking system and studies how shadow banks affect the transmission of monetary policy through the banking system.

3.3 Depositors

There are a group of depositors with a measure of 1. Each of them is endowed with one dollar. Depositors make a discrete choice among options including bonds, cash, commercial bank deposits, or shadow bank deposits. Each option j is characterized by a pair of convenience and deposit rate, (ℓ_j, r_j). Since shadow banks do not have bank charters that allow them to offer many transaction services, the convenience of shadow bank deposits is lower than commercial bank deposits.

$$\ell_{j \in SBs} < \ell_{j \in CBs} \tag{4}$$

In addition to bank deposits, depositors can also choose cash or bonds. Cash has the highest convenience but zero returns, while bonds have the highest return but no transaction convenience. The return of bonds equals to the Fed Funds rates, f, which are determined by monetary policy.

The optimization problem of the depositor is to choose the option which gives rise to the highest utility. The assumption that each depositor has only one dollar and can choose only one option is not as restrictive as it may appear. We can think as if depositors make multiple discrete choices for each dollar that they have, and the probability of choosing each of the options can be interpreted as the portfolio weight. Formally, define the utility of product j of depositor i as $u_{i,j}$, the depositor's problem is

$$\max_{j \in \{0,1,\ldots,J+1\}} u_{i,j} = \alpha_i r_j + \ell_j + \epsilon_{i,j} \tag{5}$$

[17] Bonds and bank loans are not perfect substitute because: i) many small and mid-size firms do not have access to bond market, ii) bonds and bank loans differ in monitoring and renegotiation.

r_j is the deposit rate, ℓ_j is the transaction convenience, $\epsilon_{i,j}$ is a mean-zero idiosyncratic utility shock for depositor i if choosing product j, which follows the extreme value distribution with a cumulative distribution function $F(\epsilon) = exp\{-exp(-\epsilon)\}$. This distribution assumption is standard in structural IO literature. It allows closed-form solution of the choice probabilities. $\{0, 1, ..., J, J+1\}$ is the choice set, where 0 represents cash, $1, ..., J$ represent commercial banks and shadow banks, and $J+1$ represents bond. Finally, α_i is sensitivity to deposit rates for each depositor type i.

$$\alpha_i = \alpha + \sigma v_i \tag{6}$$

where α is the mean of yield sensitivity and v_i is the depositor-specific taste on yields. If v_i is big, it means that depositor i is yield-sensitive. σ captures the heterogeneity among depositors. When $\sigma > 0$, depositors face different trade-offs between yield and convince. When $\sigma = 0$, depositors become homogeneous.[18]

Define $s_{i,j}$ as the choice probability for depositor type i to choose product j. Use the property of the extreme value distribution, the choice probability is given by the following formula:

$$s_{i,j}(r_j|f) = \frac{\exp(\alpha_i r_j + \ell_j)}{exp(\alpha_i f) + \exp(\ell_0) + \sum_{l=1}^{J} \exp(\alpha_i r_l + \ell_l)} \tag{7}$$

The numerator is the exponential utility from holding deposits of bank j. The denominator is the sum of exponential utility from all competing products in the market. Intuitively, if the bank j generates a higher utility, it is more likely to be chosen. Note that the first term in the denominator, $exp(\alpha_i f)$, represents the exponential utility from bonds. When the Fed raises interest rates, bonds become more attractive and banks respond by raising their deposit rates. The second term, $\exp(\ell_0)$, is the utility of holding cash. The competition from cash prevents banks from offering negative deposit rates. The rate setting decision of the banks is described in the following section.

[18] An implicit assumption here is that banks cannot conduct perfect price discrimination, that is, offering a different deposit rate to each type of depositor. In reality, banks do try to conduct some form of price discrimination. However, it is reasonable to believe such price discrimination is far from perfect since banks still face a trade-off between deposit volumes and rates.

The demand for deposits of bank j is given by summing the choice probability over different depositor types

$$d_j(r_j|f) = \sum_i \mu_i s_{i,j}(r_j|f) \tag{8}$$

where μ_i is the frequency of type i depositors. Since I normalize the total wealth to \$1 so the demand is the same as the market share.

3.4 Banks

Banks borrow from depositors and then lend to borrowers. Bank loans are homogeneous products so that banks are price-takers in the loan market. The aggregate lending rate is determined by the aggregate loan demand function, $L(r_L)$

$$L(r_L) = L_s \tag{9}$$

where r_L is the lending rate and L_s is the loan supply.[19]

On the deposit market, bank deposits are differentiated. Each bank faces its own demand function and is able to set its own deposit rates to maximize profits. For a given market loan rate, r_L, and a demand function for deposits, $d_j(r_j|f)$, a bank decides its deposit rate, r_j, to maximize profits.

$$\max_{r_j} (r_L - r_j - c_j)\, d_j\,(r_j|f) \tag{10}$$

where r_L is the lending rates, r_j is the deposit rate of bank j, c_j is the marginal cost of providing depository services, and $d_j\,(r_j|f)$ is the demand function for bank j's deposits.[20]

Banks' optimal pricing decision is given by the following first order condition:

$$\text{FOC: } r_L - r_j = \left(\frac{\partial \log\left(d_j(r_j|f)\right)}{\partial r_j} \right)^{-1} + c_j \tag{11}$$

[19]Note that monetary policy may directly affect the loan demand function. To elaborate, if borrowers can substitute between bonds and bank loans, an increase in the bond interest rates increases the demand for bank loans. This leads to an increase in lending rates for a given loan supply. In this case, I can write the loan demand function as $L(r_L|f) = L_s$.

[20]As discussed in Section 2, in practice MMFs do not directly lend to ultimate borrowers. Instead, they pass deposits to "loan-originating shadow banks" or even to commercial banks. However, which banks conduct loan origination is not crucial here because loans are homogeneous. What matters is the total amount of deposits raised by the banking system as a whole.

The left-hand side is the interest margin. On the right-hand side, the first term $\left(\frac{\partial \log(d_j)}{\partial r_j}\right)^{-1}$ is the markup that a bank can charge on its depository service over the cost of providing it. It is inversely related to the demand elasticity. If the demand is inelastic, then the bank can charge a higher markup. In contrast, if the demand is elastic, then the markup is likely to be low. The second term is the marginal cost. A higher marginal cost leads to a higher interest margin. Monetary policy may affect banks through these two channels. In Section 4, I will estimate their relative contribution in the data.

I can decompose the interest margin into two components, $r_L - r_j = (r_L - f) + (f - r_j)$. The first component, $r_L - f$, is the lending spread. Since loans are homogeneous products, the lending spread is determined by aggregate supply and demand of loanable funds. The second component, $f - r_j$, is the deposit spread. Since deposits are differentiated, banks choose their own deposit spreads according to their own deposit demand. From the perspective of depositors, the deposit spread is also the price that they pay for the depository services.

3.5 Equilibrium

The Fed Funds rates, f, is chosen exogenously by monetary policy makers. For a given Fed Funds rate, f, each banks chooses its optimal deposit rate, r_j^*, and each depositor chooses its optimal investment, j^*, such that the deposit market clears. The lending market clears at an equilibrium lending rate, r_L, such that the aggregate loan demand equals the aggregate loan supply, $L(r_L^*) = L_s = \sum_{j=1}^{J} d_j(r_j^*|f)$.

3.6 Numerical Example

Before I take the model to the data, it is useful to use a set of numerical examples to show how monetary policy is transmitted in a banking system with both commercial and shadow banks.

First, consider the case in which there is no friction in the banking system. Specifically,

competition is perfect and banks can costlessly create deposits and loans. In this benchmark case, banks keep creating deposits until the marginal liquidity premium of deposits is zero. In the competitive limit, banks have no market power to charge any spread so that both the deposit rates and lending rates equal the bond market interest rate. In this frictionless case, monetary transmission through the banking system is completely summarized by the Fed Funds rates.

Imperfect competition creates a spread between bond-market interest rates and deposit rates as banks extract rents from their liquidity creation. How deposit speads respond to monetary policy crucially depends on depositor clientèle. When the Fed raises interest rates, commercial banks are able to widen their spreads by continuing to pay low deposit rates to the transaction-oriented depositors. However, shadow banks have to keep a tight spread; otherwise, their yield-oriented depositors will switch to bonds. This difference in depositor clientèle gives rise to the "shadow money channel" documented in Section 2 where shadow banks pass through more rate increases to depositors than commercial banks.

To illustrate this channel, I solve the model under two sets of parameters. In the benchmark case, shadow banks and commercial banks only differ in their transaction convenience. The second case introduces heterogeneous depositors, which allow monetary policy to have different impacts on market power. The set of parameters are presented in Table 6. For simplicity, I assume a constant lending spread of 0.5%.

The first row of Figure 4 shows that when the only difference between commercial and shadow banks is convenience, the two banking sectors respond to monetary policy in a very similar way. Commercial banks charge a higher spread and attract a larger share of deposits. Such difference, however, is stable over monetary cycles because the difference in convenience is constant. Therefore, the difference in convenience alone does not explain why two banking sectors respond to monetary policy in different ways.

The second row of Figure 4 shows the case in which depositors have heterogeneous yield sensitivity. Transaction-oriented depositors self-select into commercial banks while yield-

oriented depositors self-select into shadow banks. The difference in depositor clientèle gives rise to different pricing response to monetary policy. As the Fed Funds rates increase, commercial banks increase their markups while shadow banks keep charging a thin markup. This leads to a reduction in commercial banks' credit supply and an expansion of shadow banks' credit supply.

It is notable that different depositor clientèle is not the only institutional feature that could explain the different responses to monetary policy across shadow and commercial banks. An alternative channel is the reserve requirement. By regulation, commercial banks are required to hold reserves while shadow banks are not. As the Fed Funds rates increase, the opportunity cost of holding bank reserves goes up, which could also lead to an increase in deposit spreads of commercial banks. In contrast, shadow banks are not subject to the reserve requirement. Therefore, higher Fed Funds rates can lead to an expansion of the shadow banking sector.[21] The third row of Figure 4 shows the case in which shadow banks and commercial banks have different reserve costs. We can see similar patterns in deposit spreads and deposit amounts as the data.

It is difficult to disentangle the explanations based on clientèle from the explanation based on reserve requirement by looking at deposit rates and deposit amounts because they generate the same predictions qualitatively on these two variables. However, the model shows that these two explanations work through different components of the deposit spreads. Reserve requirements suggest that the effect of monetary policy should go through marginal costs, while clientèle heterogeneity suggests that the effect of monetary policy should go through markups. Columns 3 and 4 in Figure 4 show a decomposition of the deposit spreads into marginal costs and markups according to equation 11. With different depositor clientèle, the markups of commercial banks increase with the Fed Funds rates while the markups of

[21] Here is an example illustrating how reserve requirement affects the deposit spread. Suppose the reserve ratio is λ_j and the interest on reserve is zero. The profit of the bank is $((1-\lambda_j)r_L - r_j - c_j)d(r_j|f)$. Rearranging the terms we get $(r_L - r_j - (c_j + \lambda_j r_L))d(r_j|f)$, where $\lambda_j r_L$ captures the opportunity cost of holding bank reserves and this cost is increasing to the level of interest rates. The reserve requirement also has a direct effect on the loan supply because the aggregate loan supply becomes $\sum_{l=1}^{J} d_j(r_j^*)(1-\lambda_j)$ with reserve requirement. However, such effect does not vary with interest rates.

shadow banks remain stable. In contrast, with different reserve requirements, the marginal costs of commercial banks increase when the Fed Funds rates increase while the marginal costs of shadow banks remain stable.

4. Structural Estimation

In this section, I take the model to the data. The goal here is to estimate the primitive structural parameters and pin down the exact mechanism of monetary transmission. This will set the stage for the ensuing counterfactual analysis.

4.1 Parametrization

In the data, we cannot directly observe transaction convenience. Therefore, I specify transaction convenience as a function of observable product characteristics such as branch density and number of employees per branch.[22] Formally, define x_j as a vector of product characteristics of bank j and β as a vector of sensitivities to these product characteristics. The transaction convenience of bank j is given by

$$\ell_j = \beta' x_j \tag{12}$$

Note that the linear form of utility does not mean that depositors do not care about risk. In fact, aversion to risk can be easily incorporated by introducing a measure of risk such as the TED spread in the vector of product characteristics.[23] In this sense, ℓ_j can be broadly interpreted as a combination of transaction convenience and safety convenience.

Similarly, I specify the marginal cost as a linear function of cost shifters

$$c_j = \gamma' w_j + \omega_j \tag{13}$$

where w_j is a vector of observable supply shifters. Examples of supply shifters of a commercial

[22] Branch density and number of employees per branch are zero for a shadow bank.

[23] This is similar to the mean-variance utility function in which aversion to risk is modeled as a disutility to volatility.

bank include salary paid to employees and fixed-asset expenses. Examples of supply shifters of an MMF include management costs and other operating costs. γ is the sensitivity of marginal cost to these cost shifters. ω_j is an idiosyncratic supply shock.

To characterize the equilibrium in the deposit market, I need to know a set of preference parameters, α, σ, and β, which govern how depositors value different products. I also need to know a set of supply parameters, γ, which govern how much it costs to produce them. Formally, I can pin down these parameters by estimating the following two equations.

$$\delta_j(\sigma) = \alpha r_j + \beta' x_j + \xi_j \tag{14}$$

$$c_j = \gamma' w_j + \omega_j \tag{15}$$

where $\delta_j = E[u_{i,j}]$ is the mean utility of product j across all depositors and ξ_j is an unobservable common demand shock to all depositors for product j. The challenge here, however, is that neither mean utility, δ_j, nor marginal costs, c_j, are observable. To compute these two unobservable quantities, I use the optimality conditions of the model. Specifically, I use the optimal choices of depositors to link utility to market shares. I numerically solve δ from a system of $J+1$ implicit equations using the fixed-point algorithm introduced by Berry et al. (1995) for a given value of σ

$$d(\delta; \sigma) = d_0 \tag{16}$$

where $d(.)$ is a vector of $J+1$ demand (market share) function defined in equation 8, and d_0 is the vector of $J+1$ observable market shares. Solving δ from the implicit equation system, we have the mean utility equation

$$\underbrace{\delta_j(\sigma)}_{\text{Unobservable}} = d^{-1}\left(\underbrace{d_0}_{\text{Observable}}; \underbrace{\sigma}_{\text{Unobservable}}\right)_j = \alpha r_j + \beta' x_j + \xi_j \tag{17}$$

where $d^{-1}(.)$ is the inverse function of the demand equation 8.

On the supply side, I can solve the unobservable marginal costs as the difference between interest margin, and markups. The markups can be estimated from the demand parameters,

α, σ, and β.

$$\underbrace{c_j}_{\text{Unobservable}} = r_L - r_j - \underbrace{\left(\frac{\partial \log(d_j)}{\partial r_j}\right)^{-1}}_{\text{Unobservable}} \tag{18}$$

The real strength of the structural model is manifested in equations 17 and 18, where the optimality conditions of depositors and banks link unobserved primitives (preference and technology parameters) to observable quantities (such as market shares, deposit rates, etc.).

4.2 Identification

I first estimate the mean utility equation (14). Given the estimated demand-side parameters, I calculate the marginal costs and estimate the cost coefficients of equation (15).

A key challenge in identifying the demand parameters is that deposit rates are correlated with unobservable demand shocks, ξ_j. As a result, yield sensitivity α will be biased in an OLS regression of mean utility, δ_j, on deposit rates, r_j. I follow the literature to use a set of cost shocks, z_j, as instrument variables. Examples of instrument variables include salary, expenses of fixed assets, and other operating costs. These instruments are standard in the literature (Adams, Brevoors, and Kiser 2007; Ho and Ishii 2011). The rationale is that these supply shifters affect depositors' demand only through deposit rates or product characteristics instead of directly entering depositors' utility. In other words, these shocks shift the supply curve without moving the demand curve. This allows me to trace out the slope of the demand curve.

The moment condition of the mean utility equation is given by the orthogonality condition between the unobservable demand shocks, ξ_j, the product characteristics, x_j, and cost shifters, z_j:

$$E\left[\xi_j\left[x_j, z_j\right]\right] = 0 \tag{19}$$

Formally, define θ as a vector of demand parameters, $\theta = [\sigma, \alpha, \beta]$, $Z = [x, z]$, W as a

consistent estimate of $E[Z'\xi\xi'Z]$. The GMM estimator of the demand parameters is

$$\hat{\theta} = \arg\min_{\theta} \xi(\theta)' Z W^{-1} Z \xi(\theta) \tag{20}$$

As discussed above, an important distinction of the above estimation from standard GMM is that the dependent variable, δ, is not directly observable. I use the Nested Fixed Point (NFP) algorithm as detailed in Nevo (2000). The algorithm first searches over the non-linear parameter space of σ. Second, for a given σ, it solves $\delta_j(\sigma)$ through a fixed-point algorithm using the market share equation. Third, I find a set of linear parameters α, β, which minimize the GMM objective function. I repeat the three steps until the optimal set of parameters α, β, and σ is found.[24]

Estimating the supply-side equation is more straightforward. The moment condition of the cost equation is given by the orthogonality condition between the idiosyncratic supply shock, ω_j, and observable cost shifters, w_j:

$$E[\omega_j w_j] = 0 \tag{21}$$

The supply parameters γ can be estimated by an OLS regression of the marginal cost on the supply shifters. Note that since the preference parameters used to compute the marginal cost are estimated from the first stage, the standard errors of the second stage are corrected using the approach in Newey and McFadden (1994).

While it is relatively easy to see how α, β, and γ are identified, the identification of σ is worth further elaboration. Intuitively, σ measures the dispersion of depositors' yield sensitivity. A greater dispersion means that different banks have very different demand elasticity. Therefore, if we observe that the same change in deposit rates leads to quite different changes in market share, that implies that depositors have a quite dispersed yield-sensitivity.[25]

[24] In addition, to increase the estimator's efficiency and stability, I use the set of optimal instruments suggested by Reynaert and Verboven (2014). The optimal instruments are defined as the conditional expectation of the derivatives of the residuals with respect to the parameter vector. The details of constructing the optimal instruments can be found in Reynaert and Verboven (2014).

[25] In Table 1 in the Online Appendix, I show that market shares of shadow banks are much more sensitive to rate changes compared to commercial banks in a simple reduced form regression.

4.3 Data for Structural Estimation

The data used for the structural estimation are a panel of commercial banks and MMFs from 1994 to 2012. Following the literature, a market is defined as an MSA-year combination. Since commercial banks attract deposits mainly through local branches, the choice set of depositors of an MSA includes commercial banks that have local branches in the MSA. In contrast, MMFs generally compete in a national market through telephones and the internet. Therefore, local depositors can access all the MMFs in the market. In addition to deposits, depositors can also choose to hold cash that bears no interest. In addition, depositors can also choose cash or Treasury bonds.

I first construct a measure of market shares for each product. Market shares are typically measured in terms of purchase flows in the IO literature, but unfortunately, gross deposit inflows are not observable in the data. Therefore, I construct a flow-based market share measure in a similar spirit to the partial adjustment model of the money demand literature (see Goldfeld and Sichel 1990, and the reference therein). Specifically, I assume only a fraction of $1-\rho$ of depositors can adjust their choices in each year. The flow-based market share, $d_{j,t}$, is defined as the share of depositors who chooses bank j if they can adjust their portfolios in year t. I solve the flow-based market share from the observable stock-based market shares, $\bar{d}_{j,t}$, from the following relation: $\bar{d}_{j,t} = \rho \bar{d}_{j,t-1} + (1-\rho) d_{j,t}$.[26]

I calculate stock-based market shares of a commercial bank by summing deposits of local branches of the bank in the MSA. For MMFs, no MSA-level information on quantities is available. I impute MSA-level deposit amounts assuming that they are proportional to local personal income levels. More specifically, I first compute the percentage contribution of an

[26] In the baseline estimation, I use a value of 0.7 for ρ which is consistent with the estimates in Goldfeld and Sichel (1990). The partial adjustment process is a simple way to capture the stickiness in deposits. Using stock-based market shares directly in the estimation is problematic since the adjustment of stock-based market shares to steady state may be very slow. An alternative approach is to directly model the slow adjustment process. However, this alternative approach requires solving a dynamic industrial equilibrium with high dimensional state space (each bank's past clientèle composition becomes part of the state variables), which could be very hard to solve.

MSA's total personal income to the national aggregate of personal income. Then I calculate the average over the whole sample period. Finally, I impute the MSA-level deposits according to the average contribution. I apply the same procedure to cash and Treasury bills. The total market size is total financial wealth in an MSA. Following the literature, I combine tiny banks and MMFs (market share less than 0.2%) with the outside option.

Product characteristics are chosen based on the belief that they are important and recognizable to depositors' choice. Product characteristics include branch density, number of employees per branch, an interaction term between TED spreads and the banking sector dummies, and bank fixed effects. The interaction term between TED spreads and the sector dummies is a proxy of the default risks of the two banking sectors. Egan et al. (2017a) use CDS spreads of banks as a proxy of risk. However, since bank-level CDS spreads are not widely available for small commercial banks or any of the MMFs, I use the TED spread and its interaction with the banking sector dummies to capture sector-level variations in default risk. Finally, I include time fixed effects to absorb aggregate demand shocks and MSA fixed effects to absorb cross-market differences in demand.

The marginal cost equation includes a set of cost shifters. The cost shifters of MMFs include management costs and other operating costs. The cost shifters of commercial banks include salary expenses, expenses of fixed assets, and reserve costs. This set of cost shifters of commercial banks is also used in previous literature such as Dick (2008) and Ho and Ishii (2011). Note that different types of deposits face different research requirements. I calculate the weighted average reserve ratio for each bank using the actual amount of reserves divided by the amount of deposits. Then I multiply the reserve ratio with the Fed Funds rates to get the opportunity cost of holding reserves. Lastly, I include bank fixed effects to absorb time-invariant bank-specific cost shocks. These cost-shifters and their second-order polynomials also serve as instruments for the demand-side estimation.

Table 1 provides summary statistics of the sample used for the structural estimation. A commercial bank typically has a larger market share than an MMF: the average market

share is 2.12% for a commercial bank and is 0.37% for an MMF. A commercial bank also tends to offer lower deposit rates than shadow banks: the average deposit rates are 1.72% for commercial banks and 3.05% for MMFs. A commercial bank on average has 8.14 branches per million population in an MSA, and each branch has 16 employees.

4.4 Model Fit

This section presents the results of the structural estimation. The first and second rows of Figure 5 show the average deposit rates and market shares for commercial and shadow banks separately. The model generates different pass-through from the Fed Funds rates to deposit rates between commercial and shadow banks. The model also successfully generates countercyclical market shares for commercial banks and procyclical market shares for shadow banks. The magnitude matches the data closely. Given that the parameters are identified primarily off the cross-section variations, it is remarkable that the model is able to match the different time series variations for shadow and commercial banks.

4.5 Parameter Estimates

There are two key elements of the model: 1) depositors have heterogeneous sensitivities to yield; 2) the transaction convenience of shadow bank deposits is lower than commercial bank deposits. I verify these two conditions with the parameter estimates. Table 7 reports the demand parameters. Column 1 shows the estimates of a logit model where depositors are homogeneous while Column 2 shows the BLP model where depositors have heterogeneous yield sensitivity. Both models show that the estimated yield sensitivity is positive and significant. Most importantly, the BLP model in column 2 shows that there is statistically significant dispersion in depositors' sensitivity to yields. Later I will show that this parameter is crucial in the transmission mechanism.

I have shown that depositors indeed exhibit heterogeneous yield sensitivity. Now I ex-

amine the second condition: whether transaction convenience of shadow bank deposits is lower than commercial bank deposits. Table 7 show that depositors prefer higher branch density and more employees per branch. Depositors also exhibit aversion to default risks of the banking sector, as higher TED spreads are associated with lower convenience levels. The effect is stronger for the shadow banking sector, consistent with the fact that shadow bank deposits are not insured. Taking all the characteristics together, I get an estimate of convenience for each bank. Figure 6 is the histogram of the estimated convenience. Consistent with the intuition, shadow banks have lower estimated convenience than commercial banks.

With commercial and shadow banks offering differentiated products, I expect different types of depositors to self-select into different types of banks. The estimates show that this is indeed the case. Table 8 shows the summary statistics of the estimated demand elasticity. The median own-rate elasticity of commercial banks is 0.358. This estimate is close to the value estimated by previous literature such as Egan et al. (2017a). The median own-rate elasticity of MMFs is 0.904, which is almost three times as large as that of commercial banks. This estimate suggests that the clientèle of MMFs is more yield-sensitive than that of commercial banks.

Next, I examine the cross-rate demand elasticity. The cross-rate elasticity measures the percentage change of market share due to changes in deposit rates of a competitor. Table 9 presents the median and standard deviations of cross-rate elasticity. A 1% increase in the deposit rates of a commercial bank lowers a rival commercial bank's market share by 0.003%, and a rival shadow bank's market share by 0.006%. A 1% increase in the deposit rates of a shadow bank lowers a rival commercial bank's market share by 0.001%, and a rival shadow bank's market share by 0.003%. The takeaway is that the demand of an MMF is quite sensitive to its competitors' rates, while the demand of a commercial bank is relatively insensitive to its competitors' rates.

Table 10 presents the estimated cost coefficients of the logit and the BLP model. For commercial banks, higher reserve costs, salary expenses, and expenses of fixed assets are

associated with higher marginal costs. For MMFs, higher management costs and other costs are associated with higher marginal costs.

4.6 Transmission Mechanism

Next, I use the estimates to explore the transmission mechanism of monetary policy in a banking system with heterogeneous banks. Figure 7 provides a scatter plot of deposit rates against convenience in an MSA market. Each dot represents one commercial bank or MMF. The red horizontal line represents the Fed Funds rates. The left panel shows the year 2004—when the Fed Funds rates were low, while the right panel shows the year 2006—when the Fed Funds rates were high. This figure shows three main results. First, Commerical banks cluster around the higher end of the convenience while MMFs cluster around the lower end. Second, there is a clear trade-off between transaction convenience and deposit rates: products with lower convenience levels usually pay higher deposit rates. Third, a comparison of the rates in 2004 (left panel) and 2006 (right panel) shows that banks with lower convenience pass through more rate hikes to depositors.

As discussed in Section 3.6, the pass-through of the Fed Funds rates to deposit rates could be driven by either markups or marginal costs. The shadow money channel predicts that the pass-through should be driven by markups while the reserve channel predicts that the pass-through should be driven by marginal costs. To differentiate these alternative channels, Figure 8 shows the the difference in markups and marginal costs between shadow and commercial banks. It is clear that the cyclical variations in the difference of deposit spreads is fully driven by markups rather than marginal costs. This is consistent with the prediction of the shadow money channel.

Why do two types of banks set different markups over monetary cycles? In the bottom panels of Figure 8, I shut down depositor heterogeneity by setting σ to zero. I find that the cyclical variations in the difference in markups completely disappear. This result shows that depositor heterogeneity is the key reason monetary policy has differential impacts on

the market power of shadow banks and commercial banks.

The estimation result illustrates how monetary policy changes the industrial organization of the deposit market. As shown in Figure 7, when the Fed Funds rates are low, commercial banks cannot reduce deposit rates below zero given that depositors have the option to hold cash. At the same time, shadow banks cannot raise deposit rates much higher than zero. Therefore, the room for differentiation in yields is compressed and more depositors stay with commercial banks. However, when the Fed Funds rates are high, shadow banks can better differentiate themselves from commercial banks by paying higher yields. As a result, shadow banks gain a greater market share in periods of high interest rates.

This exercise highlights three advantages of the structural model compared to a reduced-form approach. First, reduced-form measures of market power such as HHI can only be constructed at the market level (see Drechsler et al. (2017) and Scharfstein and Sunderam (2017)). However, market-level HHI is not very helpful for studying the difference in market power across banks within a market. In contrast, the structural model allows me to measure market power of different banks within a market. This is very helpful for understanding the different transmission of monetary policy through different types of banks. Second, as discussed above, different transmission mechanisms have different predictions on markups and marginal costs. Reduced-formed tests cannot directly test these predictions as these quantities are not indirectly observable in the data. However, such quantities can be easily estimated using the structural approach. Third, the structural approach helps me to quantify the magnitude of each channel, which is quite difficult to do with a reduced-form approach.

4.7 Choice of Depositors

Lastly, I examine the choices of different types of depositors over monetary cycles. I classify depositors with above-median yield sensitivity as yield-oriented depositors, and depositors with below-median yield sensitivity as transaction-oriented depositors. Figure 9 plots their probability to choose commercial or shadow banks over time.

The first observation is that yield-sensitive depositors are on average more likely to choose shadow banks, while transaction-oriented depositors are more likely to choose commercial banks. The second observation is that the choice probabilities vary substantially over time. When the Fed Funds rates are low, yield-oriented depositors are more likely to choose commercial banks as both types of banks offer similar rates. When the Fed Fund rates are high, however, the yield-oriented depositors switch to shadow banks as the spread between shadow and commercial bank deposit rates widens. In contrast, transaction-oriented depositors stick to commercial banks all the time as their preference on transaction convenience dominates variations in deposit rates.

4.8 Alternative Explanations

In the above analysis, I have shown that the difference in depositor clientèle between shadow and commercial banks seems to explain their different response to monetary policy. However, there are many other institutional differences across banking sectors and some of them may also explain these different responses. In this section, I examine some of the alternative explanations.

The first intuitive candidate is reserve requirements. As discussed in 3.6, commercial banks are subject to reserve requirements while shadow banks are not. Monetary policy may have differential impacts across banking sectors through the cost of holding reserves. The bank reserve channel features the underlying mechanism of several papers such as Bernanke and Blinder (1988), Kashyap and Stein (1995), Kashyap and Stein (2000), and Stein (2012).

The reserve-based explanation is unlikely to quantitatively explain the empirical finding. Technological innovations and regulatory reforms in the past three decades have rendered reserve requirements less important.[27] The aggregate reserve balance is only $48 billion as of December 31, 2007, which is less than 0.4% of the $6,720 billion commercial bank deposits.

[27]For example, sweep technology allows banks to easily transfer funds from transaction accounts to savings accounts to avoid reserve requirements (Teles and Zhou 2005).

It is hard to imagine such a small amount of reserves and the opportunity costs associated with it could quantitatively explain the substantial deposit spreads observed in the data. After the start of the unconventional monetary policy in 2008, the reserve balance grew dramatically. However, in this period, the Fed started to pay interest on reserves, which essentially eliminated this reserve channel.

The structural model provides more concrete evidence supporting this view. In panel 2 of Figure 10, I shut down the reserve channel by assuming the opportunity cost of holding bank reserves is zero. We can see that the procyclical pattern of the difference between shadow and commercial bank deposit rates hardly changes with and without reserve costs. In comparison, panel 4 of Figure 10 shows the case in which I shut down clientèle heterogeneity. We can see the difference becomes completely flat.

The second potential explanation for the different response to monetary policy by shadow banks is default risk. Shadow bank deposits are not insured by the FDIC. Therefore, in periods of crisis, depositors may withdraw their money from shadow banks and put into commercial banks. Since the Fed may cut the Fed Funds rates when the banking system is under distress, we may find a positive correlation between the Fed Funds rates and deposit flows. To examine this alternative channel, in panel 3 of Figure 10, I shut down the risk channel by assuming that depositors do not care about risk.[28] Comparing the simulated value with the real data, the relative deposit rates hardly change after shutting down this risk channel.

5. Policy Implications

Having shown the transmission mechanism of monetary policy through shadow banks, I now conduct a set of counterfactual exercises to study its policy implications.

[28] This is achieved by setting the loading coefficients on TED spreads to zero.

5.1 Shadow Banks and Effectiveness of Monetary Policy

There is a long-standing concern that financial innovation may undermine monetary control of the central bank (Tobin and Brainard 1963; Kashyap and Stein 1995). Such concern has intensified in recent years as the shadow banking sector has grown significantly larger.

To study the impact of shadow banking on the transmission of monetary policy, I simulate a counterfactual economy without shadow banks. I calculate the aggregate supply of bank loans (scaled by total liquid assets) and then calculate its sensitivity to the Fed Funds rates. Comparing the counterfactual economy with the real data, the sensitivity of loan supply to the Fed Funds rates becomes much smaller in the presence of shadow banks. In terms of economic magnitude, the shadow banking sector reduces the sensitivity of loan supply to the Fed Funds rates by around 34%. Note that this estimate suggests that the bank lending channel is dampened by 34%. It does not mean that the overall impact of monetary policy is dampened by 34% because the calculation does not include neoclassical transmission channels through the bond market.

How do shadow banks dampen the bank lending channel of monetary policy? In the counterfactual economy, the yield-sensitive depositors do not have a buffer from shadow banks. When the Fed raises interest rates, yield-sensitive depositors flow out of the banking system altogether, leading to a reduction in the supply of loanable funds. In contrast, in an economy with shadow banks, yield-sensitive depositors can switch within the banking system from commercial banks to shadow banks. With more deposit inflow, shadow banks are able to increase their lending which offsets the reduction in commercial bank lending.

This result relates to a strand of macroeconomic literature that studies the evolution of monetary transmission mechanism over time. This literature documents that the effect of monetary policy on aggregate real activity seems to have become smaller in the post-1990s compared to the earlier period (Boivin et al. 2011). Existing explanations include the change of policy makers' policy focus and the changes of housing market credit conditions. My result

suggests that the rise of the shadow banking sector could also be a contributing factor.

5.2 Shadow Banking and Financial Stability

My findings also contribute to the debate on the costs and benefits of using monetary policy as a macro-prudential tool. Prior to the 2008–09 financial crisis, the consensus among policy makers was that monetary authority should focus on price stability and employment (Smets 2013). However, this consensus has been challenged by an alternative view that took shape after the financial crisis, which argues that monetary policy should also be used to promote financial stability (Borio and Zhu 2012; Stein 2012; Ajello et al. 2015). Proponents of this view contend that by tightening monetary policy, the central bank can curb, among other things, the creation of money-like liabilities by the banking system. The unique advantage of monetary policy over financial regulations is that monetary policy can "get into all the cracks" outside the authority of regulators (Stein 2013). On the other hand, the potential complication caused by the shadow banking sector is also discussed (Stein 2012; Yellen 2014).

My finding contributes to this debate in two aspects. First, it shows that monetary policy may not be an effective tool for influencing the creation of money-like assets in the presence of the shadow banking sector because shadow banks partially offset the tightening effect on commercial banks. Second, since shadow banks are not protected by deposit insurance, such a policy may actually increase systemic risk by driving deposits from the insured commercial banking sector to the uninsured shadow banking sector. My paper supports the view that "monetary policy is too blunt a tool to address possible financial imbalances" as argued by Bernanke (2011) and Yellen (2014).

5.3 Implication of Shadow Banking for Depositor Surplus

Commercial banks have considerable market power in local depository markets. The entry of shadow banks may increase rate competition in the deposit market and potentially bring

significant gains in depositor surpluses. To assess the impact of shadow banking on depositor surpluses, I compare the real data with the counterfactual economy without shadow banks. Specifically, I follow Nevo (2001) to compute the expected utility for each type of depositor i from its optimal choice.

$$E\left[\max_{j\in\{0,1,\dots J\}} u_{i,j}\right] = \ln\left(\sum_{j=0}^{J} \exp\left(\delta_j + \sigma v_i r_j\right)\right) \tag{22}$$

Then, I divide expected utility by the yield sensitivity to calculate the equivalent utility in the unit of deposit rates. Finally, I sum past choices and depositor types to calculate the aggregate surplus.

$$\text{Depositor Surplus}_t = \sum_i \mu_i \frac{1}{\alpha + \sigma v_i} E\left[\max_{j\in\{0,1,\dots J\}} u_{i,j}\right] \tag{23}$$

I compare the surplus in the counterfactual economy with the actual economy. The entry of shadow banks on average generates 0.31 cents on a dollar per year in the sample period. This amounts to a $43 billion increase in the depositor surplus with an aggregate money supply of $14 trillion at the end of 2015. The change in the depositor surplus has the same magnitude as national branching deregulation in the 1990s as estimated by Dick (2008), which is estimated to have been 0.50 cents on a dollar. I further examine the time-series variation of the change in depositor surplus, which is plotted in the Online Appendix Figure 3. The change in depositor surplus is larger when the Fed Funds rates are high, which is consistent with the previous result that commercial banks enjoy greater market power during these periods.

6. Conclusion

This paper documents a new monetary transmission mechanism: the shadow money channel. I find that money supply from shadow banks expands when the Fed raises interest rates. This is at odds with the conventional wisdom in the commercial banking sector that monetary tightening reduces money creation. I show that this new channel is a result of deposit

competition between commercial and shadow banks in a market with heterogeneous depositors. Fitting my model to institution-level commercial bank and MMF data shows that this channel dampens the impact of monetary policy on money supply. I also explore the macro-prudential implications of shadow banking. I show that monetary tightening could unintentionally drive deposits from the insured commercial banking sector to the uninsured shadow banking sector, which may increase the fragility of the banking system.

This paper highlights the importance of industrial organization of the banking system. Shadow banks provide a valuable alternative to commercial bank deposits that pay too little to depositors due to their market power. In this sense, shadow banks are not merely a way of regulatory arbitrage in the deposit market. They create economic value. Most likely, the shadow banking sector will keep growing and, as a result, the shadow money channel may become more important in years to come. What is the right regulatory approach in the face of the ever-growing shadow banking sector? Should we forbid shadow bank money creation altogether? Or should we extend government safety nets such as deposit insurance and the discount window to shadow banks? I will relegate these questions for future research.

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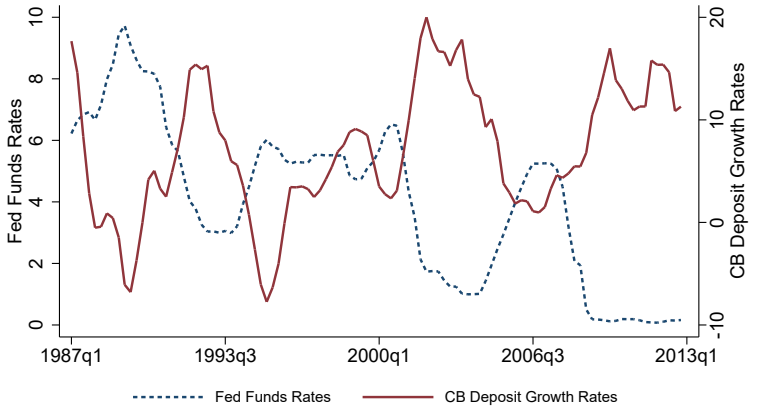
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Commercial Banks



Shadow Banks

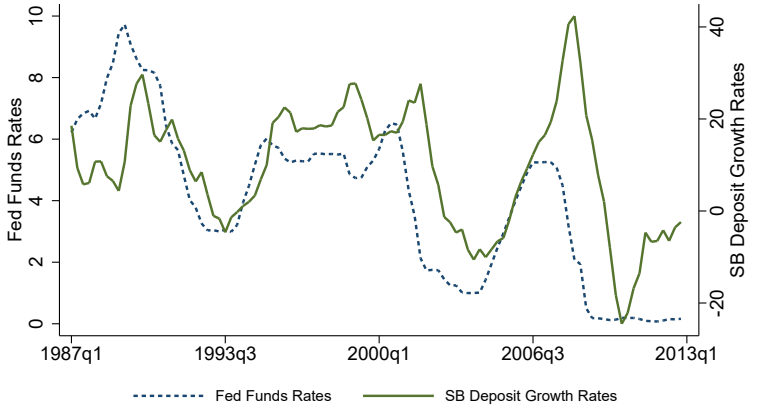


Figure 1: **Deposit Growth Rates and The Fed Funds Rates**
This figure shows the annual growth rates of U.S. commercial and shadow bank deposits from 1987 to 2012. The data are quarterly. Commercial bank deposits are the sum of checking and savings deposits. Shadow bank deposits include all U.S. retail and institutional MMF shares. The data are obtained from FRED.

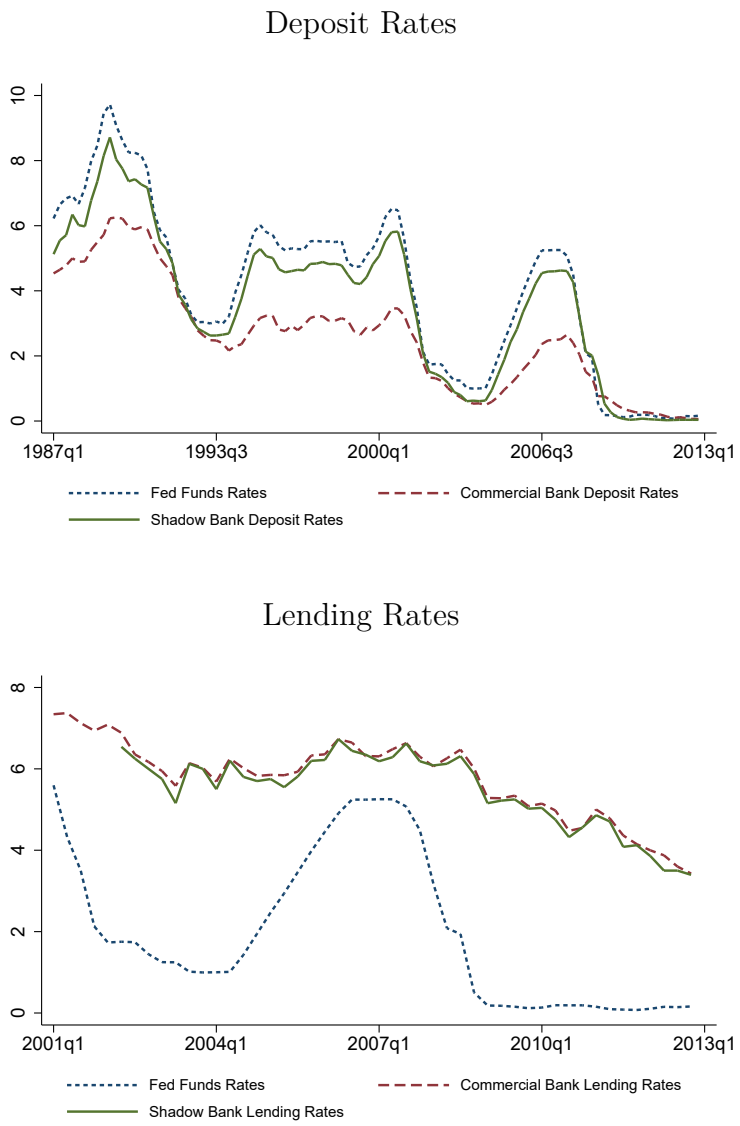


Figure 2: **Deposit and Lending Rates of Commercial and Shadow Banks**
This figure shows the average deposit and lending rates of U.S. commercial banks and shadow banks. The data are quarterly. Commercial bank deposit rates are average interest returns of demand and saving deposits. Shadow bank deposit rates are net yields of MMFs. Commercial bank lending rates are the interest rates of 30-year fixed rate mortgages. Shadow bank lending rates are the interest rates of 30-year fixed rate mortgages originated by mortgage companies. The data are from the Call Report, iMoneyNet, and RateWatch.

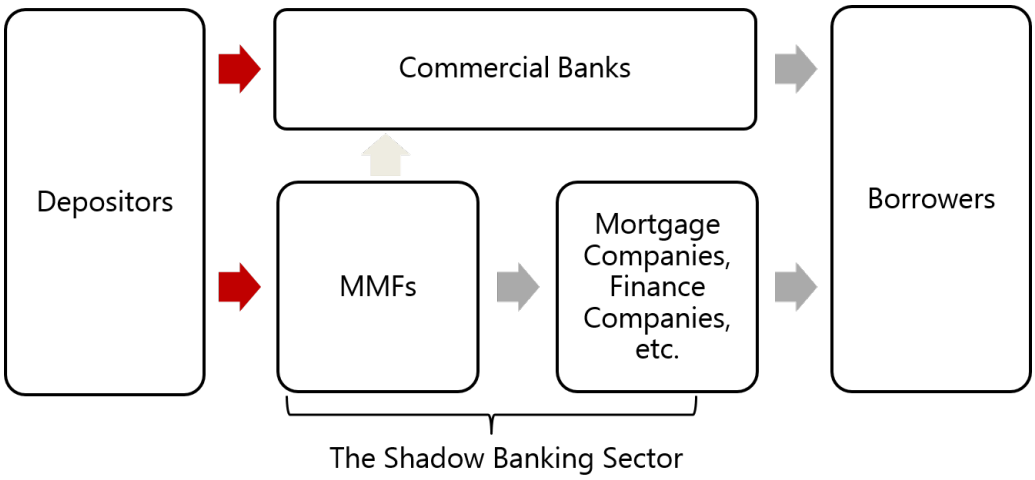


Figure 3: **The U.S. Banking System**

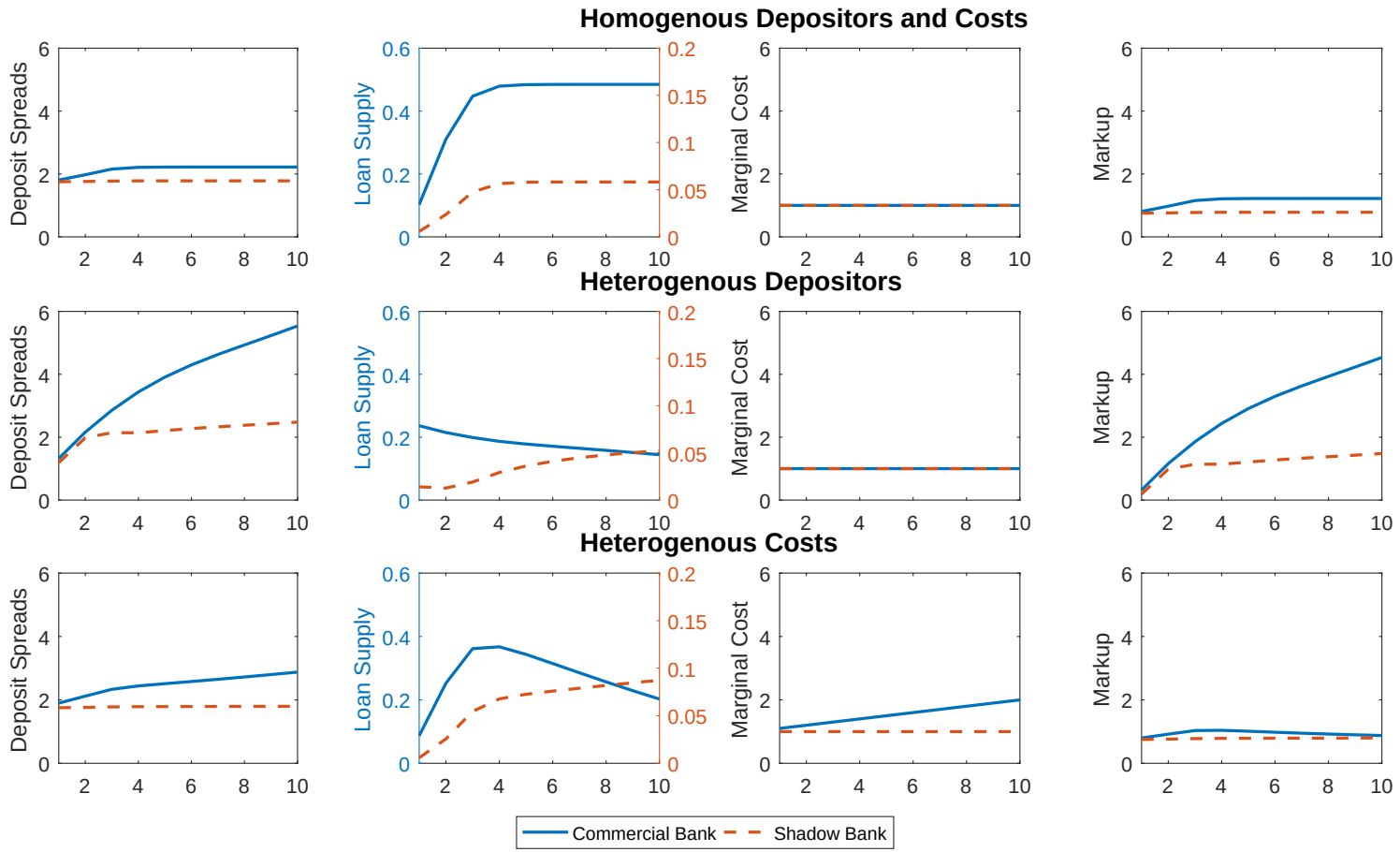


Figure 4: **Numerical Example: Deposit Spreads and Market Shares**

This figure shows the deposit spreads and market shares of commercial and shadow banks in the numerical examples. Each row is simulated using a different set of parameters in Table 6.

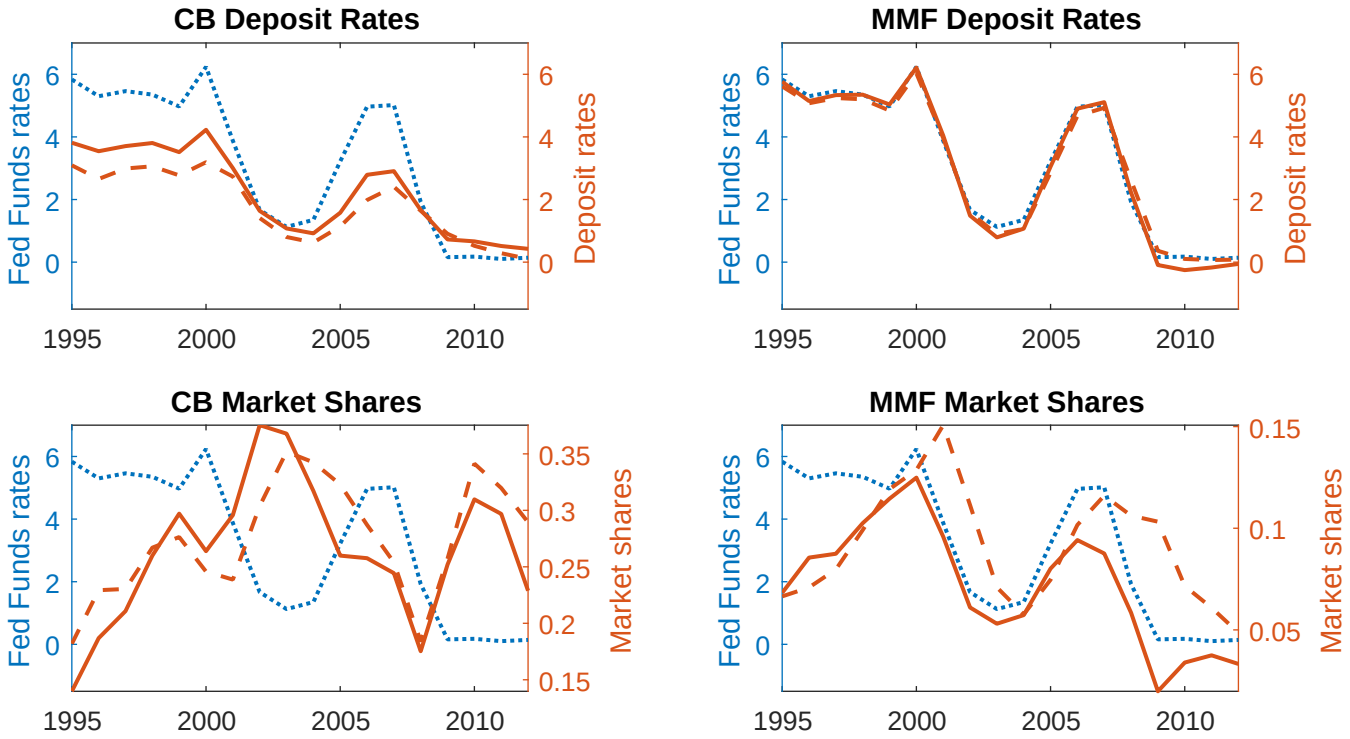


Figure 5: **Model Fit**

This figure shows deposit rates and market shares of commercial and MMFs predicted by the structural model and in the data. The model is estimated using institution-level data on U.S. commercial banks and MMFs from 1994 to 2012.

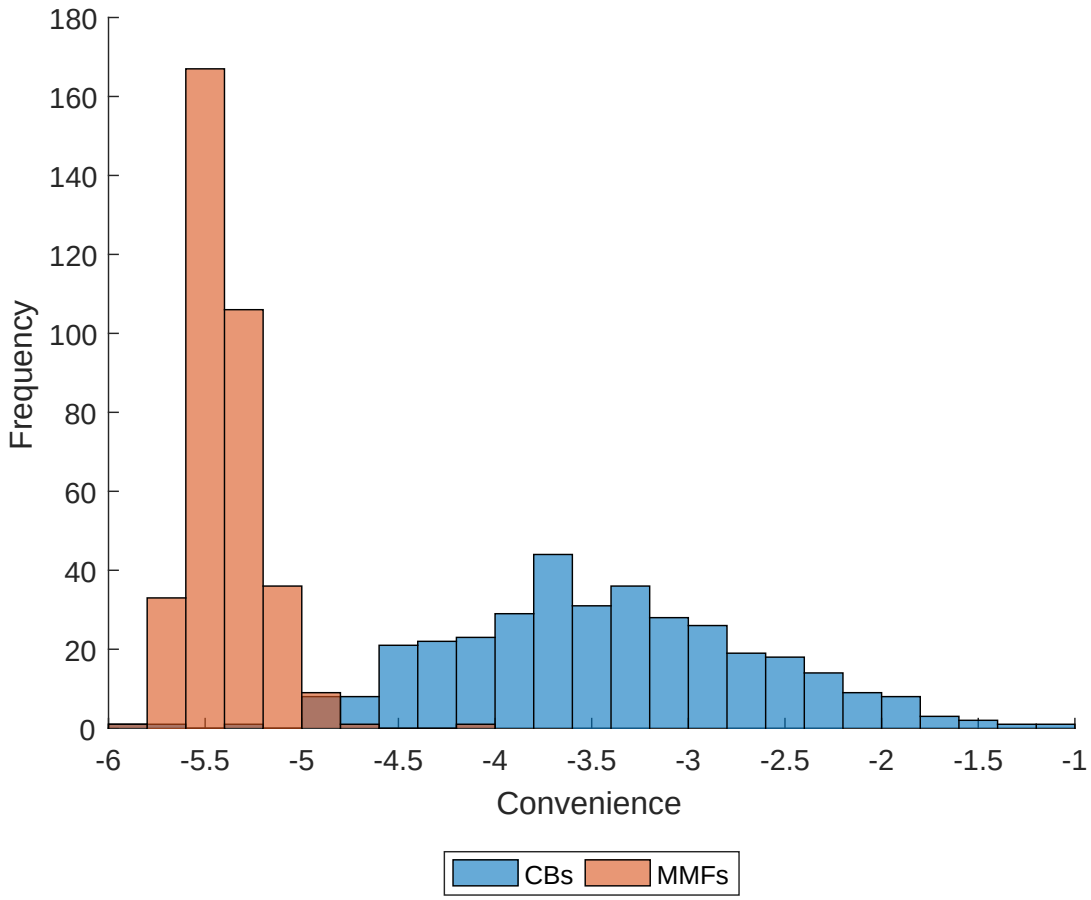


Figure 6: **Distribution of Estimated Convenience**
This figure shows the histogram of the estimated convenience for commercial banks and MMFs. The convenience is defined as the inner product between the vector of characteristics, x, and corresponding sensitivities, β. Each observation is an MSA-sector median. The model is estimated using institution-level data on U.S. commercial banks and MMFs from 1994 to 2012.

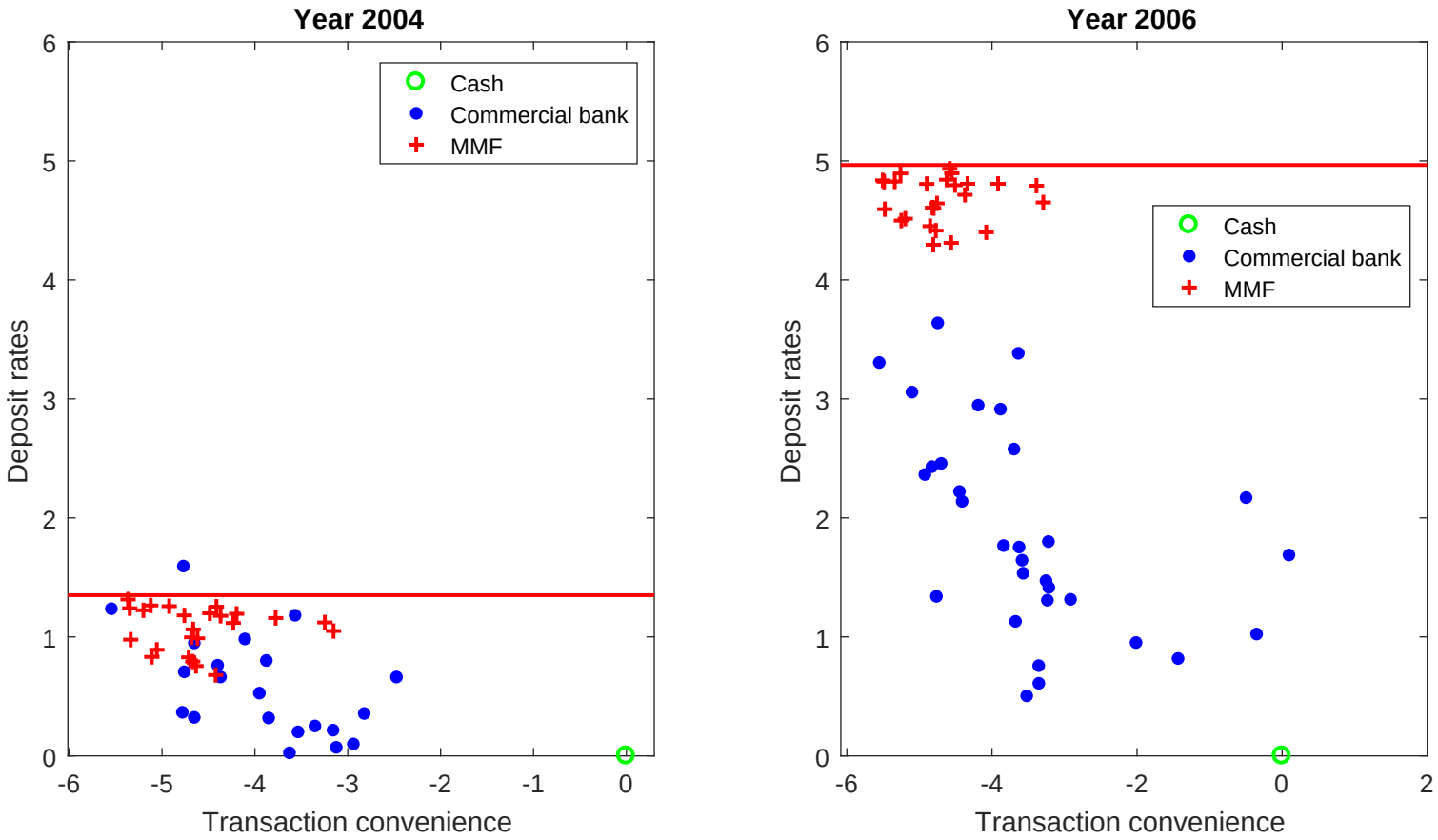


Figure 7: **Scatter Plot of Deposit Rates against Convenience in an MSA Market**

This figure shows the scatter plot of deposit rates against estimated convenience in an MSA market. Transaction convenience is defined as the inner product between the vector of characteristics, x, and corresponding sensitivities, β. Each observation is a bank. The model is estimated using institution-level data on U.S. commercial banks and MMFs from 1994 to 2012.

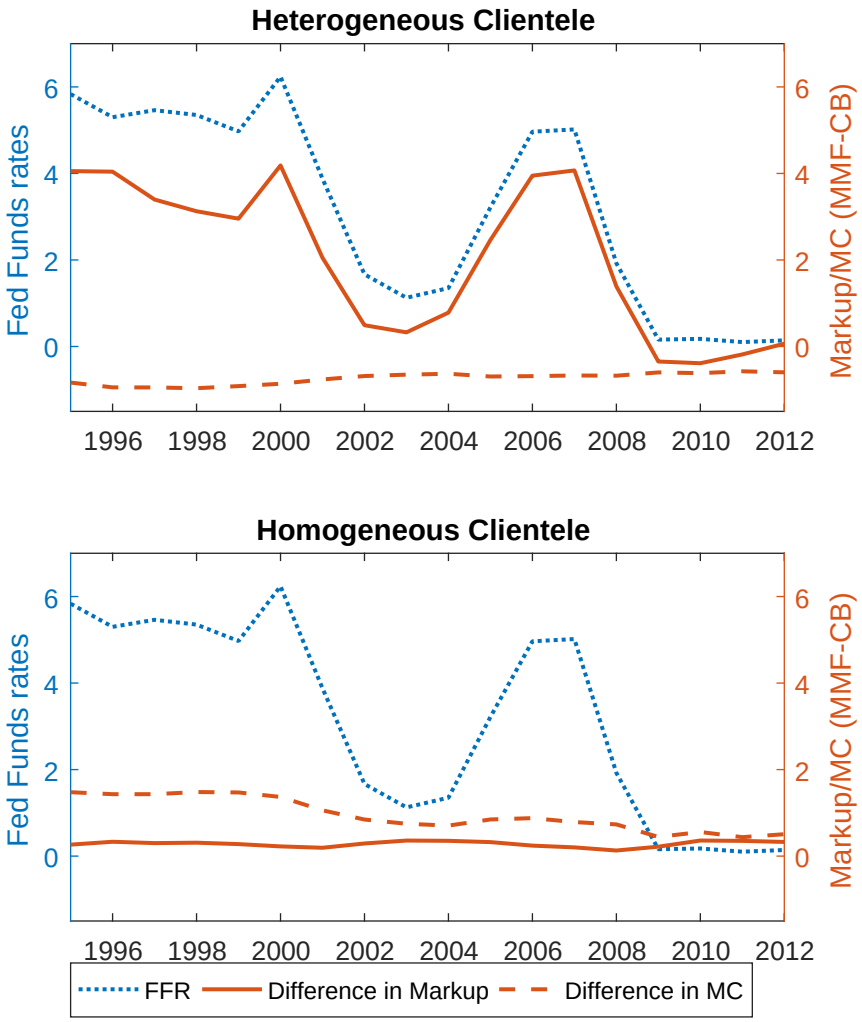


Figure 8: **Difference in Markups and Marginal Costs (CB-MMF)**
This figure shows the difference in average markups and marginal costs between commercial and shadow banks estimated by the structural model. The model is estimated using institution-level data on U.S. commercial banks and MMFs from 1994 to 2012.

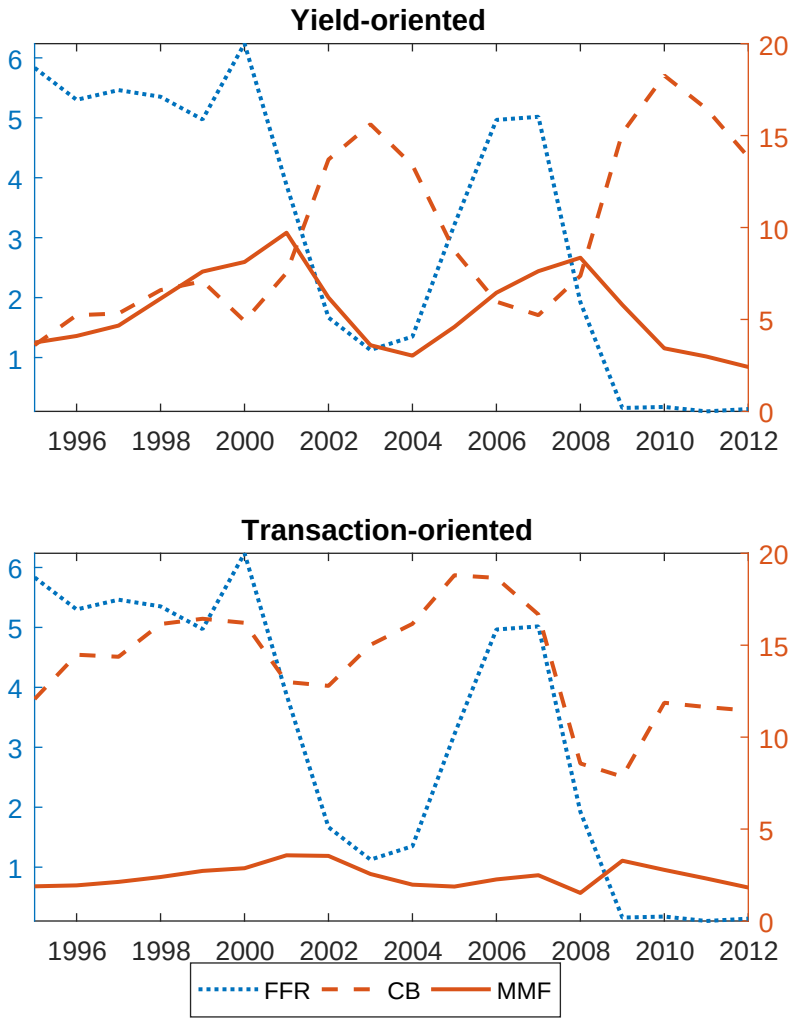


Figure 9: **Choice Probability of Depositors by Type**
This figure shows the estimated probability for yield-oriented and transaction-oriented depositors to choose commercial banks or MMFs over time. The model is estimated using institution-level data on U.S. commercial banks and MMFs from 1994 to 2012.

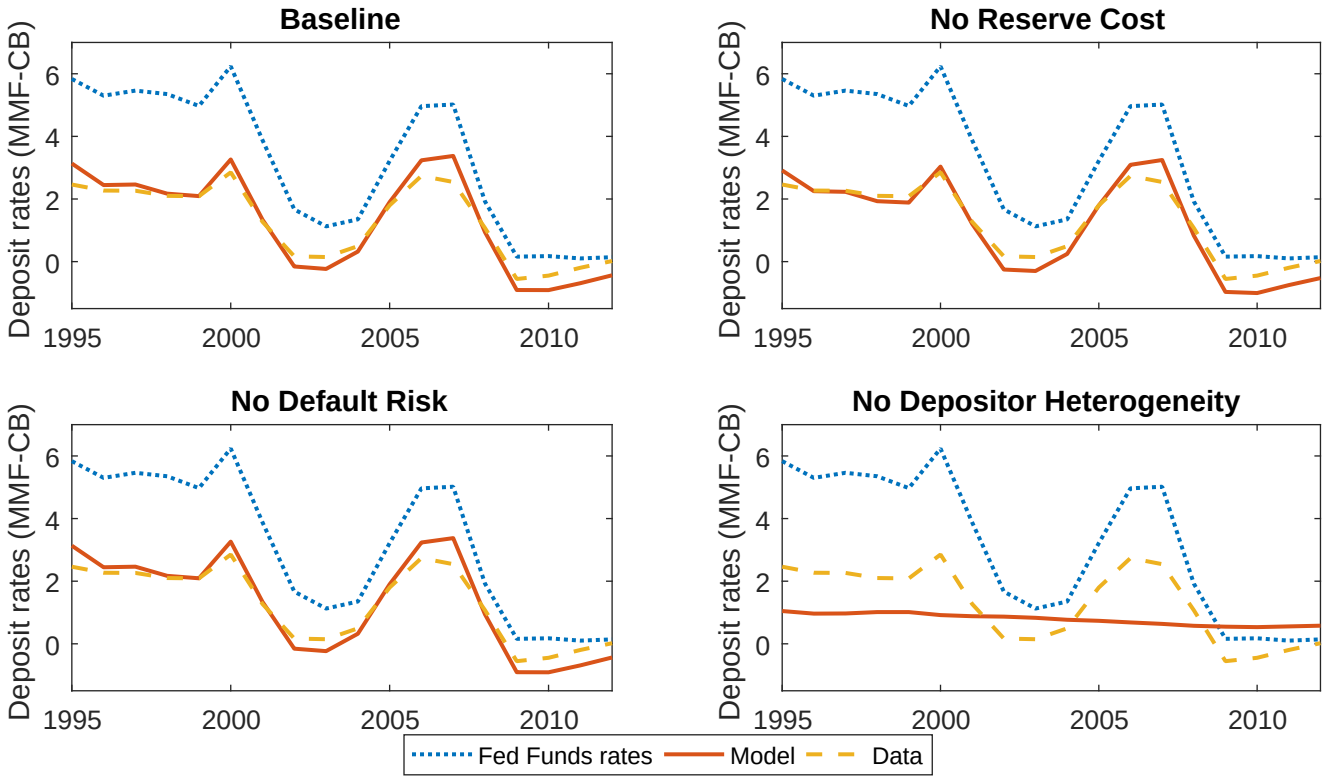


Figure 10: **Decomposition of Monetary Transmission Channels**

This figure shows the difference in deposit rates between commercial and shadow banks in the data and predicted by the structural model under different assumptions. The first panel is the baseline case in which bank reserve cost, default risk, and depositor heterogeneity are all present. The second, third, and fourth panel show the cases in which the bank reserve, default risk, or depositor heterogeneity is switched off respectively.

Table 1: Summary Statistics

	mean	sd	p25	p50	p75
Cash					
Amount	1265.944	3041.716	228.954	397.011	943.684
Market share	8.537	1.084	8.393	8.950	9.211
Commercial banks					
Amount	332.101	1533.831	25.593	69.897	191.991
Market share	2.122	3.309	0.308	0.850	2.543
Deposit rates	1.721	1.298	0.648	1.638	2.731
Branch density	8.139	17.975	2.000	4.000	8.000
Employees per branch	16.012	6.126	11.167	14.875	20.450
Age	90.564	44.987	51.000	94.000	125.000
Expenses of fixed assets	0.103	0.031	0.080	0.101	0.129
Salaries	0.487	0.110	0.415	0.489	0.577
Reserves	0.570	0.760	0.000	0.171	0.895
Money market funds					
Amount	53.427	172.836	6.262	13.993	36.391
Market share	0.376	0.352	0.134	0.270	0.519
Deposit rates	3.050	2.157	0.832	3.108	5.054
Age	28.177	7.872	23.000	26.000	34.000
Management costs	0.195	0.121	0.117	0.183	0.270
Other costs	0.136	0.130	0.041	0.094	0.181

Note: This table presents summary statistics of a sample of commercial banks and MMFs in 375 MSAs from 1994 to 2012 in the U.S. Expenses of fixed assets, salaries, and reserves are normalized by total assets. Deposit amount is in millions of dollars. Deposit rates, market shares, expenses of fixed assets, salaries, reserves, management costs, and other costs are given as percentages.

Table 2: Monetary Policy and Money Growth

	(1) CB	(2) MMF	(3) Cash	(4) Total	(5) CB	(6) MMF	(7) Cash	(8) Total
Fed Funds Rates	−2.292***	4.108***	−0.476**	−0.368	−2.918***	4.581***	−0.576***	−0.623
	(0.316)	(0.672)	(0.181)	(0.344)	(0.443)	(0.650)	(0.213)	(0.422)
GDP growth	−0.135	−1.441***	−0.254*	−0.436	−0.855**	−2.969***	−0.222	−1.335***
	(0.252)	(0.536)	(0.144)	(0.274)	(0.399)	(0.586)	(0.192)	(0.381)
Inflation	−0.097	−1.353	−0.568**	−0.453	−0.730	−6.061***	−0.577*	−2.309***
	(0.400)	(0.852)	(0.229)	(0.435)	(0.661)	(0.969)	(0.318)	(0.630)
TED Spread	−2.141	15.871***	−0.289	4.253***	3.479	13.746***	2.257*	7.152***
	(1.376)	(2.929)	(0.788)	(1.497)	(2.668)	(3.913)	(1.283)	(2.543)
Observations	92	92	92	92	72	72	72	72
Adj. R^2	0.569	0.634	0.332	0.109	0.546	0.704	0.449	0.216

Note: This table presents time series regressions of aggregate annual money growth rates on the Fed Funds rates. A time trend is also included in the regressions. The data frequency is quarterly. The sample period is from 1990 to 2012 for columns 1–4 and 1990 to 2007 for columns 5–8. Standard errors in brackets are computed with Newey-West standard errors with 4 lags. ***, **, * represent 1%, 5%, and 10% significance, respectively.

Table 3: Monetary Policy and MMF Lending

	(1) Commercial Paper	(2) ABCP	(3) Repo	(4) FRNs	(5) Treasury & Agency	(6) Bank Obligations
Fed Funds Rates	0.781***	0.170***	0.565***	0.323***	0.504***	0.330***
	(0.036)	(0.014)	(0.044)	(0.030)	(0.061)	(0.022)
GDP Growth	−0.209***	0.030**	−0.007	0.033	−0.879***	−0.187***
	(0.036)	(0.014)	(0.045)	(0.030)	(0.069)	(0.023)
Inflation Rates	−0.006	−0.059**	0.456***	−0.086	0.415***	0.244***
	(0.060)	(0.026)	(0.082)	(0.054)	(0.120)	(0.039)
TED Spread	0.079	−0.107	−0.180	0.300**	5.024***	0.110
	(0.168)	(0.069)	(0.214)	(0.145)	(0.335)	(0.106)
Observations	15060	15060	15060	15060	15060	15060
Adj. R^2	0.076	0.051	0.107	0.049	0.146	0.093

Note: This table presents regressions of MMF Lending on Fed Funds rates. The dependent variable is the annual change in a specific type of lending normalized by the lagged total lending (lagged one year). Fund characteristics include fund size (log), fund age, management costs, and other costs. The sample includes 1,148 MMFs in the period of 1998 to 2012. The data frequency is quarterly. Standard errors in brackets are clustered by time. ***, **, * represent 1%, 5%, and 10% significance, respectively.

Table 4: Monetary Policy and Asset Growth of Shadow Banks

	(1) Funding Corporations	(2) Finance Companies	(3) ABCP Issuers	(4) Captive Financials	(5) Broker Dealers	(6) Shadow Bank Total
Fed Funds Rates	2.768***	1.438***	4.526***	0.975***	0.744	1.773***
	(0.500)	(0.359)	(0.677)	(0.347)	(0.554)	(0.316)
GDP growth	3.067***	1.813***	0.850	0.840**	1.792***	1.645***
	(0.542)	(0.389)	(0.734)	(0.376)	(0.601)	(0.342)
Inflation	−2.851***	0.647	−0.138	−4.273***	1.667*	−1.002*
	(0.864)	(0.621)	(1.171)	(0.600)	(0.958)	(0.546)
VIX	0.206	0.417***	−0.203	−0.0541	−0.528***	−0.137
	(0.163)	(0.117)	(0.221)	(0.113)	(0.181)	(0.103)
TED Spread	16.98***	−5.198**	−4.000	11.61***	−5.212	2.275
	(3.349)	(2.407)	(4.536)	(2.324)	(3.711)	(2.116)
Observations	92	92	92	92	92	92
Adj. R^2	0.640	0.386	0.495	0.484	0.449	0.561

Note: This table presents time series regressions of the aggregate asset growth rates of shadow banks on the Fed Funds rates. The dependent variable is the annual growth rates of the shadow bank assets. The data frequency is quarterly. The sample period is from 1990 to 2012. Standard errors in brackets are computed with Newey-West standard error with 4 lags. ***, **, * represent 1%, 5%, and 10% significance, respectively.

Table 5: Demographic Determinants of Shadow Bank Deposit Holdings

	(1) Shadow Deposit Dummy	(2) Shadow Deposit Share
Income	0.036***	0.020***
	(0.000)	(0.000)
College	0.040***	0.014***
	(0.000)	(0.000)
Unemployed	0.005	0.002
	(0.530)	(0.755)
Age	-0.011***	-0.006***
	(0.000)	(0.000)
Age2	0.001	0.004***
	(0.456)	(0.000)
Home owner	-0.010**	-0.007**
	(0.018)	(0.017)
Car owner	-0.010**	-0.007***
	(0.017)	(0.008)
Female	0.023***	0.018***
	(0.000)	(0.000)
Married	0.018***	0.009***
	(0.000)	(0.009)
Observations	27764	27764
Adj. R^2	0.047	0.025

Note: This table presents cross-sectional regressions of shadow bank deposit holdings on demographic variables for a cross section of 27,764 households in the Survey of Consumer Finance (2013). Shadow bank deposits are defined as deposits that are not insured by the government. Shadow dummy equals 1 if a household has shadow bank deposits, 0 otherwise. Shadow share is the share of shadow bank deposits in the total deposits of a household. The independent variables are the demographics of the head of the household. Robust standard errors are in brackets. ***, **, * represent 1%, 5%, and 10% significance, respectively.

Table 6: Parameters for the Numerical Examples

	σ	α	ℓ_{cash}	ℓ_{bond}	ℓ_{cb}	ℓ_{sb}	γ_1	γ_2	w_1	w_2
Homogenous depositors and costs	0.0	2.0	0.0	-2.5	-0.3	-1.8	0.0	1.0	f	1.0
Heterogeneous depositors	3.5	2.0	0.0	-2.5	-0.3	-1.8	0.0	1.0	f	1.0
Heterogeneous costs	0.0	2.0	0.0	-2.5	-0.3	-1.8	0.1	1.0	f	1.0

Note: This table presents the parameter values of the numerical examples in Figure 4. Each row presents the set of parameters for a different model.

Table 7: Demand Parameter Estimations

	(1) Logit	(2) BLP
Yield Sensitivity(α)	0.250***	0.898***
	[0.076]	[0.066]
Yield Sensitivity Dispersion(σ)		0.688***
		[0.001]
Branch Density(β_1)	0.103***	0.104***
	[0.002]	[0.003]
No. of Employees(β_2)	0.030	0.048
	[0.099]	[0.036]
TED*CB(β_3)	-0.664***	-0.288***
	[0.144]	[0.059]
TED*MMF(β_4)	-0.146***	-0.613***
	[0.005]	[0.005]
Bank F.E.	Y	Y
City F.E.	Y	Y
Time F.E.	Y	Y
Adj. R^2	0.573	0.455
Observations	242472	242472

Note: This table presents the estimates of demand parameters. Column 1 reports the logit model and column 2 reports the BLP model. The sample is a panel of U.S. commercial banks and MMFs from 1994 to 2012. Robust standard errors are in brackets. ***, **, * represent 1%, 5%, and 10% significance, respectively.

Table 8: Own-rate Elasticity

	$\Delta log\left(s_{cb}\right)$	$\Delta log\left(s_{sb}\right)$
Δr_{cb}	0.385	
	(1.415)	
Δr_{sb}		0.904
		(0.538)

Note: This table presents the median and standard deviation (in brackets) of own-rates elasticity of commercial and shadow banks estimated from the BLP model. Each entry gives the percent change of the market share of a bank with a one percent change of its own deposit rates.

Table 9: Cross-rate Elasticity

	$\Delta log\left(s_{cb}\right)$	$\Delta log\left(s_{sb}\right)$
Δr_{cb}	-0.003	-0.006
	(0.022)	(0.009)
Δr_{sb}	-0.001	-0.003
	(0.005)	(0.007)

Note: This table presents the median and standard deviation (in brackets) of cross-rate elasticity of commercial and shadow banks estimated from the BLP model.

Table 10: Supply Parameter Estimations

	(1) Logit	(2) BLP
	CB	
Reserve cost (γ_1)	0.552***	0.085***
	[0.097]	[0.027]
Expense of fixed assets (γ_2)	6.550*	0.096
	[3.506]	[0.831]
Salaries(γ_3)	2.690**	0.409*
	[1.124]	[0.244]
	MMF	
Management costs(γ_4)	0.259	0.667
	[0.405]	[0.472]
Other costs(γ_5)	0.277	0.448*
	[0.203]	[0.259]
Share service costs(γ_6)	-0.186	-0.068
	[0.294]	[0.378]
Bank F.E.	Y	Y
Adj. R^2	0.632	0.411
Observations	242472	242472

Note: This table presents the estimates of supply parameters of the structural model. Column 1 reports the logit model and column 2 reports the BLP model. The sample is a panel of U.S. commercial banks and MMFs from 1994 to 2012. Robust standard errors reported in brackets are clustered by time. Note that since the preference parameters used to compute marginal costs are estimated from the demand estimation, the standard errors here are corrected using the approach in Newey and McFadden (1994). ***, **, * represent 1%, 5%, and 10% significance, respectively.