Money Creation and the Shadow Banking System[*]

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Abstract

Many explanations for the rapid growth of the shadow banking system in the mid-2000s focus on money demand. This paper asks whether the short-term liabilities of the shadow banking system behave like money. We first present a simple model where households demand money services, which are supplied by three types of claims: deposits, Treasury bills, and asset-backed commercial paper (ABCP). The model provides predictions for the price and quantity dynamics of these claims, as well as the behavior of the banking system (in terms of issuance) and the monetary authority (in terms of open market operations). Consistent with the model, the empirical evidence suggests that the shadow banking system does respond to money demand. An extrapolation of our estimates would suggest that heightened money demand could explain up to approximately 1/2 of the growth of ABCP in the mid-2000s.

1   Introduction

Many explanations for the rapid growth of the shadow banking system in the years before the financial crisis focus on money demand.[1] These explanations argue that the shadow banking system grew in order to meet rising demand for "money like" claims – safe, liquid, short-term investments – from institutional investors and nonfinancial firms. In doing so, they build on the long literature, starting with Diamond and Dybvig (1983) and Gorton and Pennacchi (1990), arguing that providing liquidity services through demandable deposits is a key function of banks. They extend this idea to short-term claims like asset-backed commercial paper (ABCP) and repo issued by financial intermediaries in the shadow banking system.

Despite the prominence of the money demand story in the literature, its basic premise remains untested. Were the short-term claims issued by the shadow banking system prior to the crisis "money-like"? Put differently, did these claims behave as though they were providing money services?

This paper aims to assess this question empirically by examining the price-quantity dynamics of these short-term claims and their interactions with Federal Reserve monetary policy implementation (open market operations). We focus on ABCP because high-frequency data is more readily available for ABCP than for repo. Moreover, Krishnamurthy, Nagel, and Orlov (2011) argue that ABCP was a larger source of short-term financing for the shadow banking system than repo was.

We begin by writing down a simple model where households pay a premium for claims that deliver money services. The model is similar to Krishnamurthy and Vissing-Jorgensen (2012a) and Stein (2012), where certain claims, some of which the financial sector can endogenously produce, provide monetary services. We add two ingredients. First, different claims (deposits, Treasury bills, and ABCP) deliver different amounts of monetary services. Second, the monetary authority (Federal Reserve) effectively controls the quantity of deposits. It does so by setting the amount of reserves in the banking system to implement its target policy rate, which is treated as exogenous. This simple model delivers five main predictions:

1. Shocks to money demand should increase the spread between ABCP and Treasury bill yields.

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[1]See, for instance, Dang, Gorton, and Holmstrom (2009), Greenwood, Hanson, and Stein (2012), Gorton and Metrick (2009a, b, 2010), Gorton, Lewellen, and Metrick (2012), Ricks (2011), Stein (2012), etc.

2. The injection of reserves into the banking system by the Federal Reserve should decrease the spread between ABCP and Treasury bill rates. Similarly, an increase in the supply of Treasuries should decrease the spread between ABCP and Treasury bill rates.

3. The financial sector should respond to positive money demand shocks by increasing the supply of ABCP.

4. The Federal Reserve should respond to such shocks by conducting open market operations to increase the supply of reserves and maintain a constant Federal Funds rate.

5. The supply of ABCP and the supply of reserves/deposits should be positively correlated because they both respond to money demand shocks.

We then take these predictions to the data. A key empirical difficulty is that low frequency variation in money demand is likely to be driven by changing economic fundamentals and advances in payment technologies, and therefore will be difficult to separate from broader macroeconomic conditions. To avoid the identification issues this raises, we instead focus on relatively high-frequency (weekly) variation in money demand. Variation of this kind, driven by the need to make payments, manage payroll and inventories, etc., is easier to isolate from background changes in economic conditions. Our baseline empirical specifications all utilize weekly data with month fixed effects.

We examine the pre-crisis period from January 2001 when weekly data on ABCP outstanding become available through June 2007, just before the collapse of the ABCP market. The empirical evidence is consistent with the model. Each of the five predictions above is borne out in the data, as are several other predictions of the money demand story that do not directly follow from the model.

The magnitudes of the results are not overly large. For instance, a 50 basis point (two standard deviation) increase in the spread of ABCP over Treasury bill yields, which the first prediction of the model tells us is a sign of increasing money demand, forecasts a 0.5% increase in ABCP outstanding. Of course it would be surprising if we found very large effects, given that we are looking at high frequency changes in money demand, which are likely to be relatively small and transient.

In addition to providing evidence in support of the money demand view, we also argue that the results are inconsistent other explanations. In particular, the results are inconsistent with the supply-side view that ABCP issuance is driven by the financial sector's need for

financing. Moreover, the results are also inconsistent with a more standard market timing story, where financial intermediaries issue ABCP when they perceive it to be a cheap source of financing for reasons unrelated to money demand. This is not to say that these other explanations are not important at lower frequencies, only that they cannot explain the high frequency variation we examine.

We then use our estimates to ask how much of the growth of ABCP in the years before the crisis can be explained by an increase in money demand. Obviously, many caveats apply in extrapolating from our high frequency estimates to this low frequency question. Keeping these qualifications in mind, our estimates imply that a sustained increase in money demand could explain up to approximately 1/2 of the growth in ABCP outstanding in the years before the financial crisis.

The approach taken in this paper is necessarily indirect. Investor intentions are unobservable, so it is impossible to ascertain whether they hold ABCP for the same reasons they hold cash and demand deposits.[2] However, the link to open market operations and reserves we draw here makes the indirect link as direct as possible. Reserves are at the very heart of the formal money supply.

The remainder of this paper is organized as follows. Section 2 presents the model. Section 3 presents the empirical results, which examine high-frequency variation, and discusses alternative explanations. Section 4 discusses the implications of these estimates for lower frequency patterns in the data. Section 5 concludes.

2   Model

2.1   Setup

We begin by presenting a simple model to help understand the implications of the money demand story. There are three sets of agents in the model: households, banks, and the monetary authority (i.e. the Federal Reserve). For simplicity, all agents are risk-neutral.

There are three types of claims that provide money services in the economy: deposits, Treasury bills, and asset-backed commercial paper (ABCP). Each claim provides a different

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[2]Moreover, the literature has struggled with the nature of money services since Sidrauski (1967) and Tobin (1969). In the absence of a more microfounded explanation for why certain claims provide money services, we cannot directly assert that ABCP has the characteristics necessary to provide such services. Earlier work, including Poterba and Rotemberg (1987) and Driscoll, Poterba, and Rotemberg (1995), attempt to use structural models to infer the quantity of monetary services provided by different short-term claims. These papers largely focus on different types of deposit accounts within the traditional banking sector (e.g., checking, savings, and time deposits).

amount of money services. One can think of these differences in money services provided by different claims as reflecting differences in safety and liquidity.

A dollar of deposits provides a quantity of monetary services α_D, which we normalize to 1. Call the dollar amount of deposits, m_D. This is effectively controlled by the monetary authority through a reserve requirement, which is described further below. In addition, we assume that deposits provide some additional utility that Treasury bills and ABCP do not. One can think of this utility as stemming from the fact that deposits directly provide transactional services, while Treasury bills and ABCP, despite their safety and liquidity, do not. This is a standard assumption going back to Tobin and Brainard (1963) and Brainard (1964) that makes deposits and other money claims imperfect substitutes. This allows the monetary authority to implement its target policy rate without directly controlling the quantity of all money claims produced.

A dollar of Treasuries provides α_T of monetary services. We take the supply of Treasuries, m_T, as exogenous. Finally, a dollar of ABCP provides α_{ABCP} of money services. We assume $\alpha_{ABCP} < \alpha_T$ and $\alpha_{ABCP} < \alpha_D = 1$, so that ABCP provides fewer money services than either deposits or Treasury bills. This reflects the facts that ABCP is not government guaranteed and has less secondary market liquidity than Treasury bills. Banks endogenously set the dollar amount of ABCP, m_{ABCP}. We will call the total amount of effective money services in the economy $M = m_D + \alpha_T m_T + \alpha_{ABCP} m_{ABCP}$, and assume that households have downward sloping demand for these services.

In particular, households generally require gross return R for non-money claims (e.g. bonds) but derive additional utility from money services and therefore require lower returns for money claims. Specifically, they require gross returns

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\begin{aligned}
R_D &= R - \theta v'(M) - w'(m_D) && \text{for deposits} \\
R_T &= R - \alpha_T \theta v'(M) && \text{for Treasuries} \\
R_{ABCP} &= R - \alpha_{ABCP} \theta v'(M) && \text{for ABCP}
\end{aligned}
$$

where $v(M)$ is a reduced form function for the utility from consuming total money services M, $\theta > 0$ is a money demand shifter, and $w(m_D)$ is the additional utility that comes from deposits. The comparative statics we derive below will focus on the effects of variation in θ. We assume $v', w' > 0$ and $v'', w'' < 0$ so that money services provide positive but decreasing marginal utility. For simplicity, we take these required returns as given. However, they can be derived in a more formal intertemporal optimization framework using a utility specification

similar to that of Krishnamurthy and Vissing-Jorgensen (2012a).[3]

Deposits face reserve requirement ρ: for each dollar of deposits raised, the bank must hold ρ dollars of reserves. The monetary authority uses this reserve requirement to pin down the Federal Funds (interbank lending) rate. In particular, the Federal Funds rate is the shadow cost of a bank's reserve requirement constraint. Banks must be indifferent between (i) borrowing ρ reserves in the interbank market and using them to raise a dollar of deposits and (ii) raising a dollar of ABCP financing. The Federal Reserve endogenously sets the quantity of reserves in the banking system $\mathcal{R}^*(i)$ to implement its target Federal Funds rate i. We assume that the target rate i is derived from a Taylor-style rule, reflecting inflation and unemployment concerns outside the model, not the short-run money demand considerations we will try to isolate in the empirics.

Banks have fixed (in the short-term) investment $I = 1$, which pays out $F > R$ in expectation. Banks can finance this investment from three sources: (i) long-term debt, which requires gross return R; (ii) deposits, which face a reserve requirement; and (iii) ABCP, which does not face a reserve requirement. However, we assume that raising ABCP has a private cost from the bank's perspective of $c(m_{ABCP})$. In Stein (2012), Greenwood, Hanson, and Stein (2012), and Kashyap and Stein (2012), this costs reflects the private costs of fire selling illiquid assets in the event of a run. Those papers must specify a source of costs

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[3]Suppose households maximize $E \sum \beta^t U(C_t)$ where

$$C_t = c_t + \theta v(M) + w(m_D)$$

and θ is a parameter controlling overall demand for money services.

With this utility function, the price of deposits is

$$P_{D,t} = E[x_{t+1}] + \theta v'(M) + w'(m_D)$$

where $x_{t+1} = \beta U'(C_{t+1})/U'(C_t)$ is the pricing kernel. The price of Treasury bills is

$$P_{T,t} = E[x_{t+1}] + \alpha_T \theta v'(M)$$

and the price of ABCP is

$$P_{ABCP,t} = E[x_{t+1}] + \alpha_{ABCP} \theta v'(M)$$

Yields are $R_{j,t} = -\ln(P_{j,t}) \approx 1 - P_{j,t}$. Therefore, the yield on deposits is

$$R_{D,t} \approx 1 - E[x_{t+1}] - \theta v'(M) - w'(m_D).$$

The yield on Treasuries is

$$R_{T,t} \approx 1 - E[x_{t+1}] - \alpha_T \theta v'(M)$$

and the yield on ABCP is

$$R_{ABCP,t} \approx 1 - E[x_{t+1}] - \alpha_{ABCP} \theta v'(M).$$

Setting $R = 1 - E[x_{t+1}]$ approximately provides our assumed formulation.

because they are concerned with policy implications. In contrast, we need not take a stand here on the source of the costs; they simply serve to keep banks at an interior optimum in their capital structure decisions. That is, the costs keep banks from financing themselves purely with deposits and ABCP.

For simplicity, we do not vary the amount of money services provided by ABCP, α_{ABCP}, with the quantity of ABCP produced. However, it would be reasonable to assume that α_{ABCP} should decline with the quantity of ABCP produced because, for instance, larger quantities of ABCP must be backed by riskier assets. To the extent this is the case, it is partially captured by the assumption that c'' is positive. Assuming that banks face constant benefits and increasing marginal costs of ABCP production has similar implications to assuming they have decreasing marginal benefits and fixed marginal costs.

2.2 Equilibrium

We now solve for the equilibrium. We take i, θ, $v(\cdot)$, $w(\cdot)$, ρ, F, $c(\cdot)$, and R as given and first solve for the quantity of ABCP chosen by banks, m^*_{ABCP}. We then solve for the quantity of reserves chosen by the Federal Reserve to implement its target policy rate, $\mathcal{R}^*(i)$. Banks solve

$$\max_{m_D, m_{ABCP}} F - R + m_D \left(\theta v'(M) + w'(m_D)\right) + m_{ABCP}\alpha_{ABCP}\theta v'(M) - c(m_{ABCP})$$

subject to the constraints

$$\rho m_D \leq \mathcal{R} \quad \text{and} \quad m_D + m_{ABCP} \leq 1$$

where $\mathcal{R}$ is the total quantity of reserves in the system. Note that individual banks take required returns as fixed, though they are endogenously determined in the aggregate. The Lagrangian for this problem is

$$F - R + m_D \left(\theta v'(M) + w'(m_D)\right) + m_{ABCP}\alpha_{ABCP}\theta v'(M) - c(m_{ABCP})$$
$$+ \lambda_1 \left(\mathcal{R} - \rho m_D\right) + \lambda_2 \left(1 - m_D - m_{ABCP}\right).$$

As argued above, the Federal Funds rate is given by the shadow cost of the reserve requirement constraint:

$$i = \lambda_1 = \frac{(1 - \alpha_{ABCP})\theta v'(M) + w'(m_D) + c'(m_{ABCP})}{\rho}$$

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Banks must be indifferent at the margin between funding with deposits and ABCP. A bank can generate one unit of deposit funding by borrowing ρ reserves in the Federal Funds market. This costs $i\rho$ and has benefit $\theta v'(M) + u'(m_D)$ as compared to net benefits $\alpha_{ABCP}\theta v'(M) - c'(m_{ABCP})$ of financing with ABCP. Thus, in equilibrium, λ_1 equates the costs and benefits of deposit funding with the costs and benefits of ABCP funding.

λ_2 is the shadow cost of the adding up constraint. If $\lambda_2 > 0$, a bank would be able to increase profits by using more ABCP funding, except for the fact it was already financing 100% of its investment using ABCP and deposits. Here we will just assume that c' is large enough that we are at an interior solution and the constraint is slack ($\lambda_2 = 0$). This gives the following condition for the equilibrium amount of ABCP, m_{ABCP}:

$$\alpha_{ABCP}\theta v'(M) = c'(m^*_{ABCP}). \tag{1}$$

In equilibrium, we have market clearing for reserves so

$$m^*_D = \frac{\mathcal{R}}{\rho}. \tag{2}$$

These two conditions pin down m^*_D and m^*_{ABCP}, which in turn pin down λ^*_1 (and we have assumed $\lambda^*_2 = 0$).

Given this, the Federal Reserve will endogenously set $\mathcal{R}^*(i)$ to implement the Federal Funds rate $\lambda^*_1 = i$. That is $\mathcal{R}^*(i)$ is implicitly defined by

$$i = \frac{\theta v'\left(\frac{\mathcal{R}^*(i)}{\rho} + \alpha_T m_T + \alpha_{ABCP} m^*_{ABCP}\right) + w'\left(\frac{\mathcal{R}^*(i)}{\rho}\right)}{\rho} \tag{3}$$

The following proposition summarizes the equilibrium.

Proposition 1 *There exists $\underline{c}$ such that for $c' > \underline{c}$ the market equilibrium is given by Equations (1) and (3), which together define a fixed point in $\mathcal{R}^*$ and m^*_{ABCP}.*
Proof. *All proofs are given in the Appendix.* ■

2.2.1   Comparative Statics

This simple model delivers the comparative statics we will look for in the data. We focus on the effects of shocks to money demand, which are represented in the model by shocks to θ. We first calculate comparative statics assuming the Federal Reserve and the banking system

cannot instantaneously react to money demand shocks so that M is fixed. We then consider the equilibrium response of the Federal Reserve and the banking sytem.

Note that the spread between yields on ABCP and Treasury bills is given by

$$R_{ABCP} - R_T = (\alpha_T - \alpha_{ABCP}) \theta v'(M). \tag{4}$$

This increasing in θ. Thus, if there is a positive money demand shock (an increase in θ), the ABCP - Treasury bill spread will *increase*. This is somewhat counterintuitive. A shock to money demand lowers yields on both ABCP and Treasury bills. However, since Treasury bills provide more money services than ABCP, yields on Treasury bills fall more, increasing the spread. We will use the ABCP - Treasury bill spread as a proxy for money demand in our empirical specifications below.

Similarly, hold fixed θ and consider a positive shock to the supply of Treasury bills. Until the Federal Reserve and the banking system can react, this will decrease the ABCP - Treasury bill spread. The logic is similar. An increase in Treasury bill supply increases m_T and therefore M. An increase in M lowers the marginal value of money services, which increases yields on both ABCP and Treasury bills. Since Treasury bills provide more money services than ABCP, yields on Treasury bills rise more, decreasing the spread.[4] Formally, we have

$$\frac{\partial (R_{ABCP} - R_T)}{\partial m_T} = (\alpha_T - \alpha_{ABCP}) \alpha_T \theta v''(M) < 0 \tag{5}$$

since $v'' < 0$.

The same logic holds if the Federal Reserve decides to inject reserves. This leads to a greater use of deposit financing by banks, increasing M, and lowering marginal value of money services, which increases yields on both ABCP and Treasury bills. Treasury bill yields rise more, so the spread decreases. Formally, we have

$$\frac{\partial (R_{ABCP} - R_T)}{\partial \mathcal{R}} = (\alpha_T - \alpha_{ABCP}) \frac{\theta}{\rho} v''(M) < 0. \tag{6}$$

How do the Federal Reserve and banking system react once there has been an increase in money demand θ? The following proposition characterizes their response.

Proposition 2 *Suppose there is an increase in θ. The Federal Reserve and banking system react by increasing the supply of reserves and ABCP respectively, such that $\partial \mathcal{R}^*/\partial \theta > 0$ and $\partial m^*_{ABCP}/\partial \theta > 0$.*

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[4]Of course, the same prediction holds if there is simply downward sloping demand for Treasury bills.

The intuition is as follows. As Equation (3) shows, the Federal Funds rate i is determined by the product of θ and $v'(M)$, as well as $w'(m_D)$. When θ increases, the Federal Funds rate increases. To keep the rate at the target i, the Federal Reserve responds by increasing the supply of reserves. This increases m_D and M, decreasing both $v'(M)$ and $w'(m_D)$. In addition, the banking system produces more ABCP, further decreasing $v'(M)$. These increases drive down the marginal value of money services until the product $\theta v'(M)+w'(m_D)$ has the same value it did previously, so that the Federal Funds rate remains at its target. This is where the assumption that deposits and ABCP are imperfect substitutes is key. If they were perfect substitutes, the Federal Reserve would have to drive the product $\theta v'(M)$ back to its original value. In this case, Equation (1) would then imply that the banking system did not produce any more ABCP.

Finally, the following proposition shows that despite the response of the monetary authority and the banking sector, an increase in θ increases equilibrium spreads.

Proposition 3 *Suppose there is an increase in θ. The equilibrium spread $R_{ABCP} - R_T$ is higher than its initial level, even after the Federal Reserve and the banking system respond by increasing supply.*

The intuition is that deposits and reserves, which determine the Federal Funds rate, are imperfect substitutes for Treasuries and ABCP. Thus, the injection of reserves that pushes the Federal Funds rate back to its target does not fully restore rates on Treasuries and ABCP to their initial levels.

To summarize, the model delivers the following five predictions, which we take to the data in the next section:

1. Shocks to money demand should increase the spread between ABCP and Treasury bill yields.

2. An increase in the supply of Treasuries should decrease the spread between ABCP and Treasury bill rates. Similarly, the injection of reserves by the Federal Reserve should decrease the spread between ABCP and Treasury bill rates.

3. The financial sector should respond to such shocks by increasing the supply of ABCP.

4. The Federal Reserve should respond to such shocks by conducting open market operations to increase the supply of reserves and maintain a constant Federal Funds rate.

5. The supply of ABCP and the supply of reserves/deposits should be positively correlated because they both respond to money demand shock.

3   Empirical Evidence

3.1   Data

We construct a weekly data set beginning in January 2001, when data on ABCP outstanding becomes available. We focus on the pre-crisis period and end the sample at the end of June 2007, just before the collapse of the ABCP market. Table 1 presents summary statistics.

The data come from several sources. Interest rates are from the Federal Reserve H.15 Statistical Release. Data on ABCP outstanding comes from the Commercial Paper Rates and Outstanding Summary, also a Federal Reserve Board Statistical Release. Data on open market operations come from the Federal Reserve Bank of New York.[5] Weekly data on Treasury bills outstanding are from the US Treasury Office of Debt Management. Data on monetary aggregates are from the Federal Reserve H.6 Statistical Release.

3.2   Results

3.2.1   ABCP Outstanding Increases with Spreads

Table 2 Panel A studies the response of the shadow banking system to an increase in money demand. As seen in Equation (4), spreads impound information about general level of money demand, θ. Specifically, when θ is high, spreads of ABCP over Treasury bills should be high. Proposition 2 suggests that the shadow banking system should respond to this money demand shock by increasing the amount of ABCP outstanding. To examine this prediction, we run the regression specification:

$$\ln\left(ABCP\_OUTSTANDING\right)_t = \alpha + \beta \cdot SPREAD_{t-1} + \varepsilon_t.$$

We examine the spreads of 4-week ABCP over 4-week Treasury bills, 3-month ABCP over 3-month Treasury bills, and the Federal Funds rate over 4-week Treasury bills. All three are positively and significantly associated with the amount of ABCP outstanding. All columns except the first in Table 2 Panel A have month fixed effects. As the table shows, the results are also robust controlling for the lagged level of ABCP outstanding and lagged ABCP issuance.

These findings are consistent with the money demand story. When money demand θ is high, spreads are high. The shadow banking system responds by increasing ABCP issuance.

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[5]http://www.newyorkfed.org/markets/omo/dmm/historical/tomo/search.cfm

In contrast, the sign of the relation is not consistent with a standard market-timing story, where the banking system caters to demand shocks for short-term credit instruments unrelated to money demand. In particular, suppose for simplicity that the Treasury bill rate were fixed but the return required on ABCP varied. If the shadow banking system opportunistically issued ABCP, then ABCP outstanding should be high when ABCP yields and thus spreads were low (prices were high). We are finding the opposite: ABCP outstanding is high when spreads are high.

The results are also inconsistent with a supply-driven explanation. For instance, suppose the shadow banking system needed a large amount of financing. It would then increase the amount of ABCP outstanding, driving up spreads if demand for ABCP slopes downward. The timing of the regressions helps to mitigate these concerns. We show that high ABCP outstanding follows high spreads, rather than high spreads following high ABCP outstanding. However, the level of ABCP outstanding is positively autocorrelated. Thus, it could be the case that high ABCP outstanding increases spreads and is followed by high ABCP outstanding, generating our results. The fact that our results remain strong when we add controls for the lagged level of ABCP outstanding and lagged ABCP issuance help rule out such concerns.

Our specifications with month fixed effects also help to rule out alternative explanations. Within a given month, weeks that have high spreads are followed by weeks with high ABCP outstanding. By examining variation within a given month, we can rule out lower frequency explanations based on changes in market structure over time. For instance, the results cannot be explained by a low-frequency trend where ABCP outstanding is both increasing and becoming riskier.

The magnitudes of the effects we find are not overly large. Spreads are measured in percentage points, so the regressions say a 1% higher the spread is associated with a 1-2% higher level of ABCP outstanding. In the pre-crisis period, the 4-week ABCP - Treasury bill spread has a mean of 26 basis points (bps) and a standard deviation of 18 bps. Of course it would be surprising if we found very large magnitudes, given that we examine high frequency changes in money demand, which are likely to be relatively small.

In Table 2 Panel B, we report regressions similar to those Table 2 Panel A, but we use the supply of Treasury bills as an instrument for spreads. Greenwood and Vayanos (2010), Krishnamurthy and Vissing-Jorgensen (2012a), and Greenwood, Hanson, and Stein (2010, 2012) suggest that changes in the supply of Treasuries change the prices of Treasuries. Thus, the supply of Treasury bills should shift the spreads we are examining.

Is Treasury bill supply a valid instrument? Formally, the exclusion restriction here requires that supply shifts at high frequencies be unrelated to the broader economic conditions determining ABCP outstanding except through their effect on spreads. This seems plausible given that high frequencies Treasury bill issuance is largely driven by seasonal variation in the government's outlays and tax receipts. In particular, weekly Treasury bill supply is unlikely to be correlated with the financial system's need for financing. Thus, using it as an instrument helps rule out supply-driven explanations for our results.

The first 3 columns of Table 2 Panel B show that the supply of Treasury bills is negatively correlated with spreads. The sign of the relation is as expected: higher supply lowers prices, increasing yields, and lowering spreads. This is also consistent with the predictions of Equation (5). The last 3 columns of Table 2 Panel B show that ABCP outstanding is still positively correlated with spreads when we use Treasury bill supply as an instrument. The magnitudes are similar to those obtained from OLS in Panel A. These instrumental variable regressions also help to rule out supply-driven explanations based on the banking system's need for financing.

Table 2 Panels C and D repeat the exercise using net ABCP issuance rather than ABCP outstanding.[6] While the model presented above suggests the relationship should be in levels, in a dynamic model money demand would grow with the economy and it would therefore be more instructive to examine issuance, even though we use month FE in Table 2 Panels A and B to address this concern. In addition, it is somewhat easier to think about cumulative effects with an issuance regression.

The magnitudes we find here are similar to those in Table 2 Panels A and B. A 1% higher the spread is associated with 1% more net issuance. If the spread is one standard deviation (18 bps) higher for a year, this implies that net ABCP issuance is 9.4% higher than it otherwise would have been.

3.2.2   Open Market Operations Increase With Spreads

We next examine the response of the monetary authority to an increase in money demand. Before turning to the results, a brief description of the relationship between the demand for deposits, the demand for reserves in the interbank market, and open market operations may be helpful.

The demand for reserves in the Federal Funds market is ultimately driven by reserve requirements, which apply to "transaction deposits", demand deposits and all interest-bearing

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[6]Specifically, we examine changes in log ABCP outstanding, $\Delta \ln \left(ABCP\_OUTSTANDING \right).$

accounts that offer unlimited checking, at all depository institutions (Board of Governors 2005).[7] Thus, to the extent that demand for transaction deposits reflects demand for money services, as we assume in the model, the demand for reserves in the Federal Funds market will also reflect demand for money services.

Transactions in the Federal Funds market also take place to facilitate payment clearing between banks. We can usually think of these transactions as netting to zero so that they do not have much effect on the aggregate demand for reserves. However, transactions may affect aggregate demand for reserves to the extent that banks hold reserves as a precaution against over-drafting their accounts with at the Federal Reserve. These precautionary reserve holdings, which are called "contractual clearing balances", will be higher when the volume of transactions is higher. These interbank transactions are driven by transactions in the real economy, which are ultimately the source of money demand. Thus, we can also think of this kind of reserve demand as reflecting money demand.

Overall, this institutional background suggests that the demand for reserves in the interbank market is indeed related to money demand, consistent with the assumptions of the model. If these assumptions are correct, the model predicts that increases in money demand, which should be reflected by increasing spreads, should lead the Federal Reserve to inject reserves into the banking system. The logic is as follows. Equation (3) shows that an increase in money demand θ increases the Federal Funds rate. Proposition 2 shows that in order to keep the Federal Funds rate at its target, the Federal Reserve injects reserves into the banking system. This increases the supply of deposits, reducing the value of money services, and driving the Federal Funds rate back to its target level.

In practice, the Federal Reserve injects reserves by conducting open market operations. It engages in repo transactions, in which it borrows collateral from primary dealers in exchange for additional reserves. This increases the total quantity of reserves in the banking system. To withdraw reserves the Federal Reserve engages in reverse repo transactions, in which it lends collateral to the primary dealers in exchange for reserves. This decreases the total quantity of reserves. Thus, to examine the predictions of the money demand story, we run the regression specification:

$$RESERVE\_INJECTION_t = \alpha + \beta \cdot SPREAD_{t-1} + \varepsilon_t.$$

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[7]To reduce the burden of reserve requirement, banks use sweep accounts to transfer depositor funds to special money-market accounts that are not subject to reserve requirements. However, to the extent there is some limit on their ability to do this, an increase in deposits will translate into some increase in demand for reserves.

where $RESERVE\_INJECTION_t$ is the net reserve injection (repo minus reverse repo) in week t.[8]

Panel A of Table 3 presents the results. All columns except the first have month fixed effects. As in Table 2, we examine the effect using both OLS and IV, instrumenting for the spread with the supply of Treasury bills. Consistent with the money demand story, the coefficients are all positive and significant. Again, the magnitude of the coefficients is not overly large. A 1% higher spread leads to a $15 - 30$ million larger reserve injection, relative to a mean injection of \$35 million and a standard deviation of \$16 million.

Table 3 Panel B examines a prediction of the money demand that does not come directly from the model. When the Federal Reserve conducted open market operations in the pre-crisis period it typically accepted three types of collateral: Treasuries, the debt of the Government Sponsored Enterprises (GSEs), and mortgage-backed securities guaranteed by the GSEs. A natural prediction of the money demand story is that when money demand is high the banking sector would like to obtain additional reserves using the least money-like collateral, thus maximizing the net creation of money services. In particular, the fraction of reserve injections collateralized by Treasuries should decrease, assuming that Treasuries provide more money services than GSE debt and MBS. We examine this prediction by running the specification

$$\%nonTREASURY\_COLLATERAL_t = \alpha + \beta \cdot SPREAD_{t-1} + \varepsilon_t.$$

Again, all columns except the first have month fixed effects. We examine the effect using both OLS and IV, instrumenting for the spread with the supply of Treasury bills. The coefficients here are positive and significant, and the magnitudes are relatively large. A 1% increase in spreads results in a 20% or larger increase in the use of non-Treasury collateral. These results are consistent with a desire of the banking system to create new reserves with the least money-like collateral when money demand is high.

An alternative interpretation of the results is that they simply reflect variation in Treasury supply rather than money demand. It could just be that the spread is high when the supply of Treasuries is low (so the Treasury bill yield is low). However, in untabulated results, we find that the effect remains if we control for the supply of Treasury bills outstanding, though the statistical significance is sometimes weaker.

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[8] We do not take logs here because the net injection can be negative if there are more reverse repo transactions than repo transactions.

3.2.3 Spreads Decrease with Open Market Operations

What effect does the injection of reserves into the banking system have? The model suggests that it should decrease spreads. As Equation (6) shows, reserve injections should increase the total amount of money services available, driving down their marginal value and thus reducing spreads. To examine this prediction, we run the regression

$$\Delta SPREAD_t = \alpha + \beta \cdot RESERVE\_INJECTION_t + \varepsilon_t.$$

Table 4 Panel A shows the results. All columns except the first have month fixed effects. We also control for the supply and issuance of Treasury bills to ensure that the results are not driven purely by supply-driven changes in Treasury bill yields. The coefficients are negative and significant. The magnitudes are again not overly large. A \$35 million injection (the mean size) is associated with a spread decline of 4-5 bps, relative to an average spread of 26 bps.[9]

This is consistent with the money demand story. Additional reserves increase the supply of money, which in turn reduces spreads. Moreover, the results inconsistent with the idea that all variation is coming from supply effects in the Treasury bill market. Reserve injections decrease the supply of Treasury bills in the private market because bills are exchanged for reserves in repo transactions. This should decrease yields and increase spreads.

Panel B of Table 4 examines the effect on spreads of reserve injections backed by different types of collateral. One could imagine that reserve injections have the largest effect on spreads when they are backed by the least money-like collateral. There is some suggestive evidence to this effect in the table. Reserve injections backed by either GSE debt or GSE-guaranteed MBS tend to have a larger and more statistically significant impact on spreads than injections backed by Treasuries.

3.2.4 Spreads Increase with Aggregate Money Quantities

We next examine the joint dynamics of spreads and monetary quantities. The money demand story suggests that shocks to money demand should both increase spreads (Equation 4) and result in increasing money quantities (Equation 6). Table 5 examines this prediction directly by looking at contemporaneous relationships between spreads and money quantities. We run

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[9]In untabulated results, we find negative but usually not significant coefficients when we examine the effect of reserve injections on the spread of the Federal Funds rate over 4-week Treasury bills. This may be due to the fact that the Federal Reserve actually targets the Federal Funds rate, so the spread largely reflects movements in the Treasury bill yield, which may contain Treasury market specific noise.

regressions of the form

$$\ln\left(M_t\right) = \alpha + \beta \cdot SPREAD_t + \varepsilon_t$$

where M_t is some measure of the quantity of money. For brevity, we focus on the spread of 4-week ABCP rates over 4-week Treasury bill yields and examine different measures of the quantity of money.

In the first column, we use the quantity of reserves in the banking sector as a proxy for M_t. There is a positive and significant relationship. This is not surprising given the results in Table 3 Panel A, but it is still reassuring. The most direct measure of the banking system's ability to produce money is positively related to spreads. In the second column we see that the quantity of deposits in the banking sector is positively, but not significantly, related to the spread.

The third and fourth columns, show that the assets under management of retail money market mutual funds are positively associated with the spread, but there is no relationship for institutional money market funds. The fifth and sixth columns show that the size of the money supply, as measured by M1 or M2, is positively associated with the spread, though the relationship is only significant for M2. Importantly, this relationship is not mechanical: ABCP outstanding is not automatically included in M2.[10]

Overall, there is suggestive evidence that some monetary quantities are positively correlated with spreads. This is consistent with the money demand story.

3.2.5 ABCP Outstanding Responds to Other Money Quantities

Table 6 examines the dynamics of quantities outstanding for different types claims that provide money services. Specifically, we examine the contemporaneous relationship between ABCP outstanding, reserve injections, deposits outstanding, and Treasury bills outstanding. We run regressions of the form:

$$\ln\left(ABCP\_OUTSTANDING_t\right) = \alpha + \beta \cdot \ln\left(M_t\right) + \varepsilon_t.$$

where M_t is the outstanding amount of some type of money claim.

The results are consistent with the money demand story. ABCP outstanding, reserve injections, and deposits are all contemporaneously positively correlated. This is consistent with the idea that they are all responding to a single state variable: money demand.

On the other hand, ABCP outstanding and Treasury bills outstanding are negatively

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[10]Unless it is held by retail (not but institutional) money market funds.

correlated. This is also consistent with the money demand story, as argued by Krishna-murthy and Vissing-Jorgenson (2012b). Treasury bill issuance is driven by the short-term financing and cash management needs of the Federal government and does not respond to money demand. However, because Treasury bills provide money services they can crowd out other forms of private money creation, reducing the amount of ABCP the banking system issues. This is consistent with the argument of Greenwood, Hanson, and Stein (2012), who present a model where the government should tilt its debt maturity towards Treasury bills to discourage private money creation, which is associated with fire sale externalities.

Table 7 further explores this connection with Greenwood, Hanson, and Stein (2012). They construct a proxy for the money services provided by Treasury bills using the spread between fitted bill yields and actual yields. The fitted yields are constructed based on Gurkaynak, Sack, and Wright (2006), who estimate the Treasury yield curve using only Treasury notes and bonds with remaining maturities greater than three months. Thus, the spread between fitted and actual yields, called the "z-spread", is a measure of the deviation of actual Treasury bills yields from an extrapolation of the rest of the yield curve. Consistent with the idea that Treasury bills provide greater money services than long-term Treasuries, fitted yields are typically significantly higher than actual yields. The z-spread for 4-week bills averages 27 bps in our sample period and 40 bps in the longer sample studied in Greenwood, Hanson, and Stein (2012).

If the z-spread is a proxy for the value of the money services embedded in Treasury bills, it should be positively correlated with our proxy for money demand, the spread between ABCP rates and Treasury bill yields. Table 7 examines this prediction. Specifically, we run regressions of the form

$$SPREAD_t = \alpha + \beta \cdot ZSPREAD_t + \varepsilon_t$$

The first column of Table 7 shows the regression in levels without month fixed effects. The z-spread is strongly positively correlated with the ABCP-Treasury spread, and explains almost 50% of the variation in it. The second column of the table shows that the relationship remains positive and significant once we add month fixed effects.

The third column shows that the positive relationship between the ABCP-Treasury spread and the z-spread is not driven by the fact that they both contain the actual 4-week Treasury bill yield. Even after we separately control for the bill yield, the relationship remains strongly significant. The fourth and fifth columns show the same regressions in first differences rather than levels. Changes in the ABCP-Treasury spread are also positively and

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significantly correlated with changes in the z-spread, though the statistical significance is somewhat lower.

These results are consistent with the money demand story. Demand for claims that provide money services influences the prices of these claims and shows up in a variety of spreads.

3.2.6 Response of Other Parts of the Shadow Banking System

Finally, in Table 8 we briefly examine the response of the primary dealers to variation in money demand. The dealers are another channel through which the shadow banking system can respond to shocks to money demand. In particular, one could imagine that the liabilities of the primary dealers provide more money services than some securities and less money services than others. Thus, when money demand is high, the dealers should reduce their positions in securities that provide a lot of money services and increase their positions in securities that provide few money services.

Table 8 examines this prediction. Specifically we run regressions of the form

$$NET\_DEALER\_POS_t = \alpha + \beta \cdot SPREAD_{t-1} + \varepsilon_t.$$

where NET_DEALER_POS is the aggregate net position (long minus short) of the primary dealers in a given security type.[11] In column 1, we examine dealer positions in Treasury bills. The coefficient is negative and significant, suggesting that dealers supply more Treasury bills to the market when money demand is high. An alternative explanation would reverse the interpretation of this result: one might imagine that dealers absorb the excess when the supply of Treasury bills high, implying high Treasury bill yields and low spreads. To address this concern, in column 2 we control for Treasury bills outstanding. The coefficient on the ABCP-Treasury spread remains negative and significant. Similarly, in columns 3 and 4, we repeat the exercise using dealer positions as a fraction of Treasury bills outstanding to normalize by total supply. Overall, it seems like supply cannot explain the negative coefficient.

In the remaining columns, we see that dealer positions in all Treasury securities and GSE debt decrease when spreads are high. In contrast, net positions in GSE-guaranteed mortgage-backed securities and especially corporate securities increase when spreads are high. This is consistent with the money demand story. Treasuries and GSE debt provide more

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[11]Note that we do not take logs here because net positions can be negative (i.e., dealers can be net short securities).

money services than the liabilities of the primary dealers. Therefore, when money demand is high, the dealers hold less of these securities. In contrast, GSE-guaranteed mortgage-backed securities and especially corporate securities provide less money services than the liabilities of the primary dealers. Thus, when money demand is high, the dealers hold more of these securities.

3.3 Alternative Explanations

The results above are all consistent with the money demand story as formalized in the model in Section 2. However, one may be concerned that there could be other explanations for the empirical patterns we document. There are two alternative explanations that deserve particular scrutiny.

First, we consider the alternative that our results are simply driven by supply effects in the market for Treasury bills. Krishnamurthy and Vissing-Jorgensen (2012a) and Greenwood and Vayanos (2008) show that yields on Treasuries increase with supply. Under this alternative hypothesis, ABCP provides no monetary services, but Treasuries do and our results simply reflect this. For instance, we use variation in the spread of ABCP rates over Treasury bill yields as a proxy for changing money demand. This variation in the spread could simply be driven by supply-related variation in Treasury bill yields.

Many of our results would not emerge if this alternative explanation were true. For instance, if variation in the ABCP-Treasury spread simply reflects changes in Treasury bill supply, there is no reason that ABCP outstanding should respond to the spread as we saw in Table 2. Moreover, in contrast to the results in Table 4, reserve injections should increase spreads under this alternative since they reduce the quantity of Treasury bills in the private market. Furthermore, under this alternative, there is no reason for ABCP outstanding to be positively correlated with reserve injections and negatively correlated with Treasury bills outstanding in Table 6. Finally, in Table 7, we show that the ABCP-Treasury spread is positively correlated with the z-spread, another proxy for money demand, even after controlling for the Treasury bill yield. Taken together, these tables suggest that the Treasury supply alternative cannot fully explain our results.

Second, we consider the possibility that our results are driven by the need for financing in the banking sector. Consider an increase in the need for financing. This increased need would be met by an increase in both ABCP and deposit financing, which would drive up the ABCP-Treasury spread if demand for ABCP slopes downward. Again, under this alternative hypothesis, ABCP provides no monetary services. It is simply a source of financing for the

banking sector.

Several of our results cut against this alternative. First, to the extent that banks' need for financing is driven by the demand for credit, the sign of the relationship between ABCP outstanding and spreads goes the wrong way. A long literature, including Stock and Watson (1989) and Friedman and Kuttner (1992), shows that high spreads forecast lower economic activity. This implies the demand for credit, and by extension banks' need for financing, should be lower when spreads are high. In contrast, Table 2 shows that high spreads forecast high ABCP outstanding.[12] Second, the timing of the regressions in Table 2 helps mitigate concerns that our results are driven by banks' financing needs. Under this alternative, high ABCP issuance should drive spreads higher, while we show that high ABCP outstanding follows high spreads. Third, the results in Table 2 Panels B and D, which instrument for the ABCP-Treasury spread using Treasury bill supply, show that variation in the spread only related to this supply induce a response from the shadow banking system. Fourth, under this alternative, there is no reason that the composition of the collateral used in reserve injections should change as it does in Panel B of Table 3. Finally, the bank financing alternative does not explain why Treasury bills outstanding should be negatively correlated with ABCP outstanding as in Table 6.

Overall, the results seem most consistent with the money demand story articulated in the model in Section 2. Of course, the approach taken in this paper is indirect, so we cannot claim that the results are definitive. However, the money demand explanation is consistent with more of the results than the alternatives considered here.

4 Cumulative Effects over the Pre-Crisis Period

4.1 Extrapolating the Demand-Side Evidence

So far we have shown that the data are consistent with the idea that the liabilities of the shadow banking system, in particular ABCP, provide monetary services. But how much of the pre-crisis growth in the shadow banking system can increased money demand explain? Figure 1 shows the growth of ABCP over our sample period. Most is concentrated from mid-2004 to mid-2007. ABCP outstanding grew 8% from January 2001-June 2004 and 70% from June 2004-July 2007.

We can use the estimates from Table 2 to try to assess how much of this growth is related

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[12]Of course, the frequency of the analyses are different. The macroeconomic forecasts use quarterly data, while we use weekly data.

to money demand. We can compare the level of spreads from June 2004-July 2007 relative to the baseline period of January 2001-June 2004, asking whether the results in Table 2 would predict higher issuance. Many caveats are in order in interpreting such a calculation. First, throughout the paper we take no stand on the sources of money demand, which are critical for understanding the welfare implications of the shadow banking system. Moreover, without a view on its sources, it is difficult to assess the plausibility of the idea that money demand suddenly and significantly increased in the mid-2000s. Second, there are substantial external validity concerns. Our results are based on high-frequency variation that we argue are ascribable to money demand. It is not entirely clear whether we can extrapolate these results when thinking about the low frequency growth of short-term funding in the shadow banking system before the financial crisis. Moreover, the results, while qualitatively similar, vary across the various specifications examined in Table 2. Third, while our results are statistically significant, the standard errors are relatively large, and estimation error will be compounded in the calucalation. Nonetheless, with these caveats in mind, the calculation is probably still worth doing.

We do the calculation using the estimates in Panel C of Table 2, which relate ABCP issuance to spreads.[13] Consistent with increased money demand in the mid-2000s, the spread of 4-week ABCP rates over 4-week Treasury bills yields was 21 bps higher on average from June 2004-July 2007 than it was from January 2001-June 2004. This could potentially reflect increased riskiness of ABCP, but the spread of the Federal Funds rate over 4 week Treasury bill yields is also 14 bps higher on average in the latter period than in the prior. The results in Table 2 Panel C suggest that this translates into roughly 30% (percentage points) more total ABCP issuance over the latter period than over the early period. Thus, our results suggest that increased money demand could explain up to approximately 1/2 of the overall increase in ABCP outstanding.

4.2   Suggestive Supply-Side Evidence

While the evidence presented here seems qualitatively consistent with the money demand view, quantities are of course determined by both demand and supply. Aggregate patterns in the data suggest that supply may have also played an important role in the growth of ABCP in the mid-2000s. In particular, the 4-week ABCP - Treasury bill spread was 21 bps (approximately one standard deviation) higher on average from June 2004-July 2007 than it

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[13]Note that Panel C is estimated over the entire sample period, January 2001-July 2007. However, if we restrict the estimation period to January 2001-June 2004, the results are statistically similar and quantitatively a bit larger.

was from January 2001-June 2004. This relatively small movement in prices, coupled with a very large change in quantities, suggests a high elasticity of ABCP supply.

The model suggests one way that the elasticity of supply manifests itself in the data, which is given in the proposition below: the banking system should respond to increases in the Federal Funds rate by issuing more ABCP.

Proposition 4 *Suppose the Federal Reserve wishes to increase its policy rate i. It does so by reducing the supply of reserves so that $\partial \mathcal{R}^*/\partial i < 0$. The banking system reacts by increasing the supply of ABCP so we have $\partial m_{ABCP}^*/\partial i > 0$. When w'' is small so deposits and ABCP are nearly perfect substitutes $\partial m_{ABCP}^*/\partial i \approx \rho \alpha_{ABCP}/c''$ where $c(\cdot)$ is the cost of manufacturing ABCP.*

The intuition is as follows. The reserve requirement is effectively a tax on deposits, and when the Federal Reserve wishes to increase the Federal Funds rate, it must increase this tax. This causes the banking system to substitute towards ABCP financing.[14] The degree to which it does so is related to the elasticity of ABCP supply, which is captured by c''. When c'' is low the banking sector can easily produce more ABCP (i.e. supply is elastic), so the banking system substitutes more heavily towards ABCP.

As seen in Figure 1, the timing of the explosion in ABCP is consistent with this prediction. Most of the growth of ABCP took place between mid-2004 and mid-2007, and the Federal Reserve began increasing rates in June 2004. Of course, several other institutional changes took place in 2004 that may also have played an important role in the growth of ABCP. Specifically, changes to the bankruptcy code and to the regulatory capital requirements for bank lines of credit extended to ABCP vehicles may have played an important role, either by improving the ability of the financial system to create money-like securities (Gorton and Metrick 2010) or by fostering regulatory arbitrage (Acharya, Schnabl, and Suarez 2011).

Has the elasticity of supply changed over time? To explore this, in Figure 2 we examine the relationship between commercial paper outstanding and the Federal Funds rate over a longer period using rolling regressions with data from the Flow of Funds. At each date we run a regression of commercial paper outstanding normalized by GDP on the Federal Funds rate over the following 5 years and plot the coefficient from that regression. As seen in Figure 2, the relationship has strengthened considerably over the last twenty years, and particularly in the last ten, suggesting supply is substantially more elastic than it used to be.

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[14]Kashyap, Stein, and Wilcox (1993) derive a similar result, but then use it for a different purpose. In particular, they argue that the mix of commercial paper versus bank financing is a measure of the stance of monetary policy and show that it can forecast output.

Finally, as mentioned above, one can think of the costs of ABCP production $c(\cdot)$ as capturing the idea that the money services provided by ABCP α_{ABCP} should decline with the quantity of ABCP produced. Under this alternative interpretation, what changed is not ABCP production technology, but instead investor perceptions of the banking system's ability to produce high-quality ABCP. This is consistent with the idea that neglected risks played an important role in the boom, as argued by Gennaioli, Shleifer, and Vishny (2011, 2012). The key question under this interpretation is why perceptions changed beginning in the 1990s.

5 Conclusion

Many explanations for the rapid growth of the shadow banking system in the years before the financial crisis focus on money demand. Despite the prominence of the money demand story in the literature, its basic premise remains untested. Did the short-term claims issued by the shadow banking system provide money services before the crisis? This paper aims to assess this question empirically by examining the price-quantity dynamics of these short term claims and their interactions with Federal Reserve open market operations.

Examining the pre-crisis period from January 2001 through June 2007, the empirical evidence is consistent with the money demand story. Our estimates imply that a sustained increase in money demand could explain up to approximately 1/2 of the growth in ABCP outstanding in the years before the financial crisis. This is a substantial fraction, suggesting that money demand did play an important role. However, it also suggests that money demand was by no means the sole driver of the growth of ABCP. Other explanations, including regulatory arbitrage and mispricing, are likely to have also played significant roles. We provide some suggestive evidence that changes in the elasticity of ABCP supply may have played an important role.

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A Proof of Proposition 1

Banks solve

$$\max_{m_D, m_{ABCP}} F - R + m_D \left(\theta v' \left(M \right) + w' \left(m_D \right) \right) + m_{ABCP} \alpha_{ABCP} \theta v' \left(M \right) - c \left(m_{ABCP} \right)$$

subject to the constraints

$$\rho m_1 = \mathcal{R}$$
$$m_D + m_{ABCP} \leq 1$$

where $\mathcal{R}$ is the total quantity of reserves in the system.

The Lagrangian is

$$F - R + m_D \left(\theta v' \left(M \right) + w' \left(m_D \right) \right) + m_{ABCP} \alpha_{ABCP} \theta v' \left(M \right) - c \left(m_{ABCP} \right)$$
$$+ \lambda_1 \left(\mathcal{R} - \rho m_1 \right) + \lambda_2 \left(1 - m_D - m_{ABCP} \right)$$

Differentiating with respect to m_D and m_{ABCP} yields FOCs

$$\theta v' \left(M \right) + w' \left(m_D \right) - \rho \lambda_1 - \lambda_2 = 0$$
$$\alpha_{ABCP} \theta v' \left(M \right) - c' \left(m_{ABCP} \right) - \lambda_2 = 0.$$

These can be rearranged to solve for the multipliers

$$\lambda_1 = \frac{\left(1 - \alpha_{ABCP} \right) \theta v' \left(M \right) + w' \left(m_D \right) + c' \left(m_{ABCP} \right)}{\rho}$$
$$\lambda_2 = \alpha_{ABCP} \theta v' \left(M \right) - c' \left(m_{ABCP} \right).$$

λ_2 is the shadow cost of the adding up constraint. If $\lambda_2 > 0$, the bank would be able to increase profits by using more ABCP funding, except that it is already financing 100% of its investment using ABCP and deposits. For a large enough value of c', we will be at an interior solution and the constraint is slack..

In equilibrium, we have market clearing for reserves so

$$m_D^* = \frac{\mathcal{R}}{\rho}$$

and

$$\alpha_{ABCP} \theta v' \left(m_D^* + \alpha_T m_T + \alpha_{ABCP} m_{ABCP}^* \right) = c' \left(m_{ABCP}^* \right).$$

(assuming $c' > \underline{c}$). These two conditions pin down m_D^* and m_{ABCP}^*, which in turn pin down λ_1^*.

Finally, we can implicitly define the quantity reserves $\mathcal{R}^* \left(i \right)$ that implements the Federal

Funds rate $\lambda_1^* = i$ as

$$i = \frac{\theta v' \left(\frac{\mathcal{R}^*(i)}{\rho} + m_T + m_{ABCP}^*\right) + w' \left(\frac{\mathcal{R}^*(i)}{\rho}\right)}{\rho}.$$

B Proof of Proposition 2

Differentiating the first order condition (1) with respect to θ yields

$$\alpha_{ABCP} v'(M) + \alpha_{ABCP} \theta v''(M) \left[\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta} + \frac{\partial m_{ABCP}^*}{\partial \theta}\right] = c''(m_{ABCP}^*)\frac{\partial m_{ABCP}^*}{\partial \theta}$$

which implies

$$\frac{\partial m_{ABCP}^*}{\partial \theta} = \frac{\alpha_{ABCP} v'(M)}{c''(m_{ABCP}^*) - \alpha_{ABCP}\theta v''(M)} + \frac{\alpha_{ABCP}\theta v''(M)}{c''(m_{ABCP}^*) - \alpha_{ABCP}\theta v''(M)}\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta}$$

Similarly, differentiating (3) with respect to θ yields

$$\frac{\partial i}{\partial \theta} = 0 = v'(M) + \theta v''(M)\left[\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta} + \frac{\partial m_{ABCP}^*}{\partial \theta}\right] + w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta}.$$

Simplifying and plugging in the expression for $\frac{\partial m_{ABCP}^*}{\partial \theta}$ gives

$$
\begin{aligned}
0 ={} & \theta v''(M)\left[\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta} + \frac{\alpha_{ABCP} v'(M)}{c''(m_{ABCP}^*) - \alpha_{ABCP}\theta v''(M)} + \frac{\alpha_{ABCP}\theta v''(M)}{c''(m_{ABCP}^*) - \alpha_{ABCP}\theta v''(M)}\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta}\right] \\
& + v'(M) + w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta} \\
={} & v'(M) + \frac{\theta v''(M)\alpha_{ABCP} v'(M)}{c''(m_{ABCP}^*) - \alpha_{ABCP}\theta v''(M)} \\
& + \left[\frac{\theta c''(m_{ABCP}^*) v''(M)}{c''(m_{ABCP}^*) - \alpha_{ABCP}\theta v''(M)} + w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\right]\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta} \\
={} & -\underbrace{\left[\frac{c''(m_{ABCP}^*) v'(M)}{c''(m_{ABCP}^*) - \alpha_{ABCP}\theta v''(M)}\right]}_{>0} \Bigg/ \underbrace{\left[\frac{\theta c''(m_{ABCP}^*) v''(M)}{c''(m_{ABCP}^*) - \alpha_{ABCP}\theta v''(M)} + w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\right]}_{<0} > 0
\end{aligned}
$$

$$\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta} = -\left[\frac{c''(m_{ABCP}^*) v'(M)}{\theta c''(m_{ABCP}^*) v''(M) + (c''(m_{ABCP}^*) - \alpha_{ABCP}\theta v''(M)) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)}\right] > 0.$$

Finally plugging back into the expression for $\frac{\partial m^*_{ABCP}}{\partial \theta}$

$$
\frac{\partial m^*_{ABCP}}{\partial \theta} = \frac{\alpha_{ABCP} v'(M)}{c''(m^*_{ABCP}) - \alpha_{ABCP}\theta v''(M)}
$$
$$
-\frac{\alpha_{ABCP}\theta v''(M)}{c''(m^*_{ABCP}) - \alpha_{ABCP}\theta v''(M)} \times
$$
$$
\left[\frac{c''(m^*_{ABCP}) v'(M)}{\theta c''(m^*_{ABCP}) v''(M) + (c''(m^*_{ABCP}) - \alpha_{ABCP}\theta v''(M)) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)} \right]
$$
$$
\underbrace{\frac{1}{c''(m^*_{ABCP}) - \alpha_{ABCP}\theta v''(M)}}_{>0} \times
$$
$$
= \left[\frac{\overbrace{\alpha_{ABCP} v'(M) (c''(m^*_{ABCP}) - \alpha_{ABCP}\theta v''(M)) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)}^{<0}}{\underbrace{\theta c''(m^*_{ABCP}) v''(M) + (c''(m^*_{ABCP}) - \alpha_{ABCP}\theta v''(M)) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)}_{<0}} \right] > 0
$$

C   Proof of Proposition 3

The ABCP - Treasury bill spread is given by

$$
R_{ABCP} - R_T = (\alpha_T - \alpha_{ABCP})\,\theta v'(M).
$$

Differentiating with respect to θ yields

$$
\frac{\partial (R_{ABCP} - R_T)}{\partial \theta} = (\alpha_T - \alpha_{ABCP}) v'(M) + (\alpha_T - \alpha_{ABCP})\theta v''(M)\frac{dM}{d\theta}
$$
$$
= (\alpha_T - \alpha_{ABCP})\left[v'(M) + \theta v''(M)\left(\frac{1}{\rho}\frac{\partial \mathcal{R}^*(i)}{\partial \theta} + \alpha_{ABCP}\frac{\partial m^*_{ABCP}}{\partial \theta}\right) \right].
$$

We can sign the quantity in the square brackets using the fact that in equilibrium, the Federal Funds rate is unchanged. We have

$$
\frac{\partial i}{\partial \theta} = 0 = v'(M) + \theta v''(M)\left[\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta} + \frac{\partial m^*_{ABCP}}{\partial \theta}\right] + w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta},
$$

which implies

$$
v'(M) + \theta v''(M)\left[\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta} + \frac{\partial m^*_{ABCP}}{\partial \theta}\right] = \underbrace{-w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial \theta}}_{>0}.
$$

Thus, since $\alpha_T > \alpha_{ABCP}$ we have $\frac{\partial (R_{ABCP} - R_T)}{\partial \theta} > 0$.

D   Proof of Proposition 4

Differentiating the first order condition (1) with respect to i gives

$$\alpha_{ABCP}\theta v''(M)\left[\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}+\frac{\partial m^*_{ABCP}}{\partial i}\right]=c''(m^*_{ABCP})\frac{\partial m^*_{ABCP}}{\partial i}$$

and simplifying yields

$$\frac{\partial m^*_{ABCP}}{\partial i}=\frac{-\alpha_{ABCP}\theta v''(M)}{\alpha_{ABCP}\theta v''(M)-c''(m^*_{ABCP})}\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}.$$

Differentiating (3) with respect to i yields

$$
\begin{aligned}
\rho &= \theta v''(M)\left[\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}+\frac{\partial m^*_{ABCP}}{\partial i}\right]+w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}\\
&= \left(\theta v''(M)+w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\right)\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}+\theta v''(M)\frac{\partial m^*_{ABCP}}{\partial i}\\
&= \left(\theta v''(M)+w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\right)\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}-\frac{\alpha_{ABCP}\theta v''(M)\,\theta v''(M)}{\alpha_{ABCP}\theta v''(M)-c''(m^*_{ABCP})}\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}\\
&= \left[\underbrace{w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)}_{<0}-\underbrace{\frac{\overbrace{c''(m^*_{ABCP})\,\theta v''(M)}^{<0}}{\alpha_{ABCP}\theta v''(M)-c''(m^*_{ABCP})}}_{<0}\right]\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}\\
\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i} &< 0\\
\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i} &= \rho\left[\frac{\alpha_{ABCP}\theta v''(M)-c''(m^*_{ABCP})}{w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)(\alpha_{ABCP}\theta v''(M)-c''(m^*_{ABCP}))-c''(m^*_{ABCP})\,\theta v''(M)}\right]
\end{aligned}
$$

Finally plugging back into the expression for $\frac{\partial m^*_{ABCP}}{\partial i}$ yields

$$\frac{\partial m^*_{ABCP}}{\partial i}=-\rho\left[\frac{\overbrace{\alpha_{ABCP}\theta v''(M)}^{<0}}{\underbrace{w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)(\alpha_{ABCP}\theta v''(M)-c''(m^*_{ABCP}))-c''(m^*_{ABCP})\,\theta v''(M)}_{>0}}\right]$$

$$\frac{\partial m^*_{ABCP}}{\partial i}>0.$$
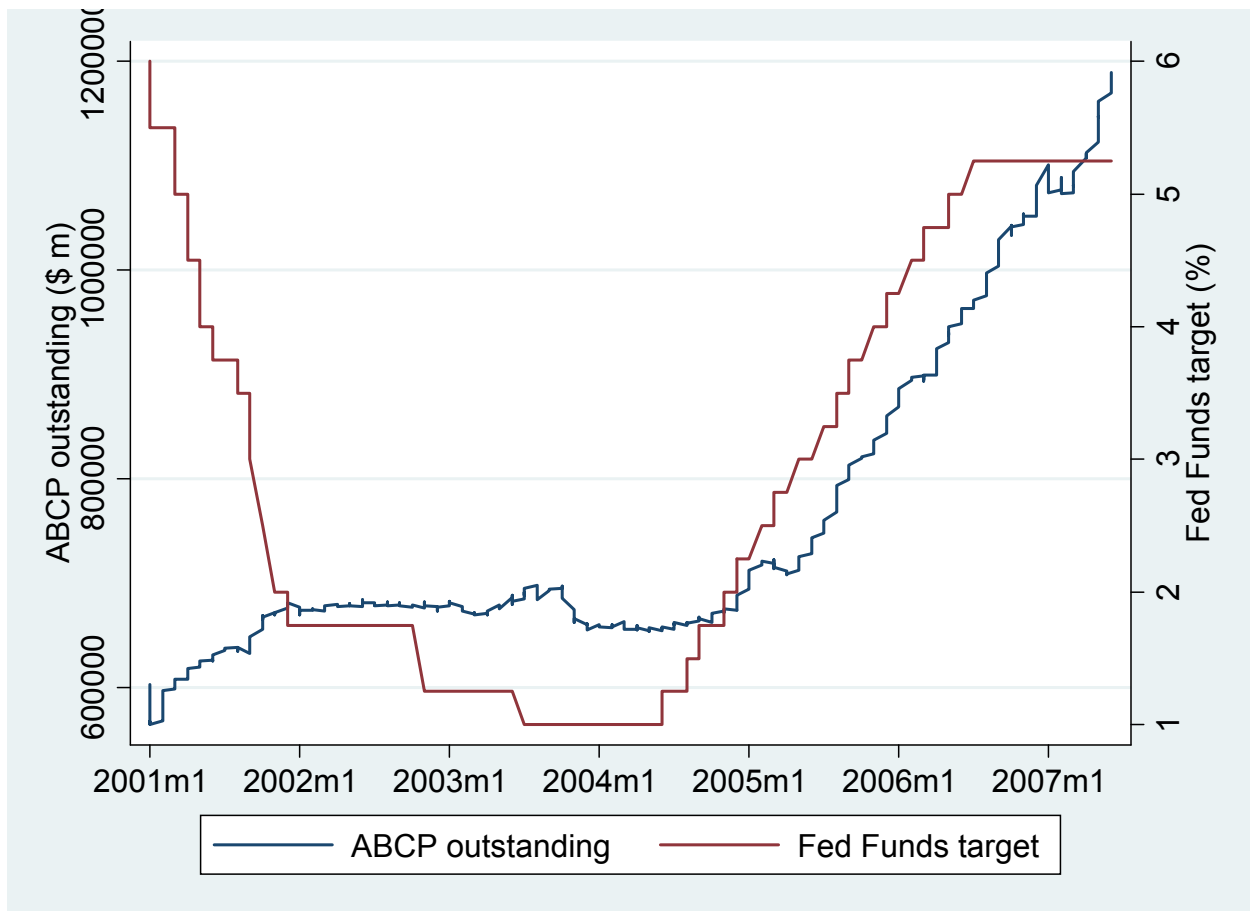
Figure 1
ABCP Outstanding and the Federal Funds Rate

This figure shows ABCP outstanding and the Federal Funds target rate over our sample period.
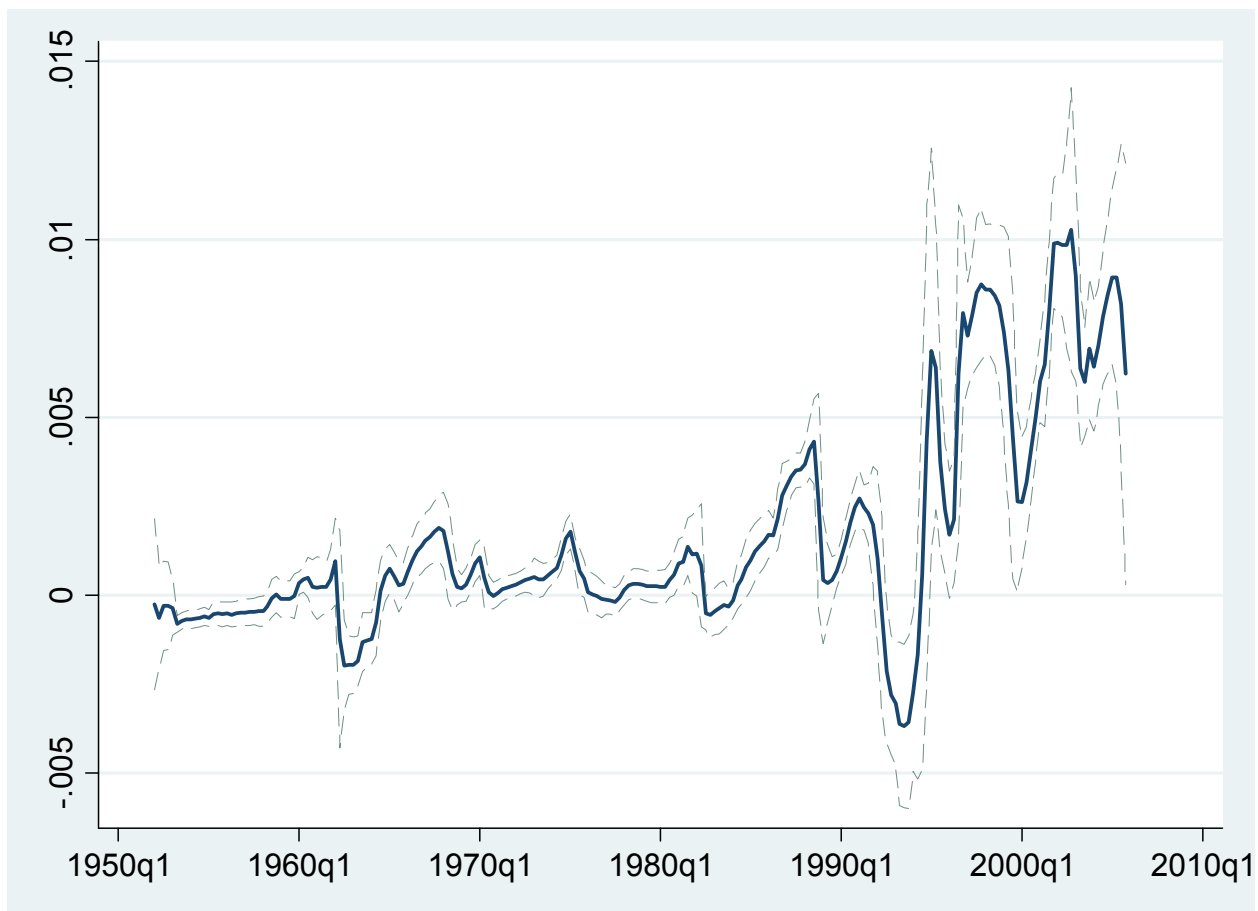
Figure 2
Relationship between CP outstanding and the Federal Funds Rate over Time

This figure reports the coefficients from a rolling regression of commercial paper outstanding on the Federal Funds rate. At each date we run a regression of commercial paper outstanding on the Federal Funds rate over the following 5 years and plot the coefficient from that regression. Confidence intervals (dotted lines) computed using robust standard errors are reported.

Table 1 Summary Statistics

This table presents summary statistics for the variables used in the paper. 4w ABCP - T-bill is the spread of 4-week ABCP over 4-week Treasury bills; 3m ABCP - T-bill is the spread of 3-month ABCP over 3-month Treasury bills; Fed Funds - T-bill is the spread of the Federal Funds rate over 4-week Treasury bills; ln(ABCP Out) is log ABCP outstanding; Δ ln(ABCP Out) is log net ABCP issuance; ln(T-bills Out) is log Treasury bills outstanding; Reserves Injected is net reserve injections (repo minus reverse repo); Non-Treasury Collateral is the percentage of reserve injections backed by non-Treasury (i.e. GSE debt and GSE-guaranteed MBS) collateral. The Net Dealer variables are net dealer positions in different types of securities. The sample runs weekly from January 2001-June 2007.

	N	Mean	SD	Min	Max
4w ABCP - T-bill (%)	303	0.259	0.179	0.070	1.120
3m ABCP - T-bill (%)	303	0.239	0.126	0.060	0.740
Fed Funds - T-bill (%)	303	0.194	0.181	-0.080	1.050
ABCP Outstanding ($m)	303	776,101	153,802	632,920	1,189,572
ln(ABCP Out)	303	13.545	0.181	13.358	13.989
Δ ln(ABCP Out$_{t-1}$)	303	0.002	0.005	-0.016	0.018
T-bills Outstanding ($b)	303	932	75	691	1089
ln(T-bills Out$_t$)	303	6.834	0.084	6.538	6.993
Reserves Injected ($m)	303	34	12	5	114
Non-Treasury Collateral	303	0.25	0.17	0.00	0.85
Net Dealer Tbills ($m)	303	12,328	18,133	-29,771	63,405
Net Dealer MBS ($m)	303	24,937	13,578	-3,110	65,442
Net Dealer Treasuries ($m)	303	-87,297	47,403	-184,456	6180
Net Dealer Agencies ($m)	303	86,614	16,209	49,666	131,535
Net Dealer Corporate ($m)	303	138,031	54,725	41,808	266,072

Table 2
ABCP Outstanding and Spreads

This table shows regressions of the form

$$\ln\left(ABCP\_OUTSTANDING_t\right) = \alpha + \beta \cdot SPREAD_{t-1} + \varepsilon_t.$$

4w ABCP - T-bill$_{t-1}$ is the spread of 4-week ABCP over 4-week Treasury bills, 3m ABCP - T-bill$_{t-1}$ is the spread of 3-month ABCP over 3-month Treasury bills, Fed Funds - T-bill$_{t-1}$ is the spread of the Federal Funds rate over 4-week Treasury bills, ln(ABCP Out$_{t-1}$) is lagged log ABCP outstanding, and Δ ln(ABCP Out$_{t-1}$) is lagged log net ABCP issuance (the lagged change in log ABCP outstanding. In Panel B, we instrument for spreads using ln(T-bills Out$_t$), log Treasury bills outstanding. Panels C and D repeat these exercises using Δ ln(ABCP Out$_{t-1}$), log net ABCP issuance, as the dependent variable. The sample runs weekly from January 2001-June 2007. Robust standard errors are reported in parentheses, except for the specifications without month fixed effects which report Newey-West standard errors with 12 lags. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

	Panel A: ABCP Outstanding on Lagged Spreads (OLS)						
4w ABCP - T-bill$_{t-1}$	0.613***	0.018***	0.012***				
	(0.092)	(0.006)	(0.004)				
3m ABCP - T-bill$_{t-1}$				0.038***	0.022**		
				(0.015)	(0.009)		
Fed Funds - T-bill$_{t-1}$						0.011**	0.008***
						(0.005)	(0.003)
ln(ABCP Out$_{t-1}$)			0.640***		0.640***		0.645***
			(0.061)		(0.061)		(0.061)
Δ ln(ABCP Out$_{t-1}$)			0.007		0.012		0.018
			(0.074)		(0.073)		(0.078)
Constant	13.387***	13.540***	4.874***	13.535***	4.872***	13.543***	4.803***
	(0.030)	(0.001)	(0.830)	(0.003)	(0.826)	(0.001)	(0.825)
R^2	0.341	0.999	0.999	0.999	0.999	0.999	0.999
N	303	303	301	303	301	303	301
Month FE	N	Y	Y	Y	Y	Y	Y

Panel B: ABCP Outstanding on Lagged Spreads (IV)

	First Stage			IV estimates		
	4w ABCP - T-bill$_{t-1}$	3m ABCP - T-bill$_{t-1}$	Fed Funds - T-bill$_{t-1}$			
ln(T-bills Out$_t$)	-1.692***	-0.219*	-1.538***			
	(0.223)	(0.120)	(0.309)			
4w ABCP - T-bill$_{t-1}$				0.018***		
				(0.007)		
3m ABCP - T-bill$_{t-1}$					0.090**	
					(0.041)	
Fed Funds - T-bill$_{t-1}$						0.019**
						(0.008)
ln(ABCP Out$_{t-1}$)				0.635***	0.607***	0.638***
				(0.063)	(0.077)	(0.064)
Δ ln(ABCP Out$_{t-1}$)				-0.005	-0.048	-0.003
				(0.078)	(0.085)	(0.082)
Constant	11.818***	1.736**	10.702***	4.870***	5.239***	4.831***
	(1.523)	(0.819)	(2.112)	(0.837)	(1.027)	(0.859)
R^2	0.879	0.909	0.746	0.999	0.999	0.999
N	303	303	303	301	301	301
Month FE	Y	Y	Y	Y	Y	Y

Panel C: ABCP Issuance on Lagged Spreads (OLS)

4w ABCP - T-bill$_{t-1}$	0.013***	0.012***	0.012***				
	(0.002)	(0.004)	(0.004)				
3m ABCP - T-bill$_{t-1}$				0.022**	0.022**		
				(0.01)	(0.009)		
Fed Funds - T-bill$_{t-1}$						0.007**	0.008***
						(0.003)	(0.003)
ln(ABCP Out$_{t-1}$)			-0.360***		-0.360***		-0.355***
			(0.061)		(0.061)		(0.061)
Δ ln(ABCP Out$_{t-1}$)			0.007		0.012		0.018
			(0.074)		(0.073)		(0.078)
Constant	-0.001**	-0.001	4.874***	-0.003	4.872***	0.001	4.803***
	(0.001)	(0.001)	(0.83)	(0.002)	(0.826)	(0.001)	(0.825)
R^2	0.164	0.202	0.378	0.192	0.365	0.184	0.362
N	303	303	301	303	301	303	301
Month FE	N	Y	Y	Y	Y	Y	Y

	Panel D. ABCP Issuance on Lagged Spreads (IV)					
	First Stage			IV estimates		
	4w ABCP - T-bill$_{t-1}$	3m ABCP - T-bill$_{t-1}$	Fed Funds - T-bill$_{t-1}$			
ln(T-bills Out$_t$)	-1.692***	-0.219*	-1.538***			
	(0.223)	(0.12)	(0.309)			
4w ABCP - T-bill$_{t-1}$				0.018***		
				(0.007)		
3m ABCP - T-bill$_{t-1}$					0.077**	
					(0.038)	
Fed Funds - T-bill$_{t-1}$						0.019**
						(0.008)
ln(ABCP Out$_{t-1}$)				-0.365***	-0.325***	-0.362***
				(0.063)	(0.082)	(0.064)
Δ ln(ABCP Out$_{t-1}$)				-0.005	-0.041	-0.003
				(0.078)	(0.067)	(0.082)
Constant	11.818***	1.736**	10.702***	4.870***	4.331***	4.831***
	(1.523)	(0.819	(2.112)	(0.837)	(1.087)	(0.859)
R^2	0.879	0.909	0.746	0.368	0.111	0.314
N	303	303	303	301	301	301
Month FE	Y	Y	Y	Y	Y	Y

Table 3
Reserve Injections and Spreads

This table shows regressions of the form

$$RESERVE\_INJECTION_t = \alpha + \beta \cdot SPREAD_{t-1} + \varepsilon_t.$$

The dependent variable is net reserve injections (repo minus reverse repo) in week t. 4w ABCP - T-bill$_{t-1}$ is the spread of 4-week ABCP over 4-week Treasury bills, 3m ABCP - T-bill$_{t-1}$ is the spread of 3-month ABCP over 3-month Treasury bills, and Fed Funds - T-bill$_{t-1}$ is the spread of the Federal Funds rate over 4-week Treasury bills. In Panel B, the dependent variable is the percentage of reserve injections backed by non-Treasury (i.e. GSE debt and GSE-guaranteed MBS) collateral. The sample runs weekly from January 2001-June 2007. Robust standard errors are reported in parentheses, except for the specifications without month fixed effects which report Newey-West standard errors with 12 lags. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

	Panel A. Reserve Injections on Lagged Spreads						
	OLS	OLS	IV	OLS	IV	OLS	IV
4w ABCP - T-bill$_{t-1}$	28.227***	25.324**	32.025**				
	(6.157)	(9.752)	(13.936)				
3m ABCP - T-bill$_{t-1}$				66.070**	152.182**		
				(26.345)	(71.068)		
Fed Funds - T-bill$_{t-1}$						15.180**	33.812**
						(5.978)	(15.049)
Constant	26.832***	27.579***	17.802*	18.373***	31.781	31.190***	17.747
	(2.412)	(2.618)	(10.675)	(6.294)	(28.175)	(1.3)	(11.006)
R^2	0.154	0.448	0.445	0.462	0.38	0.43	0.403
N	303	303	303	303	303	303	303
Month FE	N	Y	Y	Y	Y	Y	Y

	Panel B. Reserve Injections w/ Non-Treasury Collateral on Lagged Spreads						
	OLS	OLS	IV	OLS	IV	OLS	IV
4w ABCP - T-bill$_{t-1}$	0.116*	0.313**	0.648***				
	(0.063)	(0.12)	(0.236)				
3m ABCP - T-bill$_{t-1}$				0.470**	2.106***		
				(0.233)	(0.725)		
Fed Funds - T-bill$_{t-1}$						0.238**	0.827**
						(0.101)	(0.326)
Constant	0.219***	0.168***	-0.039	0.137**	-0.253	0.203***	-0.14
	(0.017)	(0.033)	(0.19)	(0.057)	(0.315)	(0.021)	(0.241)
R^2	0.011	0.39	0.356	0.373	0.218	0.383	0.246
N	303	303	303	303	303	303	303
Month FE	N	Y	Y	Y	Y	Y	Y

Table 4
Spreads and Reserve Injections

This table shows regressions of the form

$$SPREAD_t = \alpha + \beta \cdot RESERVE\_INJECTION_t + \varepsilon_t.$$

Reserves Injected$_t$ is net reserve injections (repo minus reverse repo) in week t, 4w ABCP - T-bill$_{t-1}$ is the spread of 4-week ABCP over 4-week Treasury bills, 3m ABCP - T-bill$_{t-1}$ is the spread of 3-month ABCP over 3-month Treasury bills, ln(T-bills Out$_{t-1}$), is lagged log Treasury bills outstanding, and Δ ln(T-bills Out$_{t-1}$) is lagged log net Treasury bill issuance. In Panel B, we separate reserve injected by the type of collateral used to back the injections: Treasuries (TSY), GSE debt (AGY), and GSE-guaranteed MBS (MBS).. The sample runs weekly from January 2001-June 2007. Robust standard errors are reported in parentheses, except for the specifications without month fixed effects which report Newey-West standard errors with 12 lags. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

	Panel A. Spreads on Reserve Injections						
	4w ABCP - T-bill$_{t-1}$				3m ABCP - T-bill$_{t-1}$		
Reserves Injected$_t$	-0.001	-0.001***	-0.001**	-0.001**	-0.001***	-0.001**	-0.001**
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(T-bills Out$_t$)			1.118***	1.092***		0.446***	0.437***
			(0.205)	(0.235)		(0.14)	(0.147)
Δ ln(T-bills Out$_{t-1}$)				-0.08			-0.03
				(0.223)			(0.133)
Constant	0.021*	0.046***	-7.607***	-7.424***	0.037***	-3.018***	-2.952***
	(0.012)	(0.016)	(1.401)	(1.61)	(0.012)	(0.957)	(1.009)
R^2	0.005	0.252	0.33	0.328	0.059	0.103	0.099
N	303	303	303	303	303	303	303
Month FE	N	Y	Y	Y	Y	Y	Y

	Panel B. Spreads on Reserve Injections, by Type					
	4w ABCP - T-bill$_{t-1}$			3m ABCP - T-bill$_{t-1}$		
Reserves Injected$_t$ (TSY)	-0.001			-0.001		
	(0.001)			(0.000)		
Reserves Injected$_t$ (AGY)		-0.001			-0.002**	
		(0.002)			(0.001)	
Reserves Injected$_t$ (MBS)			-0.005***			-0.001
			(0.002)			(0.001)
Constant	0.018	0.005	0.019***	0.019	0.011**	0.006
	(0.016)	(0.009)	(0.006)	(0.012)	(0.005)	(0.003)
R^2	0.233	0.229	0.281	0.022	0.031	0.015
N	303	303	303	304	304	304
Month FE	Y	Y	Y	Y	Y	Y

Table 5
Aggregate Monetary Quantities and Spreads

This table shows regressions of the form

$$\ln\left(M_t\right) = \alpha + \beta \cdot SPREAD_t + \varepsilon_t$$

where M_t is some measure of aggregate money in week t. 4w ABCP - T-bill$_{t-1}$ is the spread of 4-week ABCP over 4-week Treasury bills. The sample runs weekly from January 2001-June 2007. Robust standard errors are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

	Reserves	Deposits	MMMF Retail	MMMF Institutional	M1	M2
4w ABCP - T-bill$_t$	0.158**	0.004	0.008*	-0.004	0.015	0.010**
	(0.08)	(0.004)	(0.004)	(0.013)	(0.014)	(0.004)
Constant	10.637***	15.418***	6.670***	7.091***	7.170***	8.735***
	(0.02)	(0.001)	(0.001)	(0.003)	(0.004)	(0.001)
R^2	0.664	0.999	0.999	0.984	0.982	0.999
N	303	303	303	303	303	303
Month FE	Y	Y	Y	Y	Y	Y

Table 6
ABCP Outstanding and Other Money Claims

This table shows regressions of the form

$$\ln\left(ABCP\_OUTSTANDING_t\right) = \alpha + \beta \cdot \ln\left(M_t\right) + \varepsilon_t$$

where M_t is the quantity of some other money claim. Reserves Injected$_t$ is net reserve injections (repo minus reverse repo) in week t, $\ln$(T-bills Out$_t$), is log Treasury bills outstanding, and $\ln$(Deposits$_t$) is log deposits in the banking system. The sample runs weekly from January 2001-June 2007. Robust standard errors are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

Reserves Injected$_t$	0.000**		0.000**			0.000*
	(0.00)		(0.00)			(0.00)
ln(T-bills Out$_t$)		-0.059***	-0.055***		-0.056***	-0.054***
		(0.02)	(0.02)		(0.02)	(0.02)
ln(Deposits$_t$)				0.388***	0.372***	0.319***
				0.097	0.098	0.103
Constant	13.540***	13.946***	13.917***	7.564***	8.193***	8.987***
	(0.001)	(0.136)	(0.139)	(1.499)	(1.542)	(1.605)
R^2	0.999	0.999	0.999	0.999	0.999	0.999
N	303	303	303	303	303	303
Month FE	Y	Y	Y	Y	Y	Y

Table 7
Relation to the z-spread

This table shows regressions of the form

$$SPREAD_t = \alpha + \beta \cdot ZSPREAD_t + \varepsilon_t.$$

The dependent variable is the spread of 4-week ABCP over 4-week Treasury bills. The z-spread is difference between fitted bill yields and actual yields, where the fitted yields are constructed based on Gurkaynak, Sack, and Wright (2006), who estimate the Treasury yield curve using only Treasury notes and bonds with remaining maturities greater than three months. 4wk T-bill$_t$ is the actual 4-week Treasury bill yield. The sample runs weekly from January 2001-June 2007. Robust standard errors are reported in parentheses, except for the specifications without month fixed effects which report Newey-West standard errors with 12 lags. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

z-spread$_t$	0.737***	0.432***	0.275***		
	(0.113)	(0.082)	(0.06)		
4wk T-bill$_t$			-0.420***		
			(0.074)		
Δ z-spread$_t$				0.239***	0.047*
				(0.061)	(0.028)
Δ 4wk T-bill$_t$					-0.836***
					(0.068)
Constant	0.060**	0.143***	1.249***	0.002	0.007***
	(0.024)	(0.023)	(0.197)	(0.004)	(0.002)
R^2	0.475	0.898	0.937	0.372	0.791
N	303	303	303	297	297
Month FE	N	Y	Y	Y	Y

Table 8

Response of the Primary Dealers

This table shows regressions of the form

$$NET\_DEALER\_POS_t = \alpha + \beta \cdot SPREAD_{t-1} + \varepsilon_t.$$

Net_Dealer_Pos$_t$ is the aggregate net (long minus short) position of the primary dealers in a given security type, 4w ABCP - T-bill$_{t-1}$ is the spread of 4-week ABCP over 4-week Treasury bills, and ln(T-bills Out$_{t-1}$) is lagged log Treasury bills outstanding. The sample runs weekly from January 2001-June 2007. Robust standard errors are reported in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively

| | Table 7. Dealer Net Positions on Lagged Spreads | | | | | | | |
	T-bills		T-bills (fraction of outstanding)		All Treasuries	Agency Debt	MBS	Corp
4w ABCP - T-bill$_{t-1}$	-42393***	-37056***	-43***	-37***	-35722***	-11222***	6447	8167**
	(7407)	(9182)	(8)	(9)	(11864)	(4302)	(4743)	(3966)
ln(T-bills Out$_{t-1}$)		53684		57	67234	13035	-13267	54346***
		(45547)		(47)	(56612)	(16381)	(23317)	(20291)
Constant	23231***	-344952	24***	-363	-537504	439	113925	-235408*
	(1929)	(312827)	(2)	(322)	(389059)	(112382)	(159986)	(138998)
R^2	0.731	0.732	0.753	0.754	0.932	0.902	0.828	0.99
N	303	303	303	303	303	303	303	303
Month FE	Y	Y	Y	Y	Y	Y	Y	Y