Money Creation and the Shadow Banking System*

Adi Sunderam

Harvard Business School

asunderam@hbs.edu

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Abstract

It is widely argued that shadow banking grew rapidly before the recent financial crisis because of rising demand for "money-like" claims. This paper assesses the central premise of this argument: that investors treated short-term debt issued by shadow banks as a money-like claim. We present a model where demand for money-like claims can be satisfied by deposits, Treasury bills, and shadow bank debt. The model provides predictions about the price-quantity dynamics of these claims, as well as the behavior of the monetary authority. The data are consistent with the model, suggesting that shadow banks respond to demand for money-like claims.

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1 Introduction

The role of the financial system in providing liquidity services to savers is a central issue in both financial and monetary economics. A key function of financial intermediaries is to provide savers with "money-like" claims (Diamond and Dybvig, 1983; Gorton and Pennacchi, 1990; Krishnamurthy and Vissing-Jorgensen, 2013). While they are not necessarily used directly in transactions, these claims have the short-term safety and liquidity needed to function as stores of value, and thus can serve as imperfect substitutes for money. The efficiency with which the financial system supplies such money-like claims has important consequences for the macroeconomy (Tobin and Brainard, 1963). A key question is how financial innovation impacts this kind of liquidity provision by financial intermediaries.

Indeed, many argue that securitization grew rapidly before the recent financial crisis precisely because it was an innovation that enabled intermediaries to supply more money-like claims.[1] In this narrative, the so-called "shadow banking system" used highly-rated, long-term securitized bonds as collateral to back safe, liquid, money-like, short-term debt. In response to growing demand for money-like claims from institutional investors and firms, the shadow banking system manufactured more of this short-term debt.

Despite the prominence of this narrative in the literature, its basic premise remains untested. Did investors treat short-term debt issued by the shadow banking system as a money-like claim? As discussed further below, a variety of institutional facts, including the holders of short-term shadow bank debt, suggest that it is money-like. Ultimately, however, investor intentions are unobservable, so it is difficult to determine whether this debt was really held for its safety and liquidity.

Therefore, we instead take an indirect approach. We first present a model that generates predictions for the price and quantity dynamics of different money-like claims. We then document that correlations in the data are consistent with the model. The shadow banking system primarily manufactured two types of short-term debt: asset-backed commercial paper (ABCP) and repurchase agreements (repo). We focus on ABCP because data is more readily available for ABCP than for repo. Moreover, Krishnamurthy, Nagel, and Orlov (2013) argue that ABCP was a larger source of short-term financing for the shadow banking system than repo was. However, all the model predictions we test should apply to repo as well as ABCP.

The model is similar to Krishnamurthy and Vissing-Jorgensen (2012, 2013) and Stein

[1] See, for instance, Dang, Gorton, and Holmstrom (2010), Greenwood, Hanson, and Stein (2013), Gorton and Metrick (2010a, b, 2011), Gorton, Lewellen, and Metrick (2012), Krishnamurthy and Vissing-Jorgensen (2013), Ricks (2011), and Stein (2012).

(2012), where certain claims provide monetary services. Households are willing to pay a premium for such claims, some of which the financial sector can endogenously produce. We add two ingredients. First, different claims (deposits, Treasury bills, and ABCP) deliver different amounts of monetary services.[2] Second, demand for monetary services is linked to monetary policy through a reserve requirement for deposits. The monetary authority (Federal Reserve) sets the amount of reserves in the banking system to implement its target policy rate, which is treated as exogenous.

A critical insight from the model is that a high spread between ABCP yields and Treasury bill yields indicates high demand for monetary services. This is somewhat counterintuitive because a high spread suggests that ABCP is cheap relative to Treasury bills, while high demand is associated with expensive prices. The key is that Treasury bills provide more monetary services than ABCP. Therefore, an increase in the demand for monetary services raises the price of Treasury bills more than the price of ABCP. Thus, high demand for monetary services makes ABCP expensive in absolute terms, but makes it appear cheap relative to Treasury bills.

With this insight in mind, the model delivers five main predictions:

- High spreads between ABCP and Treasury bill yields should be associated with ABCP issuance.
- ABCP issuance and Treasury bill issuance should be negatively correlated.
- The supply response of ABCP should be concentrated in short-maturity ABCP.
- High spreads should be associated with open market operations that increase the supply of reserves.
- High spreads should be associated with high Federal Funds rates relative to the target policy rate.

In the model, the first two predictions are a product of upward-sloping ABCP supply and substitutability between ABCP and Treasury bills. Krishnamurthy and Vissing-Jorgensen (2012) argue that Treasuries provide monetary services, so these predictions draw an indirect link to money demand by demonstrating that demand for ABCP is high at the same time that demand for Treasury bills is high. The last three predictions draw the connection more

[2]The model in Krishnamurthy and Vissing-Jorgensen (2013) separates demand deposits, time deposits, and Treasury bills.

explicitly by linking the demand for ABCP and Treasury bills to the demand for liquidity and the demand for central bank reserves.

We then evaluate these predictions in the data. A key empirical difficulty is that low frequency variation in the demand for money-like claims is likely to be driven by changing economic fundamentals, and, therefore, will be difficult to separate from broader macroeconomic conditions. To avoid the issues this raises, we instead focus on relatively high-frequency (weekly) variation. Variation of this kind, driven by the need to make payments, manage payroll and inventories, pay dividends, and transact more broadly, is easier to isolate from background changes in economic conditions. Many of our empirical specifications utilize weekly data with year-month fixed effects to isolate this high-frequency variation.

We examine the pre-crisis period from July 2001, when weekly data first became available, through June 2007, just before the collapse of the ABCP market at the beginning of the financial crisis. The empirical evidence is broadly consistent with the model. Each of the predictions above is borne out in the data. The magnitudes of the results are plausible. For instance, a one standard deviation increase in the spread of ABCP yields over Treasury bill yields forecasts a 0.25% increase in ABCP issuance. Of course, it would be surprising if we found very large effects, given that we are looking at high frequency variation, which is likely to be relatively transient. In addition to providing evidence in support of the model, we also argue that the results are inconsistent with the supply-side view that ABCP issuance is driven by the financial sector's need for financing at the high frequencies we study.

We then ask what our high-frequency estimates imply about the low-frequency growth of ABCP in the years before the crisis. Many caveats apply to this kind of extrapolation. Keeping these qualifications in mind, our high-frequency 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 by no means implies that other explanations, including regulatory arbitrage and moral hazard, were not also important drivers of the low-frequency growth of ABCP. Our high-frequency results most clearly speak to the basic premise that ABCP is a money-like claim, and not to the quantitative importance of the demand for money-like claims in driving the growth of ABCP.

We close by returning to the role of financial innovation. We provide suggestive evidence that the elasticity of ABCP supply has increased over time, so that the same demand shock now produces a larger increase in the quantity of short term debt. The growth of securitization, by increasing the supply of collateral available to back ABCP, likely played an important role in this increase in the elasticity of supply.

Many financial innovations have affected the ability of the financial system to provide liquidity over time.[3] We focus on ABCP and the shadow banking system more broadly for two reasons. First, they played a central role in the financial crisis. Attempts to understand the origins of the crisis, as well as regulations to avoid future crises, require a better grasp of what drove the growth of the shadow banking system. Second, the growth of ABCP is representative of a broader shift in financial intermediation from traditional commercial banks to securities markets. It is important for both financial and monetary economics to better understand the extent to which these markets can perform the same functions as banks. We show that the financial system responds to shocks to the demand for money-like claims even when the central bank succeeds at pinning the policy rate at its target. Our results are relevant to the conduct of monetary policy, particularly now that financial stability has become a key focus of central banks in the aftermath of the crisis.

The remainder of this paper is organized as follows. Section 2 presents the model. Section 3 presents the empirical results 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 patterns that would arise in the data if ABCP were regarded as a money-like claim. 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.

2.1.1 Household demand

There are three types of claims that provide money services in the economy: deposits, Treasury bills, and asset-backed commercial paper (ABCP). As in Krishnamurthy and Vissing-Jorgensen (2012), there are different types of money services that are provided by different claims. We divide money services into two types: direct transactional services, which only deposits provide, and short-term safety and liquidity services, which all three claims provide.

[3] For instance, earlier work, including Poterba and Rotemberg (1987) and Rotemberg, Driscoll, and Poterba (1995), attempted 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), while we focus on the money services provided by securities.

We assume that each claim provides a different amount of safety and liquidity services. A dollar of deposits provides a quantity of these services α_D, which we normalize to 1. A dollar of Treasury bills provides α_T of safety and liquidity services. Finally, a dollar of ABCP provides α_{ABCP} of safety and liquidity services. We assume $\alpha_{ABCP} < \alpha_T$ and $\alpha_{ABCP} < \alpha_D = 1$, so that ABCP provides fewer services than either deposits or Treasury bills. These assumptions can be justified by the facts that (i) ABCP is not government-guaranteed and (ii) ABCP has less secondary market liquidity than Treasury bills.

Deposits provide additional transactional services beyond the safety and liquidity services captured by the αs, while Treasury bills and ABCP do not. This makes deposits and other money claims imperfect substitutes, a standard assumption going back to Tobin and Brainard (1963) and Brainard (1964). Imperfect substitutability allows the monetary authority to implement its target policy rate without directly controlling the quantity of all money claims produced.

Denote the dollar amount of deposits m_D, the dollar amount of Treasuries m_T, and the dollar amount of ABCP m_{ABCP}. We assume that the total amount of effective money services in the economy aggregates linearly as $M = m_D + \alpha_T m_T + \alpha_{ABCP} m_{ABCP}$ and that households have downward-sloping demand for these services.[4] In particular, we assume that households generally require gross return R for claims that are not money-like (e.g., bonds) but derive additional utility from money services and therefore require lower returns for money-like claims. Specifically, they require gross returns

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

where $v(M)$ is a reduced form function for the utility from consuming total safety and liquidity services M, $\theta > 0$ is a money demand shifter, and $w(m_D)$ is the additional transactional utility that comes from deposits. We will call the difference between the returns required on money-like claims and the return required on non-money claims the money premium. For simplicity, we work with these simple reduced-form required returns. However, in Appendix A, we show that they can be derived in a more formal intertemporal optimization framework using a utility specification similar to that of Krishnamurthy and Vissing-Jorgensen (2012).

[4] This is a strong functional form assumption but is not crucial for our results. In the Internet Appendix, we show that we obtain similar predictions using a standard constant-elasticitity-of-substitution (CES) aggregator. The key for the results is that the elasticity of substitution between deposits, Treasuries, and ABCP needs to be sufficiently high.

The comparative statics we derive below will focus on the effects of variation in the demand shifter θ. We assume $v', w' > 0$ and $v'', w'' < 0$ so that money services provide positive but decreasing marginal utility.

2.1.2 Supply of Money-like Claims

The money-like claims households value are produced by the government, which controls the quantity of Treasuries, and banks, which can produce deposits and ABCP.[5] We take the supply of Treasuries as exogenous. Below we argue that this assumption is reasonable for the high frequency variation on which our empirics rely.

We assume that there is a continuum of banks of mass one. Each bank is small and thus takes the aggregate quantity of money services and the prices of money-like claims as given. On the asset side, banks may hold reserves or invest in productive projects. We assume that the return on reserves is zero,[6] while the return on productive projects is $F > R$ in expectation. On the liabilities side, banks can finance themselves from three sources: (i) long-term bonds, (ii) deposits, and (iii) ABCP. We assume that the size of each bank's balance sheet is fixed in the short run, so that banks simply pick the composition of their assets and liabilities.[7] Let $\widehat{r}$ be the fraction of a bank's assets held as reserves, $\widehat{m_D}$ be the fraction of its liabilities that are deposits, $\widehat{m_{ABCP}}$ be the fraction of its liabilities that are ABCP. Then the bank's balance sheet is given by

Assets		Liabilities	
Projects	$(1-\widehat{r})$	Long-term bonds	$(1-\widehat{m_D}-\widehat{m_{ABCP}})$
Reserves	$\widehat{r}$	Deposits	$\widehat{m_D}$
		ABCP	$\widehat{m_{ABCP}}$

Each bank chooses $\widehat{r}$, $\widehat{m_D}$, and $\widehat{m_{ABCP}}$ to maximize its profits. Long-term debt provides no money services and, therefore, requires gross return R. By issuing deposits and ABCP, banks can lower their funding costs, capturing the money premium associated with each

[5] In practice, the distinction between traditional commercial banks and shadow banks is somewhat blurred. There are small commercial banks, which only issue deposits, standalone shadow banks, investment vehicles which only issue ABCP, and large financial institutions, which do both. For simplicity, the banks we model issue both deposits and ABCP.

[6] The model could easily be extended to consider interest payments on reserves. However, during the pre-crisis period considered in the empirical section, the Federal Reserve did not pay interest on reserves.

[7] This assumption simplifies the analysis by eliminating a variable but is unnecessary. Similar results would obtain if we had banks pick the size of their balance sheets as well. We could assume banks face reduced-form diminishing marginal returns in their productive projects. At scale I, projects would pay $F(I)$ where $F' > 0$, $F'' < 0$.

claim. However, issuing either deposits or ABCP each comes at a cost. We assume that raising ABCP has a private cost from the bank's perspective of $c\left(\widehat{m_{ABCP}}\right)$.[8] As we discuss in Section 4.2, we can capture the effects of innovations like securitization that make it less costly to issue ABCP by thinking about changes in $c(\cdot)$.[9]

The cost of raising deposits comes in the form of a reserve requirement: for each dollar of deposits raised, a bank must hold ρ dollars of reserves. We model reserves as permits for the creation of deposits. Thus, we must have $\widehat{r} \geq \rho \cdot \widehat{m_D}$. This is costly because obtaining reserves in the interbank market carries a cost, the Federal Funds rate. We assume 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 (1993)-style rule, reflecting inflation and output-gap concerns outside the model, not the short-run money demand considerations we will try to isolate in the empirics.

2.1.3 Discussion of Model Setup

Before solving the model, a few aspects of the setup are worth discussing. First, the level of demand for money-like claims θ is modeled in reduced form. Many models of money demand, including Baumol (1952), Tobin (1956), Jovanovich (1982), and Romer (1986), among others, derive demand in an optimizing framework where households trade off the lower interest paid by money-like claims against their need to transact.[10] Such models are crucial for understanding the determinants of money demand in general equilibrium. In contrast, our focus is on variation in demand over time and the supply response of the shadow banking system, so a simpler model where demand can be varied with a single parameter (θ) is sufficient. Relatedly, we take no stand on the source of variation in money demand from the household sector. The household sector can be broadly thought of as a proxy for actual households, non-financial corporations, and unmodeled parts of the financial system. Thus, variation in demand could stem from payrolls, inventories, dividends, and certain transactions in financial markets, among other sources.

[8] In Stein (2012), Greenwood, Hanson, and Stein (2013), 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 because they are concerned with policy implications. In contrast, we need not take a stand here on the source of the costs.

[9] Differences in $c(\cdot)$ may also differences in the behaviors of different types of commercial paper (e.g., nonfinancial, financial, and asset-backed), though in untabulated results, we find similar patterns for types of commercial paper other than ABCP.

[10] In these models, money typically pays zero interest, while the money-like claims we consider pay positive interest. However, the same tradeoff applies so long as there is a positive money premium. And while ABCP and Treasury bills cannot be directly used in transactions, they may still have value since they are liquid enough to be converted to cash at short notice.

Second, we take the money services provided by ABCP, α_{ABCP}, as given. Why might ABCP provide money services? First, its short-term safety makes it a good store of value. ABCP is typically backed by securitized bonds that are themselves AAA rated. In addition, virtually all ABCP programs are covered by guarantees from their sponsoring institutions to protect investors from loss. Prior to the financial crisis, this combination of collateral and guarantees ensured that ABCP programs carried the highest ratings from the credit rating agencies. Indeed, estimates suggest that even the ex post losses suffered by ABCP investors after the onset of crisis amounted to only 0.1% of assets (Acharya, Schnabl, and Suarez, 2013).

The other characteristic of ABCP that may provide money services is its liquidity. While secondary markets for commercial paper are not highly liquid (Covitz and Downing, 2007), the short maturity of ABCP allows investors to convert it into cash for transactions on short notice. Given that the underlying securitized bonds also appear to have relatively illiquid secondary markets (Bessembinder, Maxwell, and Venkataraman, 2013), this "liquidity through maturity" of ABCP may be important for its provision of money services. The institutions that hold commercial paper are consistent with the idea that ABCP provides important liquidity services to investors. According to the Flow of Funds, over 50% of commercial paper is held by foreign and domestic money market funds, which provide money-like safety and liquidity services to savers. In contrast, less than 10% is held by private pensions, insurance companies, and mutual funds, which do not primarily aim to provide such services.[11] Another 10% is held by nonfinancial corporations, which are allowed to classify commercial paper as a "cash equivalent" under GAAP accounting rules.

A third feature of the model setup is that the treatment of reserve requirements is somewhat simplistic. In practice, the demand for reserves in the Federal Funds market is ultimately driven by two sources: reserve requirements and payments and clearing. Reserve requirements apply to transaction deposits at all depository institutions (Board of Governors, 2005). However, banks have found ways to avoid reserve requirements, weakening their bite over time.

Transactions in the Federal Funds market also take place to facilitate payments between banks. These transactions net to zero in the aggregate because reserve balances are deducted

[11] These characteristics are necessary, but not sufficient, for ABCP to provide money services. The literature has struggled with the precise nature of money services since Sidrauski (1967) and Tobin (1969). Securities with identical cash flows often have very different liquidity properties (Amihud and Mendelsohn, 1991; Longstaff, 2004). In the absence of a more microfounded explanation for why certain claims provide money services, we cannot simply assert that ABCP has the characteristics necessary to provide such services. Thus, we provide indirect evidence in support of this proposition.

from one bank and credited to another in any transaction. However, they can affect the aggregate demand for reserves because banks hold reserves as a precaution against over-drafting their accounts with the Federal Reserve.[12] Since payments are driven by transactions, this kind of precautionary reserve demand also reflects money demand. Direct transactional demand for reserves is not included in the model, where money demand increases reserve demand only indirectly through reserve requirements. However, the empirical predictions are the same: demand for reserves should be high when money demand is high. It would be straightforward to modify the model to incorporate transactional reserve demand.[13]

2.2 Equilibrium

We now solve for the equilibrium. We first consider the problem of an individual bank and then the problem of the Federal Reserve. Individual banks take the aggregate money quantities M, m_D, m_T, and m_{ABCP}, as well as the prevailing Federal Funds rate $\widehat{i}$, as given.[14] They solve for their individually optimal quantities of ABCP ($\widehat{m_{ABCP}}$), deposits ($\widehat{m_D}$), and reserves ($\widehat{r}$). Since the mass of banks is 1, in equilibrium we will have $m_D = \widehat{m_D}$, $m_{ABCP} = \widehat{m_{ABCP}}$, and $M = \widehat{m_D} + \alpha_T m_T + \alpha_{ABCP}\widehat{m_{ABCP}}$. An individual bank's problem is

$$\max_{\widehat{r},\widehat{m_D},\widehat{m_{ABCP}}} \overbrace{F \cdot (1-\widehat{r})}^{\text{Asset Return}} - \overbrace{R + \widehat{m_D} \cdot (\theta v'(M) + w'(m_D)) + \widehat{m_{ABCP}} \cdot \alpha_{ABCP}\theta v'(M)}^{\text{Cost of Funding}}$$
$$- \underbrace{c\left(\widehat{m_{ABCP}}\right)}_{\text{Cost of ABCP}} - \underbrace{\widehat{r} \cdot \widehat{i}}_{\text{Cost of Reserves}}$$

subject to the constraints

$$\rho\widehat{m_D} \leq \widehat{r} \quad \text{and } \widehat{m_D} + \widehat{m_{ABCP}} \leq 1.$$

Note that individual banks take required returns as fixed, though they are endogenously determined in the aggregate. If banks are at an interior optimum in their capital structure decisions so that $\widehat{m_D} + \widehat{m_{ABCP}} < 1$ holds strictly, then the equilibrium is simple. So long as the return on projects F is sufficiently large, banks will not want to hold any excess reserves

[12] See, e.g., Poole (1968) and Ho and Saunders (1984) for theoretical models of this phenomenon. Recent empirical work, including Demiralp and Farey (2004) and Carpenter and Demiralp (2006, 2008), shows that reserve demand is high on days with high payment flows (e.g., quarter ends). Ashcraft, McAndrews, and Skeie (2011) argue that precautionary reserve demand was an important feature of the financial crisis.

[13] We could model reserve demand in reduced form as a function of money demand θ and the prevailing Federal Funds rate $\widehat{i}$. In addition, if reserve requirements are not a binding cost of issuing deposits, we would need to specify some other cost to give banks a well-defined capital structure decision.

[14] In addition, the model parameters i, θ, $v(\cdot)$, $w(\cdot)$, ρ, F, $c(\cdot)$, and R are taken as given.

and we will have $\widehat{r} = \rho \widehat{m_D}$. The first order condition for $\widehat{m_D}$ then implies

$$\widehat{i} + F = \frac{\theta v'(M) + w'(m_D)}{\rho}. \tag{1}$$

The benefit of adding a unit of deposits is that the bank can capture the money premium that deposits carry, $\theta v'(M) + w'(m_D)$. The cost of adding this unit of deposits is that ρ reserves must be purchased in the interbank market, and ρ fewer units of productive projects are held on the bank's balance sheet.[15] Thus, the prevailing Federal Funds rate $\widehat{i}$ is linked to the money premium on deposits through the reserve requirement.

The first order condition for $m\widehat{_{ABCP}}$ is simply

$$\alpha_{ABCP} \theta v'(M) = c'\left(m\widehat{_{ABCP}}\right). \tag{2}$$

The benefit of adding a unit of ABCP is the money premium that ABCP carries, $\alpha_{ABCP}\theta v'(M)$. The marginal cost is $c'(m\widehat{_{ABCP}})$.

Market clearing for reserves and symmetry imply $\widehat{m_D} = \mathcal{R}/\rho$ where $\mathcal{R}$ is the aggregate quantity of reserves in the interbank market. Substituting this into the first order condition for $\widehat{m_D}$ yields

$$\widehat{i} + F = \frac{\theta v' \overbrace{\left(\frac{\mathcal{R}}{\rho} + \alpha_T m_T + \alpha_{ABCP} m\widehat{_{ABCP}}\right)}^{=M} + w' \overbrace{\left(\frac{\mathcal{R}}{\rho}\right)}^{=\widehat{m_D}}}{\rho}.$$

Finally, the Fed endogenously sets the quantity of reserves $\mathcal{R}^*(i)$ to implement the Federal Funds rate $\widehat{i} = i$. That is, $\mathcal{R}^*(i)$ is implicitly defined by

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

The following proposition summarizes the equilibrium.

Proposition 1 *There exist $\underline{F}$ and $\underline{c}$ such that for $F > \underline{F}$ and $c' > \underline{c}$, the market equilibrium is given by Equations (2) and (3), which together define a fixed point in $\mathcal{R}$ and $m\widehat{_{ABCP}} = m_{ABCP}$.*

Proof. *All proofs are given in Appendix A.* ■

[15] The fact that adding reserves forces the bank to forego productive investment is a product of the assumption that the bank's balance sheet is fixed in the short run. In a model where banks can adjust the sizes of their balance sheets, this effect would vanish.

2.2.1 Comparative Statics

We now consider how prices and quantities vary in the model with the level of money demand, θ. Because the intuition is simpler, we first consider comparative statics assuming the Federal Reserve and the banking system cannot instantaneously react to money demand shocks so that M is fixed. We will then formally show that similar results hold in equilibrium after allowing the Federal Reserve and banking system to react to demand shocks.

The spread between ABCP and Treasury bills is given by

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

Since $\alpha_T > \alpha_{ABCP}$, this is increasing in θ, so a higher level of money demand is associated with a higher ABCP - Treasury bill spread. This may seem somewhat counterintuitive at first. Higher money demand means lower yields on both ABCP and Treasury bills. However, since Treasury bills provide more money services than ABCP, Treasury bill yields fall more than ABCP yields as θ increases. Thus, the spread increases.

Note that increasing the supply of Treasury bills m_T has similar effects to decreasing θ. An exogenous increase in Treasury bill supply m_T increases the overall supply of money services M. This lowers the marginal value of money services $\theta v'(M)$ since $v'' < 0$, increasing 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. 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 $v'' < 0$.

We next consider how the Federal Reserve and banking system react to higher levels of money demand θ. The following proposition characterizes their response.

Proposition 2 *The Federal Reserve and banking system respond to higher levels of money demand θ by increasing the supply of reserves and ABCP respectively. Formally, $\partial\mathcal{R}^*/\partial\theta > 0$ and $\partial m_{ABCP}/\partial\theta > 0$.*

Corollary 1 *If the concavity of transaction utility w'' is not too large, the ABCP supply response is stronger when ABCP is more money-like (i.e., when α_{ABCP} is larger).*

The key intuition behind the Federal Reserve's response is that it keeps the Federal Funds rate at its target. The prevailing Federal Funds rate $\widehat{i}$ is determined by the money premium on deposits, $\theta v'(M) + w'(m_D)$. Increasing the level of money demand θ increases this premium, holding fixed M and m_D. Thus, banks will wish to issue more deposits to capture this larger premium. This raises their demand for reserves and thus the prevailing Federal Funds rate. To push the rate down to the target i, the Federal Reserve must then increase the supply of reserves.

The ABCP supply response is driven by similar logic. For higher values of θ, banks can capture a larger money premium by issuing ABCP, and therefore issue more ABCP. As Corollary 1 shows, this is particularly true when ABCP is more money-like because the money premium that can be captured is larger. The total supply response of banks and the Federal Reserve drives down the money premium on deposits until $\theta v'(M) + w'(m_D)$ has the same value it did previously, so that the Federal Funds rate remains at its target.

Note that since deposits and ABCP are imperfect substitutes, control over the Federal Funds rate does not give the Federal Reserve control over the quantity of ABCP produced. The increase in reserve supply in response to increasing θ does not fully crowd out the banking sector's production of ABCP.[16]

What is the level of the ABCP - T-bill spread after these supply responses by the Federal Reserve and the banking sector? The following proposition shows that higher levels of money demand θ are associated with higher equilibrium spreads, despite the supply responses.

Proposition 3 *Suppose there is an increase in θ. After the supply responses of the Federal Reserve and the banking system, the equilibrium spread $R_{ABCP} - R_T$ is higher than its initial level. Formally $\partial (R_{ABCP} - R_T) / \partial \theta > 0$.*

This result relies on the assumption that deposits are imperfect substitutes for Treasury bills and ABCP. After an increase in money demand θ, the Federal Reserve increases the supply of reserves to push the Federal Funds rate back to its target. However, since deposits are imperfect substitutes for Treasury bills and ABCP, this increase in the supply of reserves does not fully restore yields on Treasuries and ABCP to their initial levels. The banking sector's ABCP supply response does not fully restore yields because banks face increasing marginal costs of production. When they increase the quantity of ABCP supplied, banks must capture a larger money premium at the margin.

[16] If they were perfect substitutes, the Federal Reserve would have complete control over the supply of all money claims. Formally, when faced with a positive money demand shock, the Federal Reserve would have to drive the product $\theta v'(M)$ back to its original value to maintain the Funds rate. In this case, Equation (2) would then imply that the banking system did not produce any more ABCP. Effectively, if deposits and ABCP were perfect substitutes, the Federal Reserve would have full control over all money claims because it can costlessly adjust the quantity of reserves, while banks face positive costs of producing ABCP.

Thus, supply responses do not restore the spread ABCP - T-bill spread, $R_{ABCP} - R_T$, to its original level. The spread increases in θ because Treasury bills provide more money services than ABCP, so that Treasury bill yields fall more than ABCP yields when θ rises.

Finally, we consider the effect of increasing the supply of Treasury bills. The following proposition shows that this has similar effects to decreasing the level of money demand θ.

Proposition 4 *Suppose there is an increase in m_T. The banking system responds by decreasing the supply of ABCP, and the equilibrium spread $R_{ABCP} - R_T$ decreases. Formally, we have $\partial m_{ABCP}/\partial m_T < 0$ and $\partial (R_{ABCP} - R_T)/\partial m_T < 0$.*

The intuition here is that increasing the supply of Treasury bills increases the overall supply of money services. This decreases the marginal value of money claims. In turn, this smaller money premium reduces the incentives for banks to issue ABCP, so they decrease the quantity outstanding. Essentially, increases in Treasury bill supply reduce the residual demand for money-like claims that is not met by Treasury bills.

3 Empirics

In the empirics, we will evaluate these propositions. We construct a weekly data set beginning in July 2001, when 4-week bills were reintroduced to the set of Treasury securities. We focus on the pre-crisis period and end the sample in June 2007, just before the collapse of the ABCP market. Table 1 presents summary statistics.

Using high frequency (weekly) data has two main advantages. First, six years of weekly data gives us a reasonably long time dimension to work with. Second, we can eliminate low-frequency variation that may be due to changing macroeconomic conditions. For instance, at low frequencies a positive relationship between ABCP outstanding and the ABCP - T-bill spread could simply reflect a low-frequency trend where ABCP outstanding is both increasing and becoming riskier. Figure 1 shows that there is a time trend in ABCP outstanding over the sample period. Furthermore, the trend is not linear so a simple linear control will not fully absorb it. We will use year-month fixed effects in some of our empirical specifications to eliminate this kind of variation. However, as we will show below, the results are not dependent on adding fixed effects. In addition, in the Internet Appendix, we show that the results are also robust to demeaning by last month's average values (rather than this month's average values, as month fixed effects do, and in untabulated results we find similar effects when we use 4-week differences.

The idea of looking for high frequency variation can also be motivated by the long literature on seasonalities in money demand and central bank responses, including Faig (1989), Gorton (1988), Griffiths and Winters (1995), Hamilton (1996), Miron (1986), and Sharp (1988). Prior to the founding of the Federal Reserve, seasonal needs for cash in the agricultural sector drove strong seasonalities in interbank lending rates (Miron, 1986; Gorton, 1988). Following the establishment of the Federal Reserve, these seasonalities diminished substantially thanks to open market operations that elastically supplied money during periods of high demand. Indeed, the objective of daily open market operations currently is to minimize fluctuations in the Federal Funds rate around the target.

In the model, the Federal Reserve can meet this objective perfectly, keeping the Federal Funds rate exactly at the target, because money demand θ is known exactly. The model shows that even if the Federal Funds rate is always at its target, the prices and quantities of money claims that are imperfect substitutes for deposits respond to changes in money demand. In practice, θ may not be perfectly observable. There are both expected and unexpected shocks to money demand.[17] The propositions above, which assume θ is known, essentially describe the effects of anticipated shocks. If shocks are unanticipated, then the Federal Reserve and banking system will respond by adjusting the supply of reserves and ABCP with a lag. Prior to their supply responses, only prices will shift in response to unanticipated demand shocks. The comparative statics above derived assuming no supply response by the Federal Reserve and the banking system describe these immediate effects. At the weekly frequency of our empirical tests, it seems reasonable to assume that supply responses are taking place.

3.1 Taking the Model to Data

To operationalize the model for empirical work, suppose that there are two sources of exogenous variation: i) variation in overall money demand θ and ii) variation in the supply of Treasury bills m_T. The idea that this variation is exogenous is clearly not true in general. Money demand is a function of output and thus the state of the macroeconomy. Similarly, the government tends to run budget deficits during recessions, at low frequencies, so the supply of Treasury bills may tend to rise in bad times. However, at the weekly frequencies we study, variation in money demand is driven by factors like weekly and bi-weekly payroll, inventory management, dividend payments, and financial market transactions (Diller; 1971;

[17] Hamilton (1996, 1997) uses Federal Reserve daily errors in forecasting the supply and demand for reserves to show that the Federal Funds rate is decreasing in the quantity of reserves supplied.

Poole and Lieberman, 1972; Hein and Ott, 1983; Cochrane, 1989; Faig, 1989). Similarly, as pointed out by Duffee (1996), Gurkaynak, Sack, and Wright (2006), and Greenwood, Hanson, and Stein (2013), there is seasonal variation in Treasury bill supply at the weekly level due to tax receipts and government outlays. Faig (1989) and Miron and Beaulieu (1996) argue that this type of variation, which our empirics seek to isolate, is more likely to satisfy identifying restrictions than is lower frequency variation.

Taking shocks to money demand θ and Treasury bill supply m_T as the sources of variation, the model generates the following predictions:

- Prediction 1: In the presence of shocks to θ, Propositions 2 and 3 imply that high spreads between ABCP and Treasury bills should forecast ABCP issuance. If ABCP and T-bills are substitutes, when money demand θ is high, spreads should be high. In response to high demand, banks should issue ABCP. Put differently, increased demand should raise both quantities and prices, and high ABCP - T-bill spreads are a proxy for high prices.

- Prediction 2: In the presence of shocks to m_T, Proposition 4 implies that Treasury bill issuance and ABCP issuance should be negatively correlated. If ABCP and T-bills are substitutes, high values of m_T should be associated with less ABCP outstanding.

These predictions stem from two properties of the model: i) that ABCP and T-bills are partial substitutes and ii) that ABCP supply is upward-sloping and somewhat elastic at high frequencies. The model also provides predictions that help to link the demand for ABCP and T-bills to money demand. This is important because, as discussed above, it is difficult to directly verify that ABCP provides money services. The following predictions help draw the link indirectly:

- Prediction 3: In the presence of shocks to θ, Corollary 1 implies that the issuance of short maturity ABCP should respond most strongly to spreads. Safety and liquidity are the two main money services provided by ABCP, and shorter maturity ABCP is both safer and more liquid than longer maturity ABCP. Thus, shorter maturity ABCP should provide more money services (i.e., have higher values of α_{ABCP}) and respond more strongly to money demand shocks.[18]

[18] In the Internet Appendix, we extend the model to allow banks to issue different types of ABCP that deliver different amount of money services and show that issuance of the most money-like ABCP responds most strongly to demand shocks. This is a more direct analog to the empirical prediction than Corollary 1, which concerns banks issuing a single type of ABCP that is more or less money-like.

- Prediction 4: Propositions 2 and 3 also imply that high ABCP - T-bill spreads should forecast increases in the supply of reserves by the Federal Reserve. In the model, high spreads indicate high money demand θ and thus high reserve demand. To keep the Federal Funds rate at its target, the Federal Reserve must accommodate this demand by increasing the supply of reserves.

- Prediction 5: Finally, the expression for the prevailing Federal Funds rate (1) shows that if the Federal Reserve does not perfectly stabilize the funds rate, it should be positively correlated with the ABCP-T-bill spread. This would be the case, for instance, in the presence of unanticipated shocks to money demand. Note that the prediction somewhat counterintuitively implies that the Federal Funds rate is rising at times when yields on money-like claims are falling.[19] This is because the Federal Funds rate is essentially the cost of a permit (reserves) to create more money-like assets. In the model, high money demand θ is associated with high spreads and high values of the Federal Funds rate $\widehat{i}$ before the Federal Reserve adjusts the supply of reserves appropriately.

While these predictions were derived from the specific model described above, they are likely to arise in more general models. The key components needed to generate the predictions are that i) ABCP and Treasury bills are partial substitutes and the supply of ABCP is elastic in the short run, and ii) demand for ABCP and T-bills is correlated with demand for other money-like claims.

3.2 Alternative Explanations

Before proceeding to the results, it is worth briefly discussing alternative explanations that we hope to rule out. A first alternative is that changes in ABCP supply, rather than demand, drive our empirical results. Under this alternative, ABCP provides no money services, and issuance is driven by banks' need for financing. Thus, if demand for ABCP is downward sloping, issuance should be correlated with high ABCP - T-bill spreads. Banks must offer investors more compensation in the form of higher ABCP yields (lower prices) to hold more ABCP. Similarly, if demand for reserves is high when the banking system needs funding more broadly, high spreads should be correlated with increases in reserve supply.

The critical distinction between the money demand-based explanation formalized in the model and the supply alternative is the following. Under the supply alternative, ABCP and T-bills are not substitutes. This has two implications. First, the supply of Treasury bills

[19] I thank Arvind Krishnamurthy for pointing this out.

should not be correlated with the supply of ABCP. Second, all information in the ABCP - T-bill spread relevant to the ABCP market should come through the ABCP yield. Yields on Treasury bills should not be correlated with ABCP issuance. In contrast, under the money demand explanation, Treasury bill yields (prices) themselves should reflect demand for money services and be correlated with ABCP issuance. In the empirics, we will show that this is the case: the information in T-bill yields alone is useful for forecasting ABCP issuance.

A second alternative explanation is that our results are driven by correlated, but unrelated, seasonalities. Under this alternative, seasonal variation in the markets for ABCP, Treasury bills, and reserves are unrelated to money demand, but simply happen to line up in the ways predicted by the model. Such concerns are difficult to rule out completely without direct evidence on the underlying drivers of seasonality. However, to show that the results are not solely driven by predictable weekly variation, the results presented in the paper use seasonally adjusted data series whenever available, though the results are qualitatively similar when the non-seasonally adjusted series are used. In addition, we include week-of-year fixed effects in some specifications to absorb any residual common seasonal variation.

3.3 Data

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. 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.

The overnight indexed swap (OIS) rate, which we obtain from Bloomberg, will play an important role in the empirics. The OIS rate represents the expected average of the Federal Funds rate over a given term.[20] Like most swaps, no cash is exchanged at the initiation of an OIS contract, and at maturity only the required net payment is made. Thus, OIS contracts carry little credit risk and are a good proxy for risk-free rates purged of liquidity and credit risk premia (Brunnermeier, 2009; Duffie and Choudry, 2011; Feldhutter and Lando, 2008;

[20] Formally, the OIS rate is the fixed rate in a fixed-to-floating interest rate swap. When two counterparties enter into the swap, one agrees to pay the OIS rate and in return receive the geometric average of the daily overnight Federal Funds rate over the term of the contract. Thus, the OIS rate should represent the average of the Federal funds rate over the term of the contraction. There may be a small term premium component as well, but over the 1-month horizon we focus on, this is likely to be negligible.

Gorton and Metrick, 2010; Schwarz, 2010). Moreover, since no cash is exchanged upfront, OIS is not a rate at which banks can raise funding. For these reasons, we will use it as a baseline for the overall level of short-term interest rates. In particular, the OIS - T-bill spread should capture the information in T-bill yields about the money premium.[21]

3.4 Results

3.4.1 ABCP Issuance Increases with Spreads

We now turn to the empirical results.[22] Panel A of Table 2 examines the first prediction from the model. In the presence of shocks to money demand, high ABCP - T-bill spreads should forecast ABCP issuance. In the model, high spreads indicate high money demand because investors are particularly willing to pay for the incremental money services provided by Treasury bills over ABCP. The shadow banking sector should respond to this increased demand by issuing more ABCP.

To examine this prediction, we examine the relationship between net ABCP issuance and the ABCP - T-bill spread. Specifically, we run the following regression:

$$\Delta \ln\left(ABCP\ Outstanding_t\right) = \alpha + \beta \cdot Spread_{t-1} + \varepsilon_{t.}$$

In Panel A we examine the spread between 4-week ABCP and 4-week Treasury bills. The first column shows the raw relationship, which is strongly positive and significant as predicted by the model. Figure 2 presents this relationship as a scatterplot. The second column adds year-month fixed effects to show that the relationship is not driven by low-frequency common trends in ABCP outstanding and the ABCP - T-bill spread. The remainder of the table shows that the results are also robust to controlling for the lagged level of ABCP outstanding, lagged ABCP issuance, and week-of-year fixed effects. This shows that the results are not simply capturing some kind of mechanical mean reversion or predictable weekly pattern in ABCP issuance and spreads.

Could the results simply reflect the banking system's need for financing? It could be the

[21] In the Internet Appendix, we show that we obtain similar results if we use the spread between the Federal Funds target rate and T-bill yields. The difference between using the target rate and OIS is that OIS correctly reflects short-term expected changes in the target.

[22] In the main text, we report Newey-West standard errors with 12 lags for specifications without month fixed effects and robust standard errors for specifications with month fixed effects. The reason is that once we add month fixed effects, the residuals are no longer highly autocorrelated. Month fixed effects induce negative correlation of residuals within month, so clustering by month could decrease the standard errors and inflate the t-statistics in some cases.

case that when banks need financing they issue more ABCP. If the demand for ABCP slopes downwards, this could drive up the ABCP yield and thus the ABCP - T-bill spread. 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.[23]

We can address this supply-based alternative explanation more directly by isolating the information in Treasury bill yields. Panel B of Table 2 presents the same regressions as Panel A, but instead uses the spread between 4-week OIS and 4-week Treasury bills. As discussed above, the OIS rate simply represents the expected path of the Federal Funds rate over a given term. It is not a rate at which banks can raise financing and thus should not directly reflect banks' need for financing. Thus, the OIS - T-bill spread should isolate information on the money premium in Treasury bills.

Table 2 Panel B shows that the OIS - T-bill spread also forecasts ABCP issuance. When T-bill yields are low relative to OIS, the spread is large, and ABCP issuance is high. This is consistent with the money demand model presented above. When money demand is high, Treasury bill yields should be low, reflecting a large money premium. The shadow banking system responds by issuing ABCP.

The magnitudes of the effects we find are economically plausible. Spreads are measured in percentage points, so the regressions imply a 1% higher 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 variation.

The small magnitudes are also reassuring because they admit a plausible mechanism through which the shadow banking system can adjust to changing money demand. In the model, banks adjust by changing their mix of long-term debt versus short-term deposit and ABCP financing. In practice, it may be unlikely that banks alter their long-term debt in response to week-to-week changes in money demand. However, other types of issuers in the shadow banking system may be able to more quickly respond. According to Covitz, Liang, and Suarez (2013), over 30% of ABCP in the precrisis period was issued by issuers that purchase securities on the secondary market. These issuers, including securities arbitrage programs, structured investment programs, and collateralized debt obligations, can quickly

[23] 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.

respond to money demand shocks by financing secondary market purchases of the underlying securitized bonds with short-term ABCP.

3.4.2 Treasury Bills and ABCP Issuance

We next turn to the second prediction of the model: Treasury bill issuance and ABCP issuance should be negatively correlated. In the model, increasing the supply of Treasury bills increases the total supply of money services in the economy, driving down their marginal value. This decreases the premium on money-like claims, reducing the shadow banking system's incentives to issue ABCP.

Table 3 Panel A shows that this is the case, regressing net ABCP issuance on net Treasury bill issuance. The first column shows the raw relationship, which is negative and significant. Figure 3 presents this relationship as a scatterplot. When Treasury bill issuance is high, ABCP issuance is low. The remaining columns show that the results are robust to controlling for year-month fixed effects, lagged ABCP outstanding, lagged ABCP issuance, and week-of-year fixed effects. The relationship is always negative, and statistically significant in every column except the second. Krishnamurthy and Vissing-Jorgensen (2013) provide strong corroborating evidence. Examining low-frequency (annual) changes, they find a negative correlation between the supply of Treasuries and the quantity of bank deposits.

In the model, we derived the predicted negative correlation by considering the response of the shadow banking system to an exogenous increase in Treasury bill supply. Is this a reasonable assumption for the empirics? To be interpreted as evidence in favor of the model, we need Treasury bill supply shifts at high frequencies to be unrelated to the broader economic conditions determining ABCP issuance. High-frequency Treasury bill issuance is largely driven by seasonal variation in the government's outlays and tax receipts (Duffee (1996); Gurkaynak, Sack, and Wright (2006); and Greenwood, Hanson, and Stein (2013)). In particular, weekly Treasury bill supply is unlikely to be correlated with the financial system's need for financing.

Does the relationship between ABCP issuance and Treasury bill issuance line with up the relationship between ABCP issuance and spreads in the way the model predicts? By increasing the total supply of money services, increased Treasury bill issuance should reduce their marginal value. This should reduce the ABCP - T-bill spread because investors then care less about the incremental money services offered by Treasury bills. The lower marginal value of money services decreases the shadow banking system's incentives to issue ABCP.

Panel B of Table 3 shows that the data are consistent with this mechanism. We run an instrumental variables regression where we regress ABCP issuance on the ABCP - T-bill spread, instrumenting for the spread with Treasury bill issuance. Relative to the results in Panel A, the new information in Panel B comes from the first stage regression, which shows that spreads do indeed decrease with Treasury bill issuance as predicted by the model. Essentially, the panel shows that the timing of the relationship between spreads and ABCP issuance lines up correctly with the timing of the relationship between T-bill issuance and ABCP issuance. Note that our approach is somewhat different than a standard instrumental variables approach for identifying supply elasticities. A typical instrument would shift money demand holding other determinants of ABCP outstanding constant. Here we are essentially dividing money-like claims into private claims (ABCP and deposits) and government claims (T-bills), and trying to show that the private supply curve is upward sloping. Any variable that shifts price while holding the private supply curve fixed (i.e., satisfying the exclusion restriction) is sufficient to identify the private supply elasticity. As we argued above, the change in government supply is such a variable. In the logic of the model, an exogenous increase in the supply of Treasuries reduces the marginal value of money services, which on the margin reduces demand for other claims that provide money services. Changes in Treasury supply essentially shift around the residual demand for money-like claims that is not met by Treasury bills, while holding the private supply curve constant.

3.4.3 Short-Term ABCP Responds Most

So far we have shown that the data are consistent with the idea that ABCP is a substitute for other money-like claims, specifically Treasury bills. ABCP supply is upward sloping, so that increases in demand for such claims lead to higher prices and quantities. Our remaining results seek to draw a closer link between these demand shifts and money demand.

We begin by analyzing the third prediction from the model: the issuance of short maturity ABCP should respond most strongly to demand shifts. The logic of Modigliani-Miller (1958) would imply that the shadow banking system should be indifferent to issuing different types of ABCP. However, this logic breaks down in the presence of a money premium. Money premia are not like standard risk premia, so the Modigliani-Miller argument does not apply. Investors are willing to pay a money premium for money-like claims, above and beyond any risk premia they charge. By issuing money-like claims, the banking sector can capture the money premium without bearing any additional risk. This ability to earn a riskless profit breaks the Modigliani-Miller argument.

As shown by Corollary 1 and in the Internet Appendix, issuance of claims that provide the most money services should respond the most strongly to increases in money demand. This allows the shadow banking system to capture the largest money premium from households. It seems plausible to assume that short-maturity ABCP offers greater money services than long-maturity ABCP. Secondary markets for commercial paper are not very liquid (Covitz and Downing, 2007), so much of the liquidity of ABCP stems from the fact that it has a short maturity. Thus, the household sector should be willing to pay a particularly high money premium for short-maturity ABCP.

We use data on gross ABCP issuance from the Federal Reserve Board, which is broken out by maturity, to test this prediction in Table 4. Panel A shows that gross issuance of very short maturity (1-4 day) ABCP responds most strongly to the ABCP-T-bill spread. As we examine longer maturities, the strength of the relationship weakens, eventually turning negative for the longest maturities. Panel B shows similar patterns if we use the OIS - T-bill spread instead, indicating that information in Treasury bill yields alone is useful for forecasting the maturity of ABCP issuance. The relationship here is not perfectly monotonic, but the regression coefficients generally decrease with maturity.

The negative relationship for long maturities shows that ABCP issuers not only increase their total issuance in response to money demand; they also rotate the composition of their liabilities. Specifically, as we show in the Internet Appendix, when banks are fully funding their balance sheets with money-like claims (i.e., $m_D + m_{ABCP} = 1$ in the terminology of the model), they increase the supply of more money-like claims and decrease the supply of less money-like claims in response to a money demand shock. The assumption that balance sheets are fully funded with money-like claims is plausible in the context of ABCP (Acharya, Schnabl, and Suarez 2013).[24]

3.4.4 Open Market Operations Increase with Spreads

We next draw the connection to money demand by linking the demand for ABCP and Treasury bills to the demand for reserves in the banking system. The fourth model prediction is that increases in money demand should both increase the ABCP - T-bill spread and lead the Federal Reserve to increase the supply of reserves. The logic is as follows. An increase in money demand increases demand for deposit-creation permits (reserves), and therefore the prevailing Federal Funds rate. In order to keep the Federal Funds rate at its target, the Federal Reserve injects reserves into the banking system. In the model, this increases the supply of deposits, reducing the value of money services, and driving the Federal Funds rate

[24] Equity for ABCP issuers was implicitly provided off-balance sheet through bank lines of credit.

back to its target level.

Of course, many models of the Federal Reserve's behavior predict reserve injections as a response to heightened money demand. The key distinguishing trait of the money demand model written down above is that yields on ABCP and Treasury bills impound information about money demand. The fact that reserve supply responds to these yields is consistent with the notion that ABCP and Treasury bill provide money services.

In practice, the Federal Reserve manages the supply of reserves by conducting temporary open market operations.[25] It engages in repurchase (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. In practice, in the precrisis period, the only temporary operations were repos, which temporarily increased the total quantity of reserves.

Table 5 examines this prediction, running the regression:

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

In Panel A we use the ABCP - T-bill spread. The first column shows the raw relationship, which is strongly positive and significant as predicted by the model. Figure 4 presents this relationship as a scatterplot. The second column adds year-month fixed effects, and the third column adds week-of-year effects. The relationship remains positive and significant, indicating that it is not driven by low-frequency trends or predictable weekly patterns. The final three columns repeat the exercise, excluding weeks when the Federal Reserve Open Market Committee (FOMC) makes a policy announcement. This demonstrates that the results are not driven by the implementation of changes in the Federal Reserve's policy stance. Panel B shows that we obtain similar results using the OIS - T-bill spread, though the coefficient is not statistically significant when add week-of-year effects and excluding FOMC announcement weeks. This shows that information in Treasury bill yields alone is useful for forecasting temporary increases in reserve supply.

Again, the magnitude of the coefficients is economically plausible. A 1% higher spread leads to a \$15–30 billion larger reserve injection, relative to a mean injection of \$35 billion and a standard deviation of \$16 billion.

[25] The Federal Reserve also conducts permanent open market operations when it wishes to permanently grow the size of its balance sheet. We focus on temporary operations because we are interested in high frequency variation in reserve demand.

3.4.5 Federal Funds Rate Rises with Spreads

We now turn to the fifth and final prediction of the model: deviations of the prevailing Federal Funds rate from the target rate should be positively correlated with the ABCP - T-bill spread. Prior to the reserve supply response of the Federal Reserve, an increase in money demand should increase demand for reserves, driving up the Federal Funds rate. At the same time, the ABCP - T-bill spread should increase, because investors value the incremental money services offered by Treasury bills over ABCP highly. Of course, in the model, the Federal Reserve anticipates changes in money demand, so the prevailing Federal Funds rate is always pegged to the target. However, if the increase in money demand were unanticipated by the Federal Reserve, one would obtain this prediction.

Table 5 examines the prediction, running the regression:

$$\Delta SPREAD_t = \alpha + \beta \cdot \Delta \left(FED\ FUNDS_t - TARGET_t\right) + \varepsilon_t.$$

In Panel A, we examine the ABCP - T-bill spread. The first four columns run the regression at a weekly frequency. The first column shows the raw relationship, while the second column restricts the sample to weeks when the Federal Reserve Open Market Committee does not make a policy announcement. The third and fourth columns add year-month and week-of-year fixed effects respectively.

The coefficients are positive but typically not statistically significant. This is not surprising. At a weekly frequency, the Federal Reserve has time to push the prevailing Federal Funds rate back to its target by adjusting the supply of reserves in response to unanticipated money demand shocks. The next four columns of the table run the same regressions at a daily frequency.[26] Here the evidence is more consistent. Days when the Federal Funds rate rises relative to its target are days when the ABCP - T-bill spread rises as well. Panel B shows that this is not simply driven by changes in ABCP yields. We obtain similar results if we use the OIS - T-bill spread as well.

3.4.6 Other Money Quantities Increase with Spreads

The empirics up to this point have shown that the patterns in the data are consistent with the model. Stepping outside the model, we can ask whether high ABCP - T-bill spreads are in fact a proxy for high money demand as the model suggests. Increases in demand should raise prices and quantities. If high spreads are indeed a proxy for high money demand,

[26] Spread data is available daily, while our issuance data is only available weekly.

they should be correlated with high quantities of money-like claims. Table 7 examines this prediction directly by looking at contemporaneous relationships between spreads and quantities of money-like claims. We run regressions of the form

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

where M_t is some measure of the quantity of money. As with the previous tables, Panel A uses the ABCP - T-bill spread, while Panel B uses the OIS - T-bill spread. Each column examines a different measure 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, which is not surprising given the results in Table 5 Panel A. 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 and significantly correlated with the spread, but there is no relationship for institutional money market funds. The fifth column shows that the size of the money supply, as measured by M2, is positively and significantly associated with the spread.[27]

Finally, in the sixth column we examine a different type of proxy: the dollar volume transactions going over the Fedwire Funds payment system.[28] Fedwire is used for payments and clearing services between financial institutions. To the extent that these transactions are driven by transactions in the real economy, we can think of transaction volume as reflecting money demand. The data are only available monthly, so we cannot use year-month fixed effects as in the other specifications; instead we use year-quarter fixed effects. The results show that Fedwire transaction volume is positively and significantly correlated with spreads, consistent with the money demand view.

Overall, there is suggestive evidence that some monetary quantities are positively correlated with spreads. This is consistent with the money demand story and the use of spreads to proxy for demand at high frequencies.

4 Discussion

To summarize, the empirical results suggest that:

[27] Importantly, this relationship is not mechanical: ABCP outstanding is not automatically included in M2 unless it is held by retail (not but institutional) money market funds.

[28] I thank Tobias Adrian and Adam Copeland for providing the data.

1. ABCP and T-bills are partial substitutes. ABCP supply is upward sloping, so increased demand leads to higher prices and quantities (Tables 2 and 3).
2. These demand shifts are in fact changes in the demand for money-like claims (Tables 4 -7).

Overall, the results seem most consistent with the model presented in Section 2, where variation in the demand for money-like claims plays an important role in driving ABCP issuance. Of course, the approach taken in this paper is indirect, so we cannot claim that the results are definitive. Essentially, the results show that the correlations in the data are consistent with the model in Section 2. However, the money demand explanation is consistent with more of the results than the alternatives discussed in Section 3.2.

4.1 Cumulating the Demand-Side Evidence

We now briefly discuss what our high-frequency estimates imply about the low-frequency growth of ABCP in the years before the crisis. 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.

Extrapolating from Table 2, we can try to assess how much of this growth is related to the demand for money-like claims. Specifically, we can compare spreads from June 2004-July 2007 relative to 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 demand, which are critical for understanding the welfare implications of the growth of shadow banking. Moreover, without a view on its sources, it is difficult to assess the plausibility of the idea that the demand for money-like claims significantly increased in the mid-2000s.[29] Second, there are substantial external validity concerns. Our results are based on high-frequency variation that we argue are ascribable to changes in demand. It is not clear that 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 in magnitude across the various specifications examined in Table 2. Third, while our results are

[29] In most narratives emphasizing the demand for money-like claims, the financial sector itself plays an important role. For instance, when securities lenders lend out securities to short sellers, they receive cash as collateral in case the short seller defaults on the loan. They typically invest this cash in money-like claims because it has to be returned to the short seller immediately whenever the short seller chooses to close the position. Securities lending grew rapidly in the mid-2000s, securities lenders held significant quantities of ABCP (Krishnamurthy, Nagel, and Orlov 2013).

statistically significant, estimation error will be compounded in the calculation. Nonetheless, with these caveats in mind, the calculation is probably still worth doing.

We do the calculation using the estimates in Panel A of Table 2, which relate net ABCP issuance to spreads.[30] Consistent with the idea that the demand for money-like claims increased in the mid-2000s, the ABCP - T-bill spread was 21 bps higher on average from June 2004-July 2007 than it was from January 2001-June 2004. This could potentially reflect increases in the riskiness of ABCP, but the OIS - T-bill spread was also 26 bps higher on average in the latter period than in the prior. The results in Table 2 Panel A suggest that these higher spreads translate into roughly 30% (percentage points) more total ABCP issuance over the latter period than over the early period, or approximately 1/2 of the overall increase in ABCP outstanding. This by no means implies that other explanations, including regulatory arbitrage and moral hazard, were not also important drivers of the growth of ABCP at low frequencies. Our results most clearly speak to the basic premise that ABCP is a money-like claim, and not to the quantitative importance of the demand for money-like claims in driving the growth of ABCP.

4.2 Supply-Side Elasticities

The evidence presented here is qualitatively consistent with the idea that changing demand for money-like claims plays an important role in determining the quantity of ABCP outstanding. However, for a shift in demand to create the very large change in quantities observed in the mid-2000s, the elasticity of ABCP supply must be high. The model suggests one way that the elasticity of supply manifests itself in the data: how strongly the banking system responds to increases in the Federal Funds rate.

Proposition 5 *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. In this case, $\partial m_{ABCP}/\partial i$ effectively reveals the elasticity of supply.*

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

[30] Note that Table 2 is estimated over the entire sample period, January 2001-July 2007. If we restrict the sample to January 2001-June 2004, the results are statistically similar and a bit larger in magnitude.

tax. This causes the banking system to substitute towards ABCP financing.[31] The degree to which it does so is related to the elasticity of ABCP supply, which is captured by c'' where $c(\cdot)$ is the cost of manufacturing ABCP. When c'' is low, the marginal costs of ABCP production increase slowly, so supply is more elastic and 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 that took place in 2004 likely also 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, 2013).

Has the elasticity of supply changed over time? To explore this, in Figure 5 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 t, we run a regression of the change in commercial paper outstanding normalized by GDP on the change Federal Funds rate over the 5 years following t and plot the coefficient from that regression. As seen in Figure 5, the relationship has strengthened considerably over the last twenty years, suggesting supply is substantially more elastic than it used to be.

This evidence is consistent with two ideas. First, the growth of securitization likely played an important role in changing the elasticity of ABCP supply. Estimates of the total stock of securitized bonds before the financial crisis range from \$5-\$10 trillion (Gorton and Metrick, 2010). By providing a large, elastic supply of assets that could collateralize ABCP, securitization could have significantly increased the elasticity of ABCP supply. Consistent with this idea, Xie (2012) provides evidence that the supply of securitized bonds responds to changes in the demand for money-like claims.

A second interpretation is that investor perceptions of the banking system's ability to produce high-quality ABCP are what changed, not ABCP production technology itself. 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). In the model, we assumed the amount of money services provided by ABCP, α_{ABCP}, did not vary with the quantity of

[31] 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.

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 that 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. Thus, finding a decline in c'', as Figure 5 suggests, is consistent with the notion that investors began to think the banking system could produce more and more high-quality ABCP. The key question under this interpretation is why investor perceptions changed beginning in the 1990s.

5 Conclusion

The growth of the shadow banking system is important to understand, both because of the role it played in the financial crisis and because it sheds light on the role of financial innovation more broadly. A growing literature has emphasized increasing demand for money-like claims as an explanation for the rise of shadow banking. This literature argues that investor demand for safe, liquid, money-like claims drove the financial system to manufacture large amounts of short-term debt, specifically ABCP and repo, in the years before the financial crisis.

Despite the prominence of the money demand narrative, its basic premise remains untested. Did the short-term claims issued by the shadow banking system provide money services before the crisis? This paper assesses this question empirically by examining the price and quantity dynamics of these short term claims and their interactions with Federal Reserve open market operations. Examining the pre-crisis period from July 2001 through June 2007, the empirical evidence seems broadly consistent with the money demand narrative. The results show that the financial system responds to shocks to the demand for money-like claims, even when the central bank succeeds at pinning the policy rate at its target.

It is important to note that it is unlikely that the demand for money-like claims was the sole driver of the growth of ABCP before the financial crisis. Other explanations, including regulatory arbitrage and mispricing, are likely to have also played significant roles.

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A Proofs in the Main Text

A.1 Derivation of Gross Returns

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.

A.2 Proof of Proposition 1

Banks solve

$$\max_{\widehat{r},\widehat{m_D},\widehat{m_{ABCP}}} F(1-\widehat{r}) - R + \widehat{m_D}(\theta v'(M) + w'(m_D)) + \widehat{m_{ABCP}}\alpha_{ABCP}\theta v'(M) - c(\widehat{m_{ABCP}}) - \widehat{\widehat{ri}}$$

subject to the constraints

$$\rho\widehat{m_D} \le \widehat{r} \quad \text{and } \widehat{m_D} + \widehat{m_{ABCP}} \le 1.$$

The Lagrangian for this problem is

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

Differentiating with respect to $\widehat{r}$, $\widehat{m_D}$, and $\widehat{m_{ABCP}}$ yields three FOCs:

$$\begin{aligned}-F-\widehat{i}+\lambda_1 &= 0\\ \theta v'\left(M\right)+w'\left(m_D\right)-\rho\lambda_1-\lambda_2 &= 0\\ \alpha_{ABCP}\theta v'\left(M\right)-c'\left(\widehat{m_{ABCP}}\right)-\lambda_2 &= 0.\end{aligned}$$

First note that the λ_2 is the shadow cost of the adding up constraint for the bank's liabilities:

$$\lambda_2=\alpha_{ABCP}\theta v'\left(M\right)-c'\left(\widehat{m_{ABCP}}\right).$$

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. Thus, for a sufficiently large c' we can take $\lambda_2=0$.

Second, note that so long as $F>-\widehat{i}$, we will have $\lambda_1>0$ so that the constraint $\widehat{r}=\rho\widehat{m_D}$ binds. Then combining the first two FOCs yields

$$F+\widehat{i}=\lambda_1=\frac{\theta v'\left(M\right)+w'\left(m_D\right)}{\rho}.$$

In equilibrium, we have market clearing for reserves with identical banks so

$$\widehat{m_D}=\frac{\mathcal{R}}{\rho}$$

and

$$\alpha_{ABCP}\theta v'\left(\frac{\mathcal{R}}{\rho}+\alpha_T m_T+\alpha_{ABCP}\widehat{m_{ABCP}}\right)=c'\left(\widehat{m_{ABCP}}\right).$$

(assuming $c'>\underline{c}$). These two conditions pin down $\widehat{m_D}$ and $\widehat{m_{ABCP}}$.

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

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

A.3 Proof of Proposition 2

Differentiating the first order condition (2) with respect to θ yields

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

which implies

$$\frac{\partial \widehat{m_{ABCP}}}{\partial \theta} = \frac{\alpha_{ABCP} v'(M)}{c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)} + \frac{\alpha_{ABCP} \theta v''(M)}{c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)} \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial \theta}.$$

A key feature of the equilibrium is that the Federal Reserve will alter the supply of reserves so that the Federal Funds rate remains at its target, $\widehat{i} = i$ .Thus, differentiating (3) with respect to θ yields

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

Plugging in the expression for $\frac{\partial \widehat{m_{ABCP}}}{\partial \theta}$ yields

$$\begin{aligned} 0 &= \theta v''(M) \left[\frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial \theta} + \frac{\alpha_{ABCP}^2 v'(M)}{c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)} + \frac{\alpha_{ABCP}^2 \theta v''(M)}{c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)} \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial \theta} \right] \\ & \quad + v'(M) + w'' \left(\frac{\mathcal{R}^*(i)}{\rho} \right) \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial \theta}, \end{aligned}$$

and simplifying gives

$$\frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial \theta} = - \left[\frac{c''(\widehat{m_{ABCP}}) v'(M)}{\theta c''(\widehat{m_{ABCP}}) v''(M) + (c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)) w'' \left(\frac{\mathcal{R}^*(i)}{\rho} \right)} \right].$$

Since $c'' > 0$ and $v' > 0$, the numerator is positive. Since $\theta > 0$, $c'' > 0$, and $v'' < 0$, the first term of the denominator is negative. Since $c'' > 0$, $v'' < 0$, and $w'' < 0$, the second term of the denominator is also negative. Thus, the overall expression is positive and $\frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial \theta} > 0$.

Finally, plugging back into the expression for $\frac{\partial \widehat{m_{ABCP}}}{\partial \theta}$ yields

$$\begin{aligned} \frac{\partial \widehat{m_{ABCP}}}{\partial \theta} &= \frac{\alpha_{ABCP} v'(M)}{c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)} \\ & \quad - \frac{\alpha_{ABCP} \theta v''(M)}{c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)} \times \\ & \quad \left[\frac{c''(\widehat{m_{ABCP}}) v'(M)}{\theta c''(\widehat{m_{ABCP}}) v''(M) + (c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)) w'' \left(\frac{\mathcal{R}^*(i)}{\rho} \right)} \right], \end{aligned}$$

and simplifying gives

$$\frac{\partial \widehat{m_{ABCP}}}{\partial \theta} = \left[\frac{\alpha_{ABCP} v'(M) w'' \left(\frac{\mathcal{R}^*(i)}{\rho} \right)}{\theta c''(\widehat{m_{ABCP}}) v''(M) + (c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)) w'' \left(\frac{\mathcal{R}^*(i)}{\rho} \right)} \right].$$

Since $v' > 0$ and $w'' < 0$, the numerator is negative. Since $\theta > 0$, $c'' > 0$, and $v'' < 0$, the first term of the denominator is negative. Since $c'' > 0$, $v'' < 0$, and $w'' < 0$, the second term of the denominator is also negative. Thus, the overall expression is positive and $\frac{\partial \widehat{m_{ABCP}}}{\partial \theta} > 0$.

The corollary can be proven by differentiating $\frac{\partial \widehat{m_{ABCP}}}{\partial \theta}$ with respect to α_{ABCP}. This yields

$$\begin{aligned}\frac{\partial^2 \widehat{m_{ABCP}}}{\partial \theta \partial \alpha_{ABCP}} &= v'(M)\, w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right) \times \\ &\left[\frac{2\alpha_{ABCP} c''\left(\widehat{m_{ABCP}}\right)\left(\theta v''(M) + w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\right)}{\left(\theta c''\left(\widehat{m_{ABCP}}\right) v''(M) + \left(c''\left(\widehat{m_{ABCP}}\right) - \alpha_{ABCP}^2 \theta v''(M)\right) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\right)^2}\right].\end{aligned}$$

Since $v' > 0$ and $w'' < 0$, the term outside the square brackets is negative. Since $c'' > 0$, $v'' < 0$, and $w'' < 0$, the numerator of the term in square brackets is negative. Since the denominator of the term in square brackets is squared, it is positive. Thus the overall expression is positive and $\frac{\partial^2 \widehat{m_{ABCP}}}{\partial \theta \partial \alpha_{ABCP}} > 0$.

$$\begin{aligned}\frac{\partial \widehat{m_{ABCP}}}{\partial \theta} &= \left[\frac{\alpha_{ABCP} v'(M)\, w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)}{\theta c''\left(\widehat{m_{ABCP}}\right) v''(M) + \left(c''\left(\widehat{m_{ABCP}}\right) - \alpha_{ABCP}^2 \theta v''(M)\right) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)}\right] \\ \frac{\partial^2 \widehat{m_{ABCP}}}{\partial \theta \partial \alpha_{ABCP}} &= v'(M)\, w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right) \times \\ &\left[\frac{\left(\theta c''\left(\widehat{m_{ABCP}}\right) v''(M) + \left(c''\left(\widehat{m_{ABCP}}\right) + \alpha_{ABCP}^2 \theta v''(M)\right) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\right)}{\left(\theta c''\left(\widehat{m_{ABCP}}\right) v''(M) + \left(c''\left(\widehat{m_{ABCP}}\right) - \alpha_{ABCP}^2 \theta v''(M)\right) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)\right)^2}\right]\end{aligned}$$

A.4 Proof of Proposition 3

The yield on ABCP is given by

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

Differentiating with respect to θ yields

$$\frac{\partial R_{ABCP}}{\partial \theta} = -\alpha_{ABCP}\left[v'(M) + \theta v''(M) \frac{dM}{\partial \theta}\right].$$

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

$$\frac{\partial \widehat{i}}{\partial \theta} = 0 = v'(M) + \theta v''(M) \frac{dM}{\partial \theta} + w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right) \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial \theta},$$

which implies

$$v'(M) + \theta v''(M) \frac{dM}{\partial \theta} = -w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right) \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial \theta}.$$

Since $w'' < 0$ and $\frac{\partial \mathcal{R}^*}{\partial \theta} > 0$, we have $v'(M) + \theta v''(M) \frac{dM}{\partial \theta} > 0$. This implies $\frac{\partial R_{ABCP}}{\partial \theta} < 0$. Similar logic implies $\frac{\partial R_T}{\partial \theta} < 0$.

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

$$\frac{\partial (R_{ABCP} - R_T)}{\partial \theta} = (\alpha_T - \alpha_{ABCP}) \left[v'(M) + \theta v''(M) \frac{dM}{\partial \theta} \right].$$

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

A.5 Proof of Proposition 4

We follow the same logic as in the proofs of Propositions 2 and 3. Differentiating the first order condition (2) with respect to m_T yields

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

which implies

$$\frac{\partial \widehat{m_{ABCP}}}{\partial m_T} = \frac{\alpha_T \alpha_{ABCP} \theta v''(M)}{c''\left(\widehat{m_{ABCP}}\right) - \alpha_{ABCP}^2 \theta v''(M)} + \frac{\alpha_{ABCP} \theta v''(M)}{c''\left(\widehat{m_{ABCP}}\right) - \alpha_{ABCP}^2 \theta v''(M)} \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial m_T}.$$

A key feature of the equilibrium is that the Federal Reserve will alter the supply of reserves so that the Federal Funds rate remains at its target, $\widehat{i} = i$ .Thus, differentiating (3) with respect to m_T yields

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

Plugging in the expression for $\frac{\partial \widehat{m_{ABCP}}}{\partial m_T}$ yields

$$0 = \theta v''(M) \left[\begin{array}{c} \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial m_T} + \alpha_T + \\ \alpha_{ABCP} \left(\frac{\alpha_T \alpha_{ABCP} \theta v''(M)}{c''\left(\widehat{m_{ABCP}}\right) - \alpha_{ABCP}^2 \theta v''(M)} + \frac{\alpha_{ABCP} \theta v''(M)}{c''\left(\widehat{m_{ABCP}}\right) - \alpha_{ABCP}^2 \theta v''(M)} \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial m_T} \right) \end{array} \right] + w'' \left(\frac{\mathcal{R}^*(i)}{\rho} \right) \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial m_T},$$

and simplifying yields

$$\frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial m_T} = - \frac{\alpha_T \theta c''\left(\widehat{m_{ABCP}}\right) v''(M)}{\theta v''(M) c''\left(\widehat{m_{ABCP}}\right) + \left(c''\left(\widehat{m_{ABCP}}\right) - \alpha_{ABCP}^2 \theta v''(M)\right) w'' \left(\frac{\mathcal{R}^*(i)}{\rho} \right)}.$$

Since $v'' < 0$ and $c'' > 0$, the numerator is negative. Similarly, the first term of the denominator is negative. Since $w'' < 0$, the second term of the denominator is also negative. Thus, the overall expression is negative and $\frac{1}{\rho}\frac{\partial \mathcal{R}^*}{\partial m_T} < 0$.

Plugging back into the expression for $\frac{\partial \widehat{m_{ABCP}}}{\partial m_T}$ yields

$$\begin{aligned}\frac{\partial \widehat{m_{ABCP}}}{\partial m_T} &= \frac{\alpha_T \alpha_{ABCP} \theta v''(M)}{c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)} \\ &\quad - \frac{\alpha_{ABCP} \theta v''(M)}{c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)} \times \\ &\quad \left[\frac{\alpha_T \theta c''(\widehat{m_{ABCP}}) v''(M)}{\theta v''(M) c''(\widehat{m_{ABCP}}) + (c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)}\right],\end{aligned}$$

and simplifying gives

$$\frac{\partial \widehat{m_{ABCP}}}{\partial m_T} = \left[\frac{\alpha_T \alpha_{ABCP} \theta v''(M) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)}{\theta c''(\widehat{m_{ABCP}}) v''(M) + (c''(\widehat{m_{ABCP}}) - \alpha_{ABCP}^2 \theta v''(M)) w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)}\right].$$

Since $v'' < 0$ and $w'' < 0$, the numerator is positive. Since $\theta > 0$, $c'' > 0$, and $v'' < 0$, the first term of the denominator is negative. Since $c'' > 0$, $v'' < 0$, and $w'' < 0$, the second term of the denominator is also negative. Thus, the overall expression is negative and $\frac{\partial \widehat{m_{ABCP}}}{\partial m_T} < 0$.

The ABCP - Treasury bill spread is given by

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

Differentiating with respect to m_T yields

$$\frac{\partial (R_{ABCP} - R_T)}{\partial m_T} = (\alpha_T - \alpha_{ABCP}) \theta v''(M) \frac{dM}{\partial m_T}.$$

We can sign $\frac{dM}{\partial m_T}$ using the fact that in equilibrium, the Federal Funds rate is unchanged. We have

$$\frac{\partial \widehat{i}}{\partial \theta} = 0 = \theta v''(M) \frac{dM}{\partial m_T} + w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right) \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial m_T},$$

which implies

$$\theta v''(M) \frac{dM}{\partial m_T} = -w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right) \frac{1}{\rho} \frac{\partial \mathcal{R}^*}{\partial m_T}.$$

Since $w'' < 0$ and $\frac{\partial \mathcal{R}^*}{\partial m_T} < 0$, we have $\theta v''(M) \frac{dM}{\partial m_T} < 0$. This implies that $\frac{\partial (R_{ABCP} - R_T)}{\partial m_T} < 0$.

A.6 Proof of Proposition 5

We prove the proposition by differentiating the first order conditions that define the equilibrium with respect to the target Federal Funds rate i. Differentiating the first order condition

(2) with respect to i gives

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

and simplifying yields

$$\frac{\partial\widehat{m_{ABCP}}}{\partial i}=\frac{-\alpha_{ABCP}\theta v''(M)}{\alpha^2_{ABCP}\theta v''(M)-c''\left(m^*_{ABCP}\right)}\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}.$$

Differentiating (3) with respect to i yields

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

and simplifying yields

$$\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}=\rho\left[w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)-\frac{c''\left(m^*_{ABCP}\right)\theta v''(M)}{\alpha^2_{ABCP}\theta v''(M)-c''\left(m^*_{ABCP}\right)}\right]^{-1}.$$

Since $w''<0$, the first term in the square brackets is negative. Since $c''>0$ and $v''<0$, the numerator of the second term is negative. Since $c''>0$ and $v''<0$, the denominator of the second term is also negative. Thus, the full term in the square brackets is negative and $\frac{1}{\rho}\frac{\partial\mathcal{R}^*}{\partial i}<0$.

Finally, plugging back into the expression for $\frac{\partial\widehat{m_{ABCP}}}{\partial i}$ yields

$$\frac{\partial\widehat{m_{ABCP}}}{\partial i}=\frac{-\alpha_{ABCP}\theta v''(M)}{\alpha^2_{ABCP}\theta v''(M)-c''\left(m^*_{ABCP}\right)}\rho\left[w''\left(\frac{\mathcal{R}^*(i)}{\rho}\right)-\frac{c''\left(m^*_{ABCP}\right)\theta v''(M)}{\alpha^2_{ABCP}\theta v''(M)-c''\left(m^*_{ABCP}\right)}\right]^{-1}.$$

We know that the term in the square brackets is negative. Since $v''<0$, the numerator of the term outside the square brackets is positive. Since $c''>0$ and $v''<0$, the denominator of the term is negative. Thus, the whole expression is positive and $\frac{\partial\widehat{m_{ABCP}}}{\partial i}>0$.

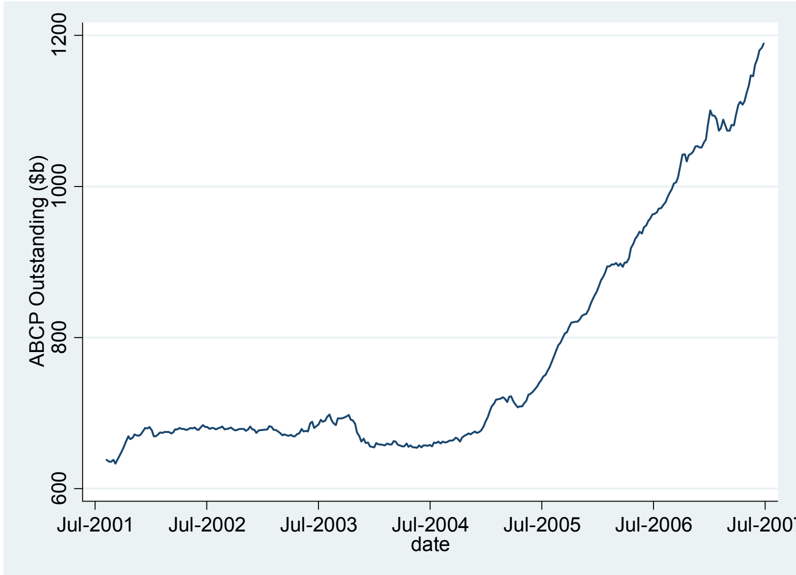

Figure 1
ABCP Outstanding

This figure shows the time series of ABCP outstanding from July 2001-June 2007.

Figure 2
ABCP Issuance and the ABCP – T-bill Spread

This figure plots net ABCP issuance against the value of the ABCP – T-bill spread from July 2001-June 2007. The red line shows the best linear fit.

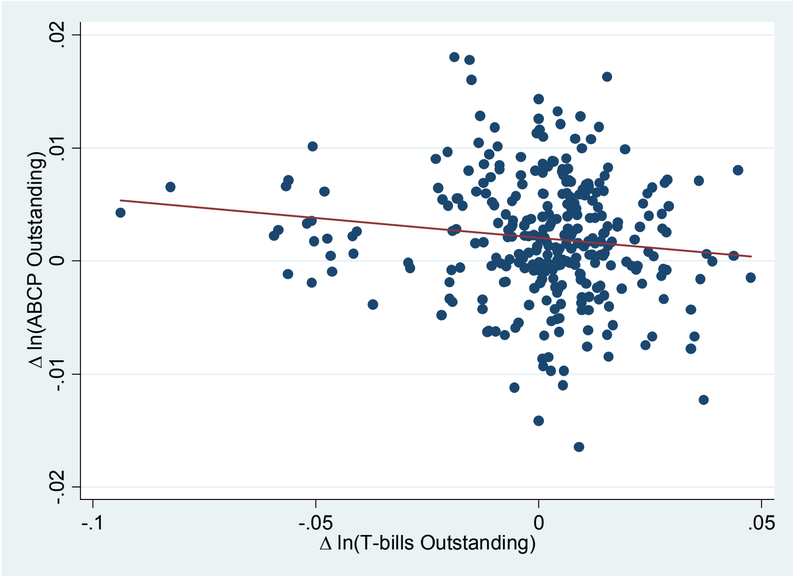

Figure 3
ABCP Issuance and Treasury Bill Issuance

This figure plots net ABCP issuance against net Treasury bill issuance from July 2001-June 2007. The red line shows the best linear fit.

Figure 4
Reserve Injections and ABCP - T-bill Spread

This figure plots temporary reserve injections against the value of the ABCP – T-bill spread from July 2001-June 2007. The red line shows the best linear fit.

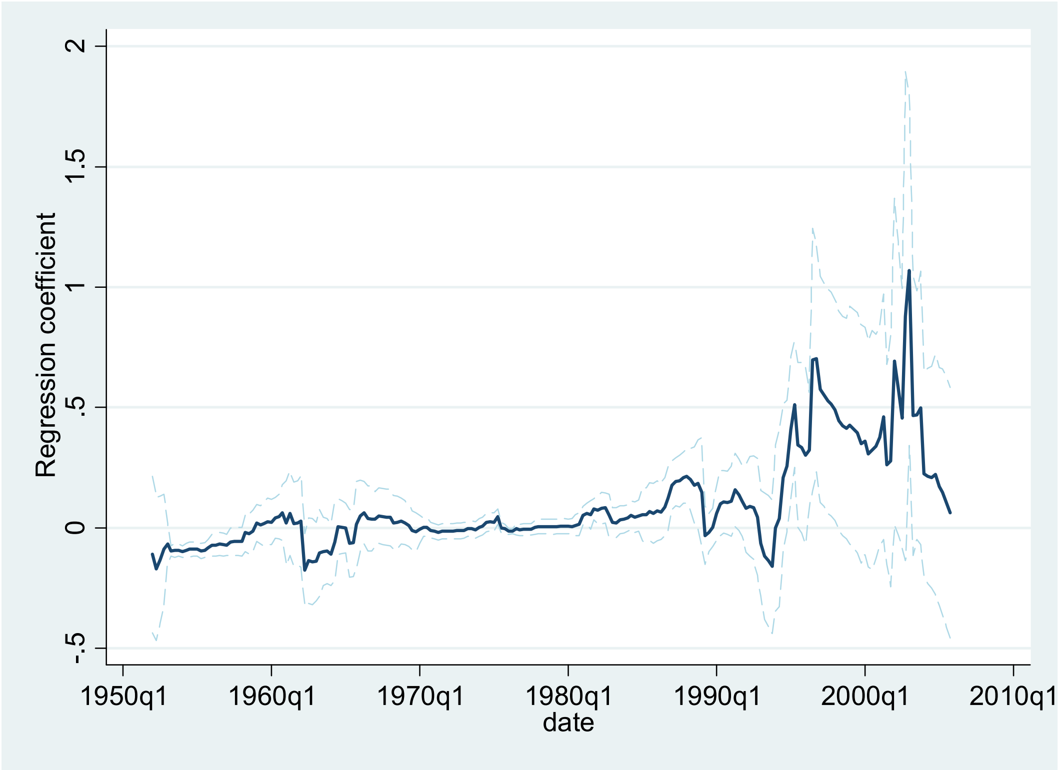

Figure 5
Relationship between CP outstanding and the Federal Funds Rate over Time

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 the change in commercial paper outstanding normalized by GDP on the change in 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. ABCP - T-bill is the spread of 4-week ABCP over 4-week Treasury bills; OIS - T-bill is the spread of the 4-week overnight indexed swap (OIS) 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; Δ ln(T-bills Out) is log net Treasury bill issuance; Reserves Injected is net reserve injections (repo minus reverse repo). The sample runs weekly from July 2001-June 2007.

	N	mean	sd	min	max
ABCP - T-bill (%)	303	0.259	0.179	0.070	1.120
OIS - T-bill (%)	288	0.226	0.193	-0.018	1.060
ABCP Outstanding ($b)	303	776.0	153.0	633	1189
ln(ABCP Out)	303	13.54	0.180	13.36	13.99
Δ ln(ABCP Out_{t-1})	303	0.002	0.005	-0.016	0.018
T-bills Outstanding ($b)	303	932.0	75.0	691	1089
ln(T-bills Out_t)	303	6.834	0.084	6.538	6.993
Δ ln(T-bills Out_{t-1})	303	0.001	0.020	-0.094	0.048
Reserves Injected ($b)	303	34.09	12.35	4.75	114.29
ln(Reserves Injected)	303	3.46	0.410	1.56	4.74

Table 2
ABCP Net Issuance and Spreads

This table shows regressions of the form

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

ABCP - T-bill$_{t-1}$ is the spread of 4-week ABCP over 4-week Treasury bills, OIS - T-bill is the spread of the 4-week overnight indexed swap (OIS) 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). Panel A uses the ABCP – T-bill spread as the independent variable, while Panel B uses the OIS-T-bill spread. The sample runs weekly from July 2001-June 2007. YM denotes year-month fixed effects, while WOY denotes week-of-year fixed effects. Robust standard errors are reported in parentheses, except for the specifications without fixed effects which report Newey-West standard errors with 12 lags. In specifications with fixed effects, we report the residual R^2. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

	Panel A: ABCP - T-bill Spread				
ABCP - T-bill$_{t-1}$	0.013***	0.012***	0.010***	0.012***	0.011**
	(0.002)	(0.004)	(0.002)	(0.004)	(0.004)
ln(ABCP Out$_{t-1}$)			0.002	-0.360***	-0.439***
			(0.002)	(0.061)	(0.066)
Δ ln(ABCP Out$_{t-1}$)			0.138**	0.007	0.073
			(0.066)	(0.074)	(0.082)
Constant	-0.001**	-0.001	-0.026	4.874***	5.991***
	(0.001)	(0.001)	(0.030)	(0.830)	(0.896)
R^2	0.164	0.045	0.172	0.243	0.362
N	303	303	301	301	301
FE	---	YM	---	YM	YM, WOY

	Panel B: OIS - T-bill Spread				
OIS - T-bill$_{t-1}$	0.012***	0.009**	0.009***	0.013***	0.012**
	(0.002)	(0.004)	(0.002)	(0.004)	(0.005)
ln(ABCP Out$_{t-1}$)			0.002	-0.359***	-0.434***
			(0.002)	(0.068)	(0.071)
Δ ln(ABCP Out$_{t-1}$)			0.125*	0.014	0.091
			(0.069)	(0.083)	(0.086)
Constant	-0.001	-0.000	-0.022	4.862***	5.919***
	(0.000)	(0.001)	(0.031)	(0.923)	(0.969)
R^2	0.169	0.028	0.178	0.224	0.356
N	287	287	286	286	286
FE	---	YM	---	YM	YM, WOY

Table 3
ABCP Net Issuance and T-bill Net Issuance

This table shows regressions of the form

$$\Delta \ln\left(ABCP\ OUTSTANDING_t\right) = \alpha + \beta \bullet \Delta \ln\left(T\text{-}BILLS\ OUTSTANDING_t\right) + \varepsilon_t.$$

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), and Δ ln(T-bills Out) is log net Treasury bill issuance. Panel A shows the quantity relationship. In Panel B, we instrument for spreads using Δ ln(T-bills Out_t). The sample runs weekly from July 2001-June 2007. YM denotes year-month fixed effects, while WOY denotes week-of-year fixed effects. Robust standard errors are reported in parentheses, except for the specifications without fixed effects which report Newey-West standard errors with 12 lags. In specifications with fixed effects, we report the residual R^2. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

	Panel A: Quantity Relationships				
Δ ln(T-bills Out_t)	-0.035***	-0.017	-0.022*	-0.037***	-0.036*
	(0.013)	(0.013)	(0.012)	(0.012)	(0.020)
ln(ABCP Out_{t-1})			0.006***	-0.368***	-0.433***
			(0.002)	(0.063)	(0.066)
Δ ln(ABCP Out_{t-1})			0.211***	0.027	0.080
			(0.067)	(0.079)	(0.083)
Constant	0.002***	0.002***	-0.085***	4.985***	5.911***
	(0.000)	(0.000)	(0.027)	(0.850)	(0.905)
R^2	0.013	0.168	0.122	0.358	0.349
N	303	303	302	302	302
FE	---	YM	---	YM	YM, WOY

	Panel B: "IV" Linking Quantities and Spreads			
	ABCP - T-bill$_{t-1}$		OIS - T-bill$_{t-1}$	
	1st Stage	2nd Stage	1st Stage	2nd Stage
Δ ln(T-bills Out_{t-1})	-1.353***		-1.404***	
	(0.237)		(0.224)	
Spread$_{t-1}$		0.017***		0.017***
		(0.005)		(0.006)
ln(ABCP Out_{t-1})		-0.364***		-0.366***
		(0.063)		(0.070)
Δ ln(ABCP Out_{t-1})		-0.003		0.008
		(0.074)		(0.083)
Constant	0.260***	4.857***	0.226***	4.932***
	(0.004)	(0.838)	(0.004)	(0.939)
R^2	0.859	0.372	0.894	0.357
N	303	301	288	286
FE	YM	YM	YM	YM

Table 4
ABCP Gross Issuance and Spreads

This table shows regressions of the form

$$\ln\left(GROSS\ \ ISSUANCE_t\right) = \alpha + \beta \bullet SPREAD_{t-1} + \varepsilon_t .$$

ABCP - T-bill$_{t-1}$ is the spread of 4-week ABCP over 4-week Treasury bills, OIS - T-bill is the spread of the 4-week overnight indexed swap (OIS) rate over 4-week Treasury bills, ln(ABCP Out$_{t-1}$) is lagged log ABCP outstanding, and ln(Issuance$_{t-1}$) is lagged log gross ABCP issuance.). Panel A uses the ABCP – T-bill spread as the independent variable, while Panel B uses the OIS-T-bill spread. The sample runs weekly from July 2001-June 2007. YM denotes year-month fixed effects. Robust standard errors are reported in parentheses. In specifications with fixed effects, we report the residual R^2. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

	Panel A: ABCP – T-bill Spread					
Maturity(days):	1-4	5-9	10-20	21-40	41-80	80+
ABCP - T-bill$_{t-1}$	0.258***	0.262	0.173	0.038	-0.423*	-0.519**
	(0.094)	(0.188)	(0.152)	(0.200)	(0.222)	(0.221)
ln(Issuance$_{t-1}$)	-0.022	-0.216***	0.052	0.040	0.329***	0.184**
	(0.071)	(0.070)	(0.075)	(0.070)	(0.078)	(0.076)
ln(ABCP Out$_{t-1}$)	-1.791	-0.450	-3.356	3.760	-4.389	3.541
	(1.511)	(3.023)	(2.666)	(2.805)	(2.911)	(3.569)
Constant	35.855*	17.171	53.987	-40.636	65.970*	-40.166
	(20.377)	(40.791)	(36.131)	(37.866)	(39.307)	(48.050)
R^2	0.033	0.049	0.015	0.013	0.101	0.071
N	303	303	303	303	303	303
FE	YM	YM	YM	YM	YM	YM

	Panel B: OIS – T-bill Spread					
Maturity(days):	1-4	5-9	10-20	21-40	41-80	80+
OIS - T-bill$_{t-1}$	0.353***	0.243	0.381**	0.172	-0.329	-0.357
	(0.098)	(0.180)	(0.149)	(0.212)	(0.253)	(0.240)
ln(Issuance$_{t-1}$)	-0.034	-0.208***	0.053	0.013	0.340***	0.191**
	(0.071)	(0.071)	(0.076)	(0.070)	(0.084)	(0.081)
ln(ABCP Out$_{t-1}$)	-1.806	-0.019	-2.946	3.222	-4.558	2.026
	(1.536)	(3.331)	(2.661)	(2.994)	(3.195)	(3.888)
Constant	36.189*	11.276	48.402	-33.118	68.150	-19.784
	(20.688)	(44.953)	(36.062)	(40.450)	(43.168)	(52.401)
R^2	0.046	0.044	0.024	0.013	0.099	0.044
N	287	287	287	287	287	287
FE	YM	YM	YM	YM	YM	YM

Table 5
Reserve Injections and Spreads

This table shows regressions of the form

$$\ln\left(RESERVE\ INJECTION_t\right) = \alpha + \beta \bullet SPREAD_{t-1} + \varepsilon_t .$$

The dependent variable is log reserve injections in week *t*. ABCP - T-bill$_{t-1}$ is the spread of 4-week ABCP over 4-week Treasury bills, OIS - T-bill is the spread of the 4-week overnight indexed swap (OIS) rate over 4-week Treasury bills. Panel A uses the ABCP – T-bill spread as the independent variable, while Panel B uses the OIS-T-bill spread. The sample runs weekly from July 2001-June 2007. The last 3 columns in both panels exclude weeks when the Federal Reserve Open Market Committee meets. YM denotes year-month fixed effects, while WOY denotes week-of-year fixed effects. Robust standard errors are reported in parentheses, except for the specifications without fixed effects which report Newey-West standard errors with 12 lags. In specifications with fixed effects, we report the residual R^2. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

	Panel A: ABCP - T-bill Spread					
ABCP - T-bill$_{t-1}$	0.870***	0.667***	0.866**	0.884***	0.766**	0.717*
	(0.109)	(0.249)	(0.380)	(0.126)	(0.298)	(0.425)
Constant	3.233***	3.285***	3.317***	3.246***	3.276***	2.848***
	(0.038)	(0.070)	(0.263)	(0.042)	(0.081)	(0.266)
R^2	0.135	0.041	0.439	0.132	0.392	0.419
N	303	303	303	255	255	255
FE	---	YM	YM, WOY	---	YM	YM, WOY

	Panel B: OIS - T-bill Spread					
OIS - T-bill$_{t-1}$	0.881***	0.538**	0.659*	0.862***	0.563**	0.423
	(0.103)	(0.210)	(0.364)	(0.116)	(0.248)	(0.438)
Constant	3.271***	3.348***	3.020***	3.290***	3.355***	2.969***
	(0.034)	(0.055)	(0.175)	(0.037)	(0.062)	(0.170)
R^2	0.167	0.042	0.46	0.151	0.413	0.432
N	287	287	287	242	242	242
FE	---	YM	YM, WOY	---	YM	YM, WOY

Table 6
Spreads and the Federal Funds Rate

This table shows regressions of the form

$$\Delta SPREAD_t = \alpha + \beta \bullet \Delta FFT_t + \varepsilon_t.$$

ABCP - T-bill$_{t-1}$ is the spread of 4-week ABCP over 4-week Treasury bills, OIS - T-bill is the spread of the 4-week overnight indexed swap (OIS) rate over 4-week Treasury bills, FFT is the spread of the Federal Funds rate over its target. Panel A uses the ABCP – T-bill spread as the dependent variable, while Panel B uses the OIS-T-bill spread. All columns except the first and fourth exclude days when the Federal Reserve Open Market Committee meets. The sample runs weekly from July 2001-June 2007. YM denotes year-month fixed effects, while WOY denotes week-of-year fixed effects. Robust standard errors are reported in parentheses, except for the specifications without fixed effects which report Newey-West standard errors with 12 lags. In specifications with fixed effects, we report the residual R^2. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

	Panel A: ABCP - T-bill Spread						
	Weekly			Daily			
Δ FFT$_t$	0.045	0.103	0.168**	0.172***	0.165***	0.196***	0.179***
	(0.072)	(0.100)	(0.076)	(0.030)	(0.032)	(0.030)	(0.031)
Constant	0.002	0.002	0.002	0.004***	0.003**	0.003**	-0.012
	(0.005)	(0.005)	(0.004)	(0.001)	(0.001)	(0.001)	(0.032)
R^2	-0.001	0.006	0.224	0.053	0.044	0.056	0.09
N	297	251	251	1118	1039	1039	1039
FE	---	---	YM	---	---	YM	YM, WOY

	Panel B: OIS - T-bill Spread						
	Weekly			Daily			
Δ FFT$_t$	-0.031	0.045	0.067	0.171***	0.179***	0.188***	0.189***
	(0.058)	(0.075)	(0.080)	(0.027)	(0.028)	(0.029)	(0.030)
Constant	0.003	0.003	0.003	0.004***	0.003**	0.003**	-0.015
	(0.004)	(0.005)	(0.004)	(0.001)	(0.001)	(0.001)	(0.029)
R^2	-0.003	-0.003	0.208	0.052	0.051	0.038	0.076
N	281	238	238	1061	988	988	988
FE	---	---	YM	---	---	YM	YM, WOY

Table 7
Aggregate Monetary Quantities and Spreads

This table shows regressions of the form

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

where M_t is some measure of aggregate money in week *t*. ABCP - T-bill$_{t-1}$ is the spread of 4-week ABCP over 4-week Treasury bills, OIS - T-bill is the spread of the 4-week overnight indexed swap (OIS) rate over 4-week Treasury bills. Panel A uses the ABCP – T-bill spread as the independent variable, while Panel B uses the OIS-T-bill spread. The sample runs weekly from July 2001-June 2007, except for the last column, which runs monthly over the same period. Robust standard errors are reported in parentheses. YM denotes year-month fixed effects, while YQ denotes year-quarter fixed effects. In specifications with fixed effects, we report the residual R^2. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively.

	Panel A: ABCP – T-bill Spread					
	Reserves	Deposits	MMMF Retail	MMMF Institutional	M2	Fedwire
ABCP - T-bill$_t$	0.068***	0.003	0.009**	0.002	0.007***	0.086***
	(0.017)	(0.003)	(0.004)	(0.013)	(0.002)	(0.024)
Constant	10.659***	15.421***	6.668***	7.090***	8.737***	14.455***
	(0.004)	(0.001)	(0.001)	(0.003)	(0.001)	(0.007)
R^2	0.058	0.002	0.034	0.001	0.048	0.189
N	303	303	303	303	303	70
FE	YM	YM	YM	YM	YM	YQ

	Panel B: OIS – T-bill Spread					
	Reserves	Deposits	MMMF Retail	MMMF Institutional	M2	Fedwire
OIS - T-bill$_t$	0.071***	0.003	0.005	0.008	0.005**	0.086***
	(0.015)	(0.003)	(0.005)	(0.009)	(0.002)	(0.024)
Constant	10.662***	15.432***	6.660***	7.091***	8.746***	14.466***
	(0.004)	(0.001)	(0.001)	(0.002)	(0.001)	(0.006)
R^2	0.072	0.002	0.007	0.004	0.033	0.190
N	287	287	287	287	287	66
FE	YM	YM	YM	YM	YM	YQ