1 Preliminary Evidence

1.1 The Structure of Inside Money

Figure 1 shows that the model setup and its mechanism are quantitatively important. The left panel shows that to nonfinancial firms, financial intermediaries are the most important suppliers of money-like securities. The right panel shows that nonfinancial firms are among the most important buyers of intermediaries’ money-like liabilities. Money-like assets include various financial instruments. Accordingly, “deposits” in the model should be interpreted broadly, including short-term debt issued by financial intermediaries that either serves as a means of payment, such as deposits at commercial banks, or close substitutes (usually held through money market funds by corporate treasuries), such as repurchase agreements and high-quality asset-backed commercial papers.

The left panel of Figure 1 decomposes the money-like assets of U.S. non-financial corporations by the types of securities, and for each security, by the types of its issuers. I use the data in December 2015 from the March 10, 2016 release of the Financial Accounts of the United States

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Figure 1: **Inside Money Demand and Supply.** This figure plots the issuers (by value) of different components of liquidity holdings of nonfinancial businesses (Panel A) and the holders (by value) of each type of money-like liabilities issued by the financial intermediation sector as of December 2015 (source: the Financial Accounts of the United States). The financial intermediation sector includes U.S.-chartered depository institutions, foreign banking offices in U.S., banks in U.S. affiliated areas, credit unions, issuers of asset-backed securities, finance companies, mortgage real estate investment trusts, security brokers and dealers, holding companies, and funding corporations (previously known as the “Flow of Funds”). From this graph, we can understand who are supplying money to the U.S. nonfinancial corporations and in what forms. Foreign deposits and time deposits are issued by depository institutions, and Treasury securities by the government. 19% of commercial papers are issued by the nonfinancial corporations themselves, 34% by domestic financial intermediaries, and 47% by foreign entities, of which 90% are issued by “foreign financial firms” (defined in the Financial Accounts). 72% of repurchase agreements are issued by the financial sector, and 27% by the foreign entities. Checkable deposits and currency are reported together in the Financial Accounts, of which 42% issued by the government are “currency outside banks”, and the remaining 58% are the liabilities of depository institutions. Given that firms usually do not hold currency directly, 58% underestimates the contribution of financial intermediaries.

The right panel of Figure 1 decomposes the outstanding money-like securities issued by financial intermediaries by the types of owners. Mainly through money market funds, nonfinancial
corporations hold a little less than a third of outstanding repurchase agreements and some commercial papers that account for a smaller fraction of the outstanding amount. They hold a significant share of checkable deposits and large time deposits.

Here are some details on how to construct this graph. Table L.103 records nonfinancial corporations’ assets and liabilities. I break down the holdings of money market fund shares and mutual fund shares into financial instruments using Table L.121 and L.122 respectively, under the assumption that funds held by nonfinancial firms invest in the same portfolio as the aggregate sector does. Corporate and foreign bonds, loans, and miscellaneous assets, all held indirectly through money market mutual funds and mutual funds, are excluded. Agency- and GSE-backed securities are excluded because of the potential spikes of repo haircuts and the secondary market illiquidity during crisis times. Municipal securities are excluded because of secondary market illiquidity.

Next, for each financial instrument, I calculate the net supply by each type of issuers using the instrument-level tables. Financial intermediaries are defined as in Krishnamurthy and Vissing-Jørgensen (2015), including the following financial institutions: U.S.-chartered depository institutions, foreign banking offices in U.S., banks in U.S. affiliated areas, credit unions, issuers of asset-backed securities, finance companies, mortgage real estate investment trusts, security brokers and dealers, holding companies, and funding corporations. Insurance companies are not included as financial intermediaries because their liabilities are long-term and usually held until maturity by insurance policy holders instead of resold in secondary market. Their liabilities are not money-like.

1.2 Cyclical money creation

The model predicts procyclical quantity of money and countercyclical price (i.e., the money premium). The banking sector expands its supply of inside money in goods times, allowing firms to better hedge against their liquidity shocks. In the model, all quantity variables are proportional to $K_t$, the capital stock, and thus, the output $\alpha K_t$, so I scale all quantities variables in data by the nominal GDP. Figure 2 plots the quarterly data of money premium (the solid line) and the

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1 It is implicitly assumed that funds are just pass-through and do not provide any liquidity services beyond the securities they hold. This ignores the potential sharing of idiosyncratic liquidity shocks through funds.
Figure 2: **Money Premium and Nonfinancial Firms’ Holdings of Money-like Securities.** Panel A plots money-like assets held by U.S. nonfinancial business (defined in Appendix III.1) and the money premium (solid line), measured by the spread between the three-month Certificate of Deposit rate and three-month Treasury Bill rate. Panel B plots the cyclical components of these two variables. I use the Baxter-King filter that removes frequencies longer than 69 months, the average length of US business cycle after World War II. Plots start from 1967Q3 and ends in 2012Q4.

U.S. nonfinancial firms’ money-like assets (defined in Appendix III.1). Following Nagel (2016), I define money premium as the spread between the three-month Certificate of Deposit rate and three-month Treasury Bill rate. Panel B plots the cyclical component of firms’ money holdings applying the Baxter-King filter. NBER recession periods are marked by gray shades.

Figure 2 shows that firms’ money holdings tend to be procyclical, and the money premium tends to be countercyclical, consistent with the equilibrium behavior of the model. The correlation between the cyclical component of firms’ money holdings and the recession dummy is $-47.3\%$, and the correlation between the money premium and the recession dummy is $53.4\%$. The correlation between the cyclical component of firms’ money holdings and the money premium is $-35.0\%$.

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2 In Nagel (2016), the preferred measure of money premium is the spread between general collateral repo rate (GC) and Treasury bill rate. However, repo rates are available only since 1991. Nagel (2016) argues that outside the crisis periods (savings and loans crisis of 1980s; the financial crisis of 2007-09), the credit risk of CD component is small, and shows that when both CD rates and GC repo rates are available, there is only a small difference between the two.

3 The filter remove frequencies longer than 69 months, the average length of NBER business cycle in 1945–2009.
Figure 3: Money-like Securities Issued by Financial Intermediaries and Government. Panel A plots the outstanding Treasury bills (solid line) scaled by nominal GDP and the money-like liabilities of financial intermediaries scaled by GDP (defined in Figure 1 in Appendix III.1). Panel B plots the share of inside money, i.e., total money-like liabilities of financial intermediaries, that is from the non-depository intermediaries (“shadow banks”). The data source is the Financial Accounts of the United States from 1967Q3 to 2012Q4.

There is a large literature on the secular trends in corporate liquidity holdings (e.g., Bates, Kahle, and Stulz (2009)), but relatively few on its cycle. Eisfeldt and Rampini (2009) document a positive correlation between the money premium and the asynchronicity between the sources and uses of funds in the productive sector. The model by He and Kondor (2016) also predicts a negative correlation between the money premium and firms’ cash holdings, but they focus on the pecuniary externality in the market of productive capital and the resulting inefficient investment waves.

Using data from the Financial Accounts of the United States, Panel A of Figure 3 plots the outstanding Treasury bills (the solid line) and the net supply of money-like securities by intermediaries, i.e., the sum of intermediaries’ net liabilities in each instrument listed in Figure 1 minus their holdings of government securities. A key message is the collapse of inside money supply in the Great Recession, a more than 50% decline from the second quarter of 2007 (the peak) to end of

Footnote 4: Government securities include Treasury securities and vault cash held by depository institutions, and Treasury securities indirectly held through money market funds by other financial intermediaries.
2009 and a continuing contraction afterwards to a level lower than 1960s. This secular depression of inside money creation is consistent with the model’s prediction on stagnant crises.

Treasury Bill supply increased by more than 100% during the Great Recession. The model predicts that such an increase prolongs the crisis by crowding out intermediaries’ profit, and thus, delaying the repairment of intermediaries’ balance sheet. To some extent, Treasury Bill supply mitigates the money shortage that the productive sector faces, so we do not see a slump in nonfinancial firms’ money holdings (Figure 2) that is as large as the slump of inside money supply. However, the yield on money-like securities has been extremely low in the post-crisis period, which signals a persistent scarcity very likely due to the depressed inside money creation.

Panel B of Figure 3 plots the share of inside money supplied by non-depository financial intermediaries, i.e. the “shadow banks”, such as broker-dealers, finance companies, and issuers of asset-backed securities. Many have argued that other sectors’ demand for money-like securities is a major driver of the growth of shadow banking (Gorton (2010), Stein (2012), and Pozsar (2011) and (2014)). In comparison with traditional banks (depository institutions), shadow banks seemed to be more responsive to rise of money demand in the productive sector in the last two decades, and until the global financial crisis, took an increasingly large share of inside money supply.

1.3 Government debt and intermediary leverage cycle

This section provides evidence on the impact of outside money on the intermediary leverage cycle. I focus on one type of intermediaries, broker-dealers (or investment banks). Adrian and Shin (2010) document the procyclicality of broker-dealer leverage: when their assets grow, their debt grows faster, leading to higher leverage. Broker-dealers issue money-like securities (mainly repurchase agreements) that are held by firms and other entities through money market mutual funds. I focus on investment banks because relative to commercial banks, their choice of leverage is subject to less regulatory constraints, and thereby, they are closer to the laissez-faire banks in the model, and as shown in Figure 3, shadow banks play a more important role than traditional banks in the pre-crisis boom of inside money creation. Leverage is defined as the ratio of total book assets to book equity, using the data from the Financial Accounts, following Adrian and Shin (2010).
Figure 4: **Intermediary Leverage Cycle and Government Debt.** Panel A plots the change of Treasury bills outstanding scaled by nominal GDP by quarter. Panel B plots the quarterly growth rate (log difference) of broker-dealer book leverage (Adrian and Shin (2010)) against the growth rate of broker-dealer book assets in the second quarterly, and Panel C plots the quarterly growth rate of leverage against the growth rate of assets in the first, third, and fourth quarters. The data source is the Financial Accounts of the United States from 1968Q3 to 2015Q3.

The sample is 1968Q3–2015Q3. He, Kelly, and Manela (2016) discuss issues related to internal capital markets that may induce measurement errors in leverage. For government debt, I use the ratio of Treasury Bills to nominal GDP. Short-term debt is more money-like in the sense that their value is more stable, their secondary market more liquid, and repo haircuts smaller.

In identifying the impact of government debt on intermediary leverage, one of the challenges is the endogeneity of government debt supply. Greenwood, Hanson, and Stein (2015) argue that Treasury Bill supply has seasonality. It expands ahead of statutory tax deadlines (e.g., April 15th) to meet its ongoing needs, and contracts following these deadlines. Greenwood, Hanson, and Stein (2015) and Nagel (2016) use week and month dummies respectively to instrument Treasury Bill supply. Panel A of Figure 4 shows that the strongest seasonality is in the second quarter of the year. Because my data is quarterly, I use the Q2 dummy as an instrument for T-bill supply.

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5 Adrian, Etula, and Muir (2014) discuss the data quality concerns in the pre-1968 sample.
Panel B and C of Figure 4 plot the log difference of book leverage (i.e., quarterly growth) against the book asset growth, extending the main result of Adrian and Shin (2010) to this longer sample. Panel B separates out the observations from the second quarters, and Panel C shows the rest of the year. The fitted line is steeper in Panel C, which seems to be consistent with the model’s prediction – increases in government debt amplify the procyclicality of intermediary leverage.

Another identification challenge is the endogeneity of asset growth. In the model, the cyclical nature of leverage is defined with respect to exogenous shocks that increase or decrease banks’ asset value through their impact of collateral quality. Such structural shocks are rarely observed in reality. However, for the purpose of empirical analysis, any exogenous shocks that affect banks’ asset value can be used as instruments. I use monetary policy shocks as such instruments, and consider two measures: the unanticipated changes in the Fed Funds Rate around the FOMC (Federal Open Market Committee) announcements (“MP-FFR”), and a composite measure of unanticipated changes in several interest rates around the FOMC announcements proposed by Nakamura and Steinsson (2017) (“MP-Comp”).

Shocks are aggregated to quarterly level. Calculated from high-frequency data, these policy shocks arguably reflect the changes in interest rates only from the unexpected content of FOMC announcements (“MP-FFR”), and thus, tend to be orthogonal to contemporaneous variations of other economic variables. Through the impact on interest rates and various spreads, monetary policy shocks affect the value of banks’ assets.

Table A.2 reports the results. The first column replicates the main regression in Adrian and Shin (2010). The left-hand side is leverage growth and the right-hand side is asset growth. A positive coefficient shows the procyclicality of leverage. The fourth column of Table A.2 shows the coefficients from regressing leverage growth on both asset growth and the interaction between asset and Treasury bill growth. A positive coefficient on the interaction term suggests when government debt increases, leverage becomes more procyclical, consistent with the model’s prediction.

Column 2 and 3 show leverage procyclicality using different measures of monetary policy

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6 A monetary policy shock is calculated using a 30-minute window from 10 minutes before the FOMC announcement to 20 minutes after it. The calculation follows Nakamura and Steinsson (2017). For earlier contributions, please refer to Cook and Hahn (1989), Kuttner (2001), and Cochrane and Piazzesi (2002) among others.

7 Gertler and Karadi (2015) show that these high-frequency monetary policy shocks affect term premia and credit spreads, and Hanson and Stein (2015) show the strong effect on forward real rates even in the distant future.
This table reports the evidence on the impact of government debt on the relation between broker-dealer asset growth and leverage growth. Column (1) reports the results of regressing leverage growth (quarterly log difference) on asset growth (as in Adrian and Shin (2010)). The sample is from 1968Q3 to 2015Q3. Column (2) and (3) repeat the regression in Column (1) with two types of monetary policy shocks, MP-FFR and MP-Comp, as instrument variables (IVs) for broker-dealer asset growth. MP-FFR and MP-Comp are the quarterly sums of unexpected Fed Funds rate change and composite rate changes respectively around FOMC announcements (available from Nakamura and Steinsson (2017) from 1995 to 2014). Column (4) reports the results of regressing broker-dealer leverage growth on asset growth and the interaction (product) between asset growth and the growth rate of Treasury bills scaled by nominal GDP. Column (5) and (6) repeat the regression in Column (4) with the second quarter dummy as IV for Treasury bill growth, and with MP-FFR (Column 5) or MP-Comp (Column 6) as IV for broker-dealer asset growth. All coefficients are estimated using GMM with Newey-West HAC standard errors reported in parentheses (optimal number of lags chosen following Newey and West (1994)). *, **, *** represent $p < 0.10$, $p < 0.05$, $p < 0.01$ respectively.

<table>
<thead>
<tr>
<th>$\Delta \ln (\text{Leverage})$</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV for $\Delta \ln (\text{Assets})$</td>
<td>MP-FFR</td>
<td>MP-Comp</td>
<td>MP-FFR</td>
<td>MP-Comp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta \ln (\text{Assets})$</td>
<td>0.910***</td>
<td>3.873***</td>
<td>2.527***</td>
<td>0.203</td>
<td>0.991**</td>
<td>0.867**</td>
</tr>
<tr>
<td></td>
<td>(0.113)</td>
<td>(1.451)</td>
<td>(0.855)</td>
<td>(1.294)</td>
<td>(0.449)</td>
<td>(0.348)</td>
</tr>
<tr>
<td>$\Delta \ln \left(\frac{\text{T-Bill}}{\text{GDP}}\right)$</td>
<td>24.40</td>
<td>10.28***</td>
<td>8.999***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(38.57)</td>
<td>(2.174)</td>
<td>(2.220)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>189</td>
<td>77</td>
<td>77</td>
<td>188</td>
<td>77</td>
<td>77</td>
</tr>
</tbody>
</table>

shocks as instruments for asset growth. Both estimates are positive and significant. Column 5 and 6 use the Q2 dummy as an instrument for Treasury Bill supply, and use two measures of monetary policy shocks respectively to instrument asset growth. The coefficient on the interaction term is positive and significant. These confirm the findings in baseline specifications.

Table A.2 provides evidence that supports the predictions of the model in main text. But it is far from conclusive. Future research based on longer samples, international data, and alternative identification strategies, shall provide a better evaluation of the model’s predictions on intermediary leverage cycle, the impact of government debt on it, and other results such as how banks’ payout and issuance policies respond to government debt supply.
2 Discussion: Government Debt as Outside Money

**Optimal timing of government debt supply.** This paper only considers the simplest case of fixed government debt supply, but the model does reveal an interesting trade-off that calls for an optimal strategy of government debt management. When the government issues more debt, it benefits the firms by reducing the money premium, but at the same time, it hurts the bankers who rely on the money premium as a source of profit. Its decision to increase or decrease its debt should balance the impact on both sectors, and in particular, depend on which sector is more constrained.

When \( \eta_t \) is high and banks are already supplying a large amount of money, the marginal benefit of increasing government debt is small. When banks are undercapitalized and not creating enough deposits, raising government debt can significantly alleviate the money shortage. This suggests a countercyclical government debt supply. However, the bank crowding-out effect favors procyclical government debt supply. In good times, banks’ leverage rises, making the economy unstable. The government should increase its debt to crowd out bank leverage. And since banks are well capitalized, the government worries less about crowding out banks’ profit.\(^8\) In low \( \eta_t \) states, the equity crowding-out effect becomes a major concern. The government may want to reduce its debt, allowing banks to rebuild equity by earning a high money premium.

**Bank equity crowding in.** So far, we have only considered the competition between government and banks as money suppliers. Under additional frictions, government debt may be held by banks for their own liquidity needs (Bianchi and Bigio (2014); Drechsler, Savov, and Schnabl (2017)) or as collateral (Saint-Paul (2005); Bolton and Jeanne (2011)). Banks may also hold government securities for regulatory purpose, for example to meet the liquidity coverage ratio (Basel Committee on Bank Supervision (2013)). Therefore, increases in government debt could relax banks’ liquidity or regulatory constraints, and thereby, may increase their profit and crowd in equity.

**Optimal bailout scale.** In bad states, the government may intervene to recapitalize the banking sector, like the Troubled Asset Relief Program (“TARP”) in the financial crisis of 2007-09. On the

\(^8\)But by crowding out banks’ profit, raising government debt gives banks more incentive to pay out dividends at a lower level of equity. By decreasing the payout boundary, it strengthens the asymmetric impact of shocks, making the impact of negative shocks stronger relative to good shocks. This negative effect needs to be weighed in against the positive effect on stability from the reduction of bank leverage.
one hand, the banking sector benefits from equity injection. On the other hand, banks’ profit from money creation is squeezed by the government debt that finances the bailout program. Balancing the two effects, the government may find an optimal scale of bailout financed by government debt in the sense that the expected time to recover is minimized.

**Instability from coexistence of regulated and unregulated banks.** We can reinterpret $M^G$ as money supplied by a separate banking sector that is fully regulated and backs deposits with 100% reserves in the form of government debt. Regulated banks’ balance sheets are just a pass-through. Their money supply grows proportionally with the economy. Such a banking sector was proposed in the Chicago Plan. The competition between government and banks in supplying money can thus be reinterpreted as the competition between fully regulated banks and unregulated banks, or “shadow banks”. Besides many issues surrounding the Chicago Plan, this paper points to a particular concern. If private money cannot be completely forbidden, the leverage cycle in unregulated shadow banking can be amplified by money that is fully backed government securities.

**Instability from market liquidity.** In reality, firms can and do hold some of other firms’ or households’ liabilities in their liquidity portfolios, provided that these securities have sufficiently liquid secondary markets. We can define $M^F K_t$ as the maximum amount of liquid securities that firms and households can issue in aggregate, so $M^F$ is almost a measure of financial market development. Since firms and households are willing to issue any securities that promise an expected return less or equal to $\rho$, firms and households will maximize their issuance in the presence of money premium. To analyze the effects of market liquidity on growth and stability, we can simply follow the analysis of government debt, and all the conclusions carry through. Through the lens of the model, larger and deeper secondary security markets (i.e., higher $M^F$) can amplify the bank leverage cycle and prolong recessions. From 1975 to 2014, the stock market capitalization in the United States increased from c.40% of GDP to c.140%. The competition between market and intermediated liquidity is not the focus of this paper, but the model does point out a possibility that from a liquidity provision perspective, financial markets can destabilize financial intermediaries.

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9It is a banking reform initially proposed by Frank Knight and Henry Simons of the University of Chicago and supported by Irving Fisher of Yale University (Phillips (1996)). Benes and Kumhof (2012) revisited the plan in the interest of financial stability.
Relaxing the financial constraint. It has been assumed that when the liquidity shock hits, a firm cannot mobilize any resources other than its money holdings because existing capital has been destroyed and the investment project is not pledgeable. One way to relax the financial constraint is to introduce a liquidation value of the firm, say $M^L k_t$, where $M^L$ is a constant, so creditors can liquidate the firm and seize $M^L k_t$ when the firm defaults. Thereby, when the liquidity shock arrives, the firm has liquidity equal to $(m_t + M^L) k_t$, the sum of money holdings and the pledgeable value of the firm. Now, we have a new money demand curve:

$$\rho - r_t = \lambda \left[ q_t^K F'(m_t + M^L) - 1 \right].$$

The role that $M^L$ plays is the same as $M^G$ (and $M^F$ in the analysis of market liquidity). Therefore, the previous analysis carries through. Relaxing the financial constraint indeed reduces firms’ demand for bank debt, but it may amplify the bank leverage cycle, prolong recessions, and actually make the economy worse. To understand the financial stability implications of liquidity provided by the government ($M^G$), the secondary market of securities ($M^F$), and the productive capital ($M^L$), we must take into account the endogenous response of the banking system. More liquidity is not always beneficial.

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10There is one caveat – more capital holdings (i.e., larger $k_t$) relaxes the liquidity constraint on future investments by raising the liquidation value, so capital price $q_t^K$ is likely to increase in comparison with the benchmark case. However, this mechanism enhances the procyclicality of $q_t^K$, and thus, amplifies the procyclicality of bank leverage.
References


