Shadow Banks and Macroeconomic Instability

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We develop a macroeconomic model in which commercial banks can offload risky loans to a "shadow" banking sector, and financial intermediaries trade in securitized assets. The model can account both for the business cycle comovement between output, traditional bank, and shadow bank credit, and for the behavior of macroeconomic variables in a liquidity crisis centered on shadow banks. We find that following a liquidity shock, stabilization policy aimed solely at the market in securitized assets is relatively ineffective.

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BETWEEN THE EARLY 1990S AND THE ONSET OF THE 2007–09 subprime crisis, the financial system in the United States and elsewhere underwent a remarkable period of growth and evolution. Banking underwent a shift, away from the traditional "commercial" activities of loan origination and deposit issuing toward a "securitized banking" business model, in which loans were distributed to entities that came to be known as "shadow" banks (Gorton and Metrick 2012a).[1]

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1. The term "shadow" banking has been used to refer to a diverse array of nonbank financial activities. For a comprehensive survey of shadow banking activities (some of which have by now disappeared), and the government programs that backstopped them during the financial crisis of 2007–09, see Pozsar et al. (2010). Our focus will be on shadow banks engaged in the bank-like activities of credit transformation (issuing fixed obligations against risky assets) and maturity transformation (issuing short maturity obligations against long maturity assets) emphasized by Tucker (2010). By securitization we mean the issuance of

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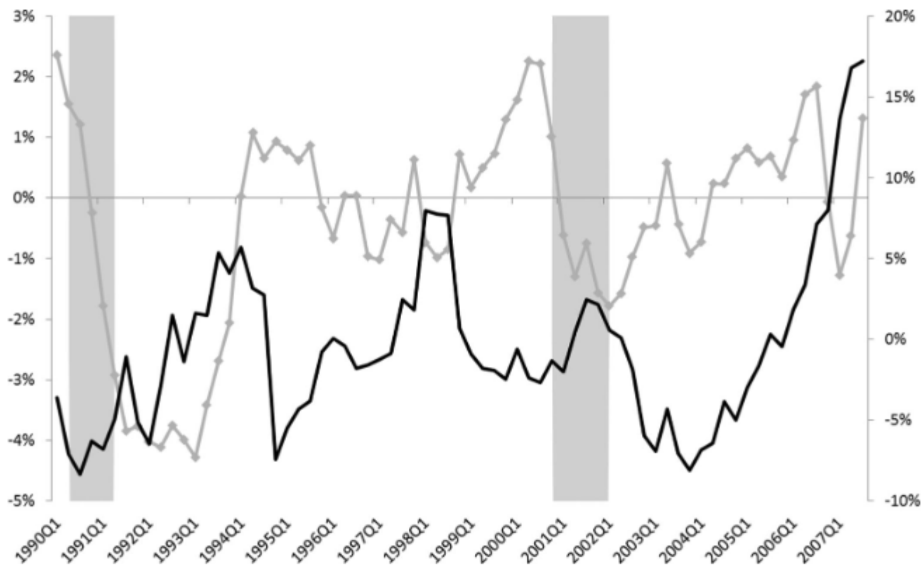

Fig. 1. Credit Cycles in Traditional and Shadow Banking.

Notes: This figure shows year-on-year real terms growth rates for traditional bank (gray line with diamonds, left-hand scale) and shadow bank credit (black line, right-hand scale) credit aggregates taken from the United States Flow of Funds (FRB release Z.1). We group U.S.-Chartered Commercial Banks and Credit Unions in the "traditional bank" sector, and Security Brokers and Dealers and Issuers of Asset-Backed Securities (ABS) in the "shadow bank" sector. Traditional bank credit excludes holdings of private ABS, cash, and reserves. For complete details of data construction and sources, see Appendix D in the Supporting Information.

As shadow banks came to replicate core functions of the traditional banking system, in particular those of credit and maturity transformation, they took on many of the same risks but with far less capital. An over-reliance on securitization, and the increased leverage of the financial system as a whole, ultimately contributed to financial instability, recession, and a substantial contraction in shadow banking activity.

The aggravating role played by flaws in the securitized banking model has been rightly emphasized in many accounts of the subprime crisis and ensuing Great Recession (Blinder 2013). But there is also a need to understand the increasingly central role played by securitization in credit provision over the decades prior to the crisis. To illustrate why, Figure 1 shows the annual growth rates of aggregate credit extended by traditional and shadow banks from 1990 to 2007 in the United States. A striking pattern is that periods when traditional bank credit underwent a contraction were often periods when shadow bank credit expanded. In the same vein, den Haan and Sterk (2010, Table 1) documented that over the post-1984 period, consumer credit and mortgage assets held by commercial banks were positively correlated with GDP,

tradeable securities against the collateral of an underlying pool of assets, including mortgages, consumer credit, or business loans. The financial system we describe later in this paper resembles the securitized banking model in Gorton and Metrick (2012a).

while holdings outside the banking system were negatively correlated. Further, they showed that the two aggregates move in different directions following a monetary tightening (see also Nelson, Pinter, and Theodoridis 2015). Similar evidence has also been found in bank-level data (Altunbas, Gambacorta, and Marquez-Ibanez 2009, Loutskina and Strahan 2009).

We claim the following contributions in this paper. First, we construct a novel dynamic general equilibrium model of the interaction between traditional and shadow banks. We then extend the results of den Haan and Sterk to show that, conditional on disturbances to total factor productivity, over the precrisis period: (i) the correlation between traditional and shadow bank credit was negative, (ii) traditional bank credit was strongly procyclical, and (iii) that shadow bank credit was countercyclical. Our model reproduces these patterns. Second, we demonstrate that when the model is subject to a liquidity shock affecting shadow banks, it predicts declines in output, investment, and consumption, and a large rise in asset-backed securities (ABS) spreads. These movements are of comparable magnitude to those observed over the subprime crisis period. Last, we discuss how, in a securitization crisis, government policies targeted at the shadow banking system, such as purchases of securitized assets, can have spillover effects on the rest of the financial system that weaken the effectiveness of interventions compared to direct purchases of primary assets. In sum, our model is able to give a reasonable account of the macroeconomic implications of shadow banking both in normal times and times of stress. And it delivers predictions and policy recommendations that are absent from more standard "representative bank" models.

The main elements of the model we develop can be summarized as follows. There are two types of financial intermediary. Commercial banks purchase primary claims from nonfinancial firms ("loans"), the economy's ultimate borrowers. They optimally choose the amount of loans to retain on balance sheet, and the amount to sell to the shadow banking system. Shadow banks, in turn, fund their asset purchases by issuing claims against the pool of loans they acquire in the form of ABS.[2]

Each intermediary type faces an endogenous balance sheet constraint that depends on their net worth. The constraint arises because bankers—of both types—are able to take hidden actions from which they benefit at the expense of creditors. This moral hazard problem means that bankers are unable to pledge the full value of the assets they hold as collateral, and gives rise to a familiar financial accelerator mechanism. Commercial banks have an incentive to invest in ABS because securitized assets, which are tradeable and backed by pools of loans, are more pledgeable than the opaque and idiosyncratic loans they retain on balance sheet. By exchanging a direct exposure to the real economy for an intrafinancial claim, commercial banks improve the quality of collateral on their balance sheets, which

2. The term "asset-backed security" encompasses issues backed by pools of assets that can include residential or commercial mortgages, consumer loans, leases on major pieces of industrial equipment, and many other asset classes. As will become clear, in our model, ABS is backed by claims on physical capital.

loosens their funding constraint, and enables them to increase their leverage and their profitability.

In our economy, shadow banks can therefore be thought of as manufacturers of collateral, who take the raw material of loans produced by commercial banks, and transform it into ABS, much as described in Holmström and Tirole (2011, Epilogue). But although increased securitization activity expands the supply of real economy credit by broadening the available base of pledgeable assets, it does not eliminate commercial banks' exposure to risk. Commercial banks are exposed to declines in the price of ABS following an adverse aggregate shock. And the supply of ABS available to commercial banks is itself governed by the strength of shadow bank balance sheets. In general, both factors contribute to the behavior of intermediary credit supply in our model.

The reader should be aware of what we do not do in this paper. First, we do not attempt to model the process of financial innovation and regulatory change that lay behind the rapid expansion of shadow banking. Second, the crisis highlighted shortcomings both in the workings of key asset markets, and in regulation, which we largely ignore. For example, we do not model complex financial instruments based on securitized assets, such as collateralized debt obligations (CDOs), which the market badly mispriced (see Coval, Jurek, and Stafford 2009). Also an important contributory factor behind the creation of some shadow banking entities, in particular structured investment vehicles (SIVs), was a desire by banks to reduce the amount of regulatory capital they held against credit exposures (see Brunnermeier 2009, Pozsar et al. 2010). However, in our model, there is no explicit regulatory motive behind the existence of shadow banks or the market for securitized assets. Allowing these factors to come into play would likely strengthen, rather than weaken, our main conclusions, but is beyond the scope of this paper.

The remainder of this paper is organized as follows. We begin in Section 1 with a brief review of related work. Section 2 outlines our baseline model, including the structure of the financial system, the behavior of commercial and shadow banks, and equilibrium in the ABS market. Section 3 details our calibration strategy and examines the behavior of macroeconomic aggregates and of asset flows to business cycle shocks in the data and in the model (Section 3.2). We go on to discuss the effects of a securitization crisis triggered by a decline in the liquidity of ABS (Section 3.3) and to demonstrate the relative ineffectiveness of government intervention in the ABS market (Section 3.4). Section 4 offers concluding comments.

1. RELATED LITERATURE

The financial stability issues around shadow banking, and securitization in particular, have by now been widely discussed (Adrian and Shin 2008). There has been increasing concern in the literature with modeling the supply-side mechanisms governing credit growth, especially the role of financial intermediaries. Recent examples include, among many others, Gerali et al. (2010), Gertler and Karadi (2011), He and

Krishnamurthy (2013), and Meh and Moran (2010). In these papers, "banks" are taken to represent the entire financial system.[3] There are fewer papers that have attempted to model shadow banking in a macroeconomic context. Verona, Martins, and Drumond (2013) introduce a distinct class of financial intermediary labeled shadow banks into a sticky price DSGE model, but their model does not feature securitization or interaction between traditional and shadow banks. Moreira and Savov (2014) focus on the liquidity aspects of shadow banking in a dynamic macrofinance model. Our model shares with Gennaioli, Shleifer, and Vishny (2013) the feature that it is demand by outside investors for good collateral that drives banks to securitize. In our model and theirs, securitization allows the financial system to pledge a greater proportion of the cash flows from underlying assets to investors. Plantin (2015) and Goodhart et al. (2013) motivate the existence shadow banks as a product of regulatory arbitrage, which we ignore.

The most important point of comparison for our model is found in Gertler and Kiyotaki (2011), who study the interbank lending market. In their model, banks are subject to idiosyncratic (locale-specific) liquidity shocks, but the interbank market allows for some (in the limit, perfect) sharing of cross-sectional risk. In the absence of a perfectly functioning interbank market, asset prices are not equalized across locales, and as a consequence, the marginal supplier of real economy credit becomes more levered than average, amplifying the effect of shocks. A similar effect is present in our model, in that the high leverage of shadow banks magnifies the effect of shocks on their demand for loans from, and their supply of ABS collateral to, commercial banks.[4]

2. THE BASELINE MODEL

The model we employ is a basic real business cycle model, augmented with a set of real frictions intended to aid comparability with recent quantitative macroeconomic models. Our analysis rests on four key assumptions. The first two are familiar from other recent work on financial intermediation, such as Gertler and Kiyotaki (2011). The third and fourth are specific to our model of shadow banking.

First, because of an inability to enforce contracts, or an inability to verify cash flows, households do not lend directly to firms, the economy's ultimate borrowers. As a consequence, financial institutions, which are able to perfectly enforce payment

3. A prominent approach, due to Holmström and Tirole (1997), allows both borrower and intermediary balance sheet condition to affect the aggregate amount of credit extended. The present paper focuses on intermediary balance sheets alone.

4. In an extension to their baseline model, Gertler and Kiyotaki discuss the case where banks consist of a commercial branch, which faces a regulatory capital requirement, and an unregulated investment branch, which is subject to market discipline. Under the assumption of unified ownership, leverage is determined by a single financing constraint operating at the consolidated level. The authors note that the consolidated entity then behaves exactly like the commercial bank in their baseline model, resulting in no new macroeconomic implications. In this paper, we dispense with the consolidated ownership assumption which, as anticipated by Gertler and Kiyotaki (p. 586), results in a rich set of novel implications.

from firms, have a vital role in intermediating funds from the economy's ultimate lenders to ultimate borrowers. Second, financial institutions are unable to completely pledge the assets they hold on their balance sheets as collateral to raise funds from outside investors. This means that creditors limit the extent of their funding for banks, and bankers are able to extract rents, in the form of incentive payments, which drive a wedge between the returns earned by savers, and the costs incurred by borrowers. Third, we assume that the shadow banking system is economically valuable because, by transforming illiquid loans into tradeable assets, securitization allows collateral to be used more efficiently.[5] Finally, and in line with much actual experience, we assume that commercial banks transfer aggregate risk to the shadow banking system (such transfers may be complete or partial), but risk is not transferred to unlevered investors outside of the intermediary sector. Shin's "hot potato" remains inside the financial system (Shin 2009).[6]

The remainder of this section details the behavior of each of the five types of agent in our model: banks and shadow banks, which we will also refer to as "brokers" for short, households, good-producing firms, and capital-producing firms.

2.1 *The Financial System*

The financial system is composed of two types of financial intermediary, commercial banks and shadow banks. As is explained in this section, the distinction between a bank and a shadow bank lies in the separate economic roles that each play in the model. Although banks specialize in originating loans, brokers have a comparative advantage in holding them. To fund itself, the shadow banking system produces ABS, which, in turn, find a market among commercial banks eager to expand their balance sheets by acquiring high-quality collateral. Crucially, both banks and brokers face financial constraints. The economic separation we introduce between banks and brokers mirrors institutional arrangements that restrict transactions between depository institutions and affiliates, such as brokerage firms, under the Federal Reserve Act in the United States.[7]

A stylized picture of the aggregate steady-state balance sheets of the principal actors in the financial system is given in Figure 2. Firms are the economy's ultimate borrowers. They are able to finance their holdings of capital K by selling a single type of primary claim S^f, which we think of as a loan, to the commercial banking system.

5. By assumption, securitization augments net aggregate liquidity, since all proceeds are effectively recycled into real investments, see Holmström and Tirole (2011). Pozsar et al. (2010) detail economic drivers, such as gains from specialization and comparative cost advantages over traditional banks, behind growth in shadow banking. They also identify forms of shadow banking that had little economic value and that were driven primarily by regulatory arbitrage.

6. Our characterization of systematic risk being retained in the financial system was more true for some types of shadow banking activity than others. For example, Acharya, Schnabl, and Suarez (2013) present evidence that risk from conduits funded by asset-backed commercial paper remained with banks, rather than being borne by outside investors, during the 2007–09 crisis. But as is well known, many "real money" investors also lost money on securitization-related securities.

7. In particular, that depository institutions may not use deposits to fund broker subsidiaries, see Section 23A and 23B of the Act.

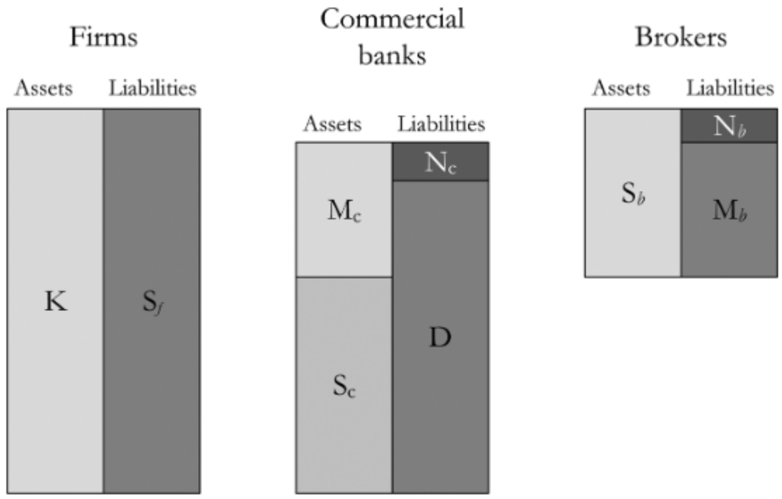

FIG. 2. Aggregate Balance Sheet Positions of Firms, Banks, and Brokers.

NOTES: A stylized representation of sectoral balance sheets in the steady-state equilibrium. For each sector: height of LH column represents assets; height of RH column represents liabilities. Key: K = aggregate physical capital; S = primary securities (bank loans); N = aggregate net worth; M = aggregate asset-backed securities; D = aggregate commercial bank deposits. A subscript c denotes commercial bank; a subscript b denotes a broker, or shadow bank; a subscript f denotes a nonfinancial firm.

Commercial banks hold a portion of the total loan stock S^c on their balance sheet. As in the traditional commercial banking model, they finance themselves through a combination of inside equity N^c, and a single class of debt D held by households. However, in our economy, commercial banks are able to use a secondary loan market to move some of the loans that they originate off their balance sheets. The loan pools S^b that result from loan sales by commercial banks are held by brokers. Brokers finance themselves with inside equity N^b and through issuing ABS M^b, which, in turn, are held by commercial banks. The balance sheet relations hold as identities for each sector and, in equilibrium, the value of each sector's assets is matched exactly by the value of the other sectors' liabilities, and in particular $S^f = S^c + S^b$.[8]

Risk-sharing and risk-taking securitization. Shadow banks in our model retain the "equity" or "first loss" tranche of securitizations, financed by the net worth component of shadow bank liabilities (as shown in Figure 2). But the distribution of the remaining aggregate risk among shadow banks and investors in ABS depends crucially on the type of liabilities that shadow banks issue. We allow for two possibilities. First, ABS may offer "pass-through" exposure to an underlying collateral pool.[9] As well as being the simplest form of securitization, pass-through has historically been

8. Ours is a simplified version of the financial sector accounting framework presented by Shin (2009).

9. The key features of pass-through securitization are that the underlying assets are transferred off the balance sheet of the originator, and investors have a claim on the cash flows from the pool, after servicing fees.

the predominant mode of financing for large classes of securitized assets, such as mortgages, in the United States. In the pass-through case, the returns on ABS are contingent on the cash flows on the underlying loan pools, and aggregate risk is shared between investors in ABS and shadow banks. We refer to this as the "risk-sharing" model of shadow banking.

The second possibility is that ABS represent fixed (noncontingent) claims. Some argue that the financial sector's drive to produce apparently safe debt-like securities in the run-up to the subprime crisis hinged on strong portfolio preferences for such assets by large institutional cash pools (Pozsar 2011, Gorton and Metrick 2012b) and by foreign creditors (Bernanke 2011). Others argue that regulation provided the incentive for commercial banks to hold highly rated securitized assets rather than loans by offering capital relief on the former, so-called regulatory arbitrage (Acharya and Richardson 2009). The idea of shadow banks taking on "bank like" risk, in the sense that they perform both credit and maturity transformation, is formalized by having brokers issue one-period discount bonds that promise a fixed return. We refer to this as the "risk-taking" model of shadow banking. In what follows, we allow shadow banks to issue both pass-through and debt-like ABS, and infer the composition of ABS portfolios from the data (see Section 3.2).

Commercial banks. The economy is populated by many competitive commercial banks, which are owned and managed by household members called bankers. By virtue of their ability to costlessly enforce repayments by borrowers, bankers alone originate loans. However, banks also face an agency problem that means they cannot pledge the entire value of their investments to creditors. As a result, the amount of external funding that a bank is able to raise is limited. A shortage of pledgeable income is the source of financial frictions in the economy. Following Gertler and Karadi (2011) and Gertler and Kiyotaki (2011), we make a set of assumptions to ensure financial constraints bind in equilibrium, and to facilitate aggregation.

As well as originating loans, banks can bundle loans together and sell them in a secondary market. Bundling is valuable because it helps banks to overcome an adverse selection problem when they come to sell the loans. Suppose the relationship between the primary lender and the borrower is such that private information on loan quality is unavoidably produced. This private information cannot be credibly communicated to outsiders. In such a case, no secondary creditor is willing to purchase an individual claim in the secondary market, as they will suspect that only the least sound claims will be sold. By destroying private information, bundling assures a secondary creditor that the loans she is purchasing are a "fair mix, not just lemons."[10] In our case, secondary creditors are shadow banks; their loan purchase decisions are discussed below.

10. See Kiyotaki and Moore 2005, p. 705; the idea that the purpose of bundling is to destroy private information is also found in DeMarzo (2005). In general, private information may exist on either the side of the seller or of the buyer. DeMarzo considers the case of sellers who specialize in originating and marketing assets, but do not have a comparative advantage in valuing or holding them. Pooling reduces the ability of sophisticated buyers, such as specialist brokers, to cherry-pick assets. As we abstract from idiosyncratic risk, the bundling technology itself is trivial.

Commercial banks use the cash raised from loan sales to acquire ABS issued by shadow banks. Their asset portfolio therefore consists of a mix of loans and ABS, and is financed by one period external debt ("deposits") and inside equity.[11] The balance sheet identity of an individual commercial bank (mnemonic c) at the end of period t is given by

$$Q_t s_t^c + m_t^c = d_t + n_t^c, \tag{1}$$

where

$$m_t^c := q_t m_t^{\mathrm{PT},c} + m_t^{\mathrm{D},c}$$

is the total value of the portfolio of pass-through (PT) and debt-like (D) ABS held by the bank; q_t is the market price of pass-through ABS; Q_t is the price of a primary claim on a firm; and other lower case symbols represent the individual-level counterparts to the aggregate amounts described above.[12] Note that, in general, q_t is different from Q_t, since ABS investors are partly protected by shadow bank equity.

A bank's end of period net worth is determined by the accumulation of its retained earnings.[13] Its earnings are generated from the interest rate spread it can earn on its assets, compared to its liabilities (equity is held internally, so carries no charge):

$$\begin{aligned} n_t^c &= R_{st} Q_{t-1} s_{t-1}^c + R_{mt}^{\mathrm{PT}} q_{t-1} m_{t-1}^{\mathrm{PT},c} + R_{mt}^{\mathrm{D}} m_{t-1}^{\mathrm{D},c} - R_t d_{t-1} \\ &= R_{st} Q_{t-1} s_{t-1}^c + \left[\eta_{t-1}^c R_{mt}^{\mathrm{PT}} + \left(1 - \eta_{t-1}^c\right) R_{mt}^{\mathrm{D}}\right] m_{t-1}^c - R_t d_{t-1}, \end{aligned}$$

where $\eta_t^c := q_t m_t^{\mathrm{PT},c} / m_t^c$ is defined as the share of pass-through ABS in the bank's portfolio, the returns on loans is R_{st}, the deposit rate is R_t, $R_{m,t+1}^{\mathrm{PT}}$ is the return on pass-through ABS, and $R_{m,t+1}^{\mathrm{D}}$ is the return on debt-like ABS.

It follows that the return on the bank's portfolio of ABS is[14]

$$R_{mt} = \eta_{t-1}^c R_{mt}^{\mathrm{PT}} + \left(1 - \eta_{t-1}^c\right) R_{mt}^{\mathrm{D}}, \tag{2}$$

and so using this, along with the balance sheet identity equation (1) to substitute out ABS holdings, the law of motion for the net worth of a commercial bank becomes:

$$n_t^c = (R_{st} - R_{mt}) Q_{t-1} s_{t-1}^c + (R_{mt} - R_t) d_{t-1} + R_{mt} n_{t-1}^c. \tag{3}$$

11. It is best to think of banks issuing deposits to households other than their home household, and purchasing ABS from shadow banks other than those owned by their home household.

12. Note that balance sheets are always valued at market prices, or "marked to market."

13. As the bank does not raise new equity or make payouts except upon entry and exit (respectively), its net worth moves only sluggishly. This is in line with evidence presented by Adrian and Shin (2010) that growth in the balance sheets of large market-based banks, in particular, has historically been associated with growth in leverage.

14. In a slight abuse of notation, we omit the c superscript from R_{mt}; it is plain enough that the returns earned by commercial banks on ABS assets, and those paid by shadow banks on ABS liabilities, must be equated.

The value of a commercial bank as a going concern is the present discounted value of its net worth. Because bankers are members of households, and households are symmetric, risky cash flows to be received between any future dates $\{\tau_1, \tau_2\}$ are discounted by the representative household's stochastic discount factor Λ_{τ_1,τ_2}. We employ a standard device to ensure that banks remain credit constrained. Each period, bankers are replaced by new management with exogenous probability $1-\sigma$, and remain in place with probability σ. Since banks face credit constraints, it is optimal for bankers to defer payouts for as long as possible, that is, until they receive an exit signal. If bankers receive an exit signal, it is at the start of the period, after any aggregate shocks are realized. Upon exit they repay depositors, and pay out the residual net worth of the bank to the home household. The value of the bank at the end of period $t-1$ is then given by

$$V_{t-1}^{c} = \mathrm{E}_{t-1}\Lambda_{t-1,t}\left[(1-\sigma)n_t^c + \sigma V_t^c\right]. \tag{4}$$

Bankers face an endogenous limit on the amount of external finance made available by creditors. As in Gertler and Karadi (2011) and Gertler and Kiyotaki (2011), we assume that between adjacent time periods, the banker has an opportunity to obtain a private benefit from the assets under her control. This idea is captured by allowing bankers to transfer (synonymously, "divert") a fraction of bank assets to the home household, leaving it unable to meet its obligations. Incentive compatibility requires that the value of the enterprise as a going concern should exceed the value of divertible assets, which we take to be a weighted fraction of the bank's end of period balance sheet value, as shown in equation (5), where an asset's weight is inversely related to its collateral value.

The key assumption underpinning the existence of a shadow banking system is that commercial bank creditors regard on balance sheet loans as less good collateral than ABS. This differentiation in collateral quality is captured by allowing bankers to divert more balance sheet loans than ABS. Formally, we allow portfolios of ABS to carry a weight in the incentive constraint that is a factor of $(1-\omega_c)$ lower than the weight on loans:

$$V_t^c \geq \theta_c\left(Q_t s_t^c + [1-\omega_c]m_t^c\right), \tag{5}$$

where $\{\theta_c, \omega_c\} \in [0, 1]$, and ABS becomes perfectly pledgeable as $\omega_c \to 1$.[15] The effect of switching a marginal unit of funds from loans into ABS is to reduce divertible assets by $\theta_c\omega_c$, loosening the bank's external finance constraint. In the absence of strong reasons to think otherwise, we take pass-through and debt-like ABS to be equally divertible, and so as they carry equal weight in equation (5), the mix between loans and total ABS pins down the amount of divertible assets.

The motivation behind equation (5) is that although loans held by banks are opaque and idiosyncratic, ABS are standardized, tradeable, and backed by broad pools of collateral. A suggestive piece of supporting evidence for the proposition that banks

15. We consider the effect of a shock to the pledgeability of ABS in Section 3.3.

demand ABS for its collateral value comes from the change in bankruptcy provisions discussed in Perotti (2010). Between 1998 and 2005, a series of amendments to bankruptcy laws in the United States and European Union led to exemptions from bankruptcy stays for all secured financial credit used in repurchase agreements. This change greatly enhanced the value of such assets as collateral to banks wishing to raise short-term secured funding, and banks' holdings of securitized assets boomed.[16]

The banker's objective is to maximize the value of the enterprise, given in equation (4), subject to the incentive constraint, equation (5), through choice of asset portfolio $\{Q_t s_t^c, m_t^c, \eta_t^c\}$. The commercial bank's value function is linear in $\{\upsilon_{st}^c, \upsilon_{mt}^{\mathrm{PT},c}, \upsilon_{mt}^{\mathrm{D},c}, \upsilon_t^c\}$, which give the marginal value of each balance sheet item at each point in time. (Appendix A in the Supporting Information establishes the linearity of the value function.) Defining the excess value of loans over each type of ABS as $\mu_{st}^c := (\upsilon_{st}^c/Q_t - \upsilon_{mt}^{\mathrm{D},c})$ and $\mu_{mt}^c := (\upsilon_{mt}^{\mathrm{PT},c}/q_t - \upsilon_{mt}^{\mathrm{D},c})$, respectively, we may write the value function as

$$V_t^c = \left[\mu_{st}^c - \eta_t^c \mu_{mt}^c\right] Q_t s_t^c + \left[\left(\upsilon_{mt}^{\mathrm{D},c} - \upsilon_t^c\right) + \eta_t^c \mu_{mt}^c\right] d_t + \left[\mu_{mt}^c \eta_t^c + \upsilon_{mt}^{\mathrm{D},c}\right] n_t^c. \quad (6)$$

Let λ_t^c be the multiplier on the constraint given by equation (5). The first-order necessary conditions for optimal $\{s_t^c, \eta_t^c, d_t, \lambda_t^c\}$ are:

$$\mu_{st}^c - \eta_t^c \mu_{mt}^c = \theta_c \omega_c \frac{\lambda_t^c}{1+\lambda_t^c}, \quad (7a)$$

$$0 = \mu_{mt}^c \left(1 + \lambda_t^c\right) \left(Q_t s_t^c + d_t + n_t^c\right), \quad (7b)$$

$$\upsilon_{mt}^{\mathrm{D},c} - \upsilon_t^c = \theta_c (1 - \omega_c) \frac{\lambda_t^c}{1+\lambda_t^c}, \quad (7c)$$

$$\begin{aligned} 0 &= \left(\mu_{st}^c - \eta_t^c \mu_{mt}^c - \theta_c \omega_c\right) Q_t s_t^c + \left(\upsilon_{mt}^{\mathrm{D},c} - \upsilon_t^c + \eta_t^c \mu_{mt}^c - \theta_c[1 - \omega_c]\right) d_t \\ &\quad + \left(\upsilon_{mt}^{\mathrm{D},c} + \eta_t^c \mu_{mt}^c - \theta_c[1 - \omega_c]\right) n_t^c, \end{aligned} \quad (7d)$$

at an interior optimum.

It is immediate from equation (7b) that $\mu_{mt}^c = 0$, as the terms in parentheses are strictly positive. Intuitively, as pass-through and debt-like ABS are equally liquid, their marginal values are also equal. With this in mind, we can then combine equations (1) and (7d), using equations (7a) and (7c) to eliminate terms, to yield the bank's ABS demand function:

$$m_t^c = \frac{1}{\omega_c} d_t - \left\{ \frac{\upsilon_{st}^c / Q_t - \theta_c}{\theta_c \omega_c - \mu_{st}^c} \right\} n_t^c. \quad (8)$$

16. According to the Flow of Funds of the United States, commercial bank holdings of all types of mortgage-backed securities (MBS) doubled from $600 billion in 1998 to more than $1.3 trillion in 2005. Note that the exemptions for Treasury and Government-Sponsored Enterprise (GSE) securities predate the wider secured financial credit exemptions discussed here. A downside to these legal changes noted by Perotti is that strong creditor protection weakens monitoring incentives, and facilitates risk shifting.

Away from corners, the demand for ABS is decreasing in net worth and increasing in deposits. Dividing equation (8) through by total funding $d_t + n_t^c$, we see that a higher proportion of equity funding increases the capacity of the bank to hold loans on balance sheet, and so reduces its desire to hold ABS. On the other hand, a higher share of debt funding tightens the bank's incentive constraint, so it seeks out pledgeable collateral.

As the shadow value of net worth is of particular importance, let us provide some intuition for it. The Lagrange multiplier on the incentive constraint in the static maximization of equation (6) subject to equation (5) is

$$\lambda_t^c = \frac{\mu_{st}^c}{\theta_c \omega_c - \mu_{st}^c} \tag{9}$$

at interior optima. The multiplier indicates the effect of relaxing the constraint by a marginal unit. Every dollar can be leveraged into additional loans of $1/(\theta_c\omega_c - \mu_{st}^c) > 1$ dollars, which raises firm value by μ_{st}^c per unit. The multiplier therefore tells us the relative attractiveness of direct versus indirect asset holdings. When the multiplier is large, we are being told that on balance sheet loans are relatively much more valuable than securitized loans, but that the bank is unable to hold more loans without violating the incentive constraint.

To understand the shadow value of an additional unit of net worth, notice first that the marginal unit relaxes the incentive constraint of the bank by $\upsilon_{st}^c/Q_t - \theta_c$. (As net worth enters both the objective and constraint functions, a unit increase does not translate into a unit relaxation of the constraint). The banker will exit and consume her net worth with probability $(1 - \sigma)$. She will continue with probability σ, in which case an additional dollar of net worth directly raises the value of the bank by υ_{st}^c/Q_t (since internal equity carries no charge). By relaxing the constraint, the extra net worth also permits a leveraged increase in loans that raises the bank's going concern value by λ_t^c. The sum of these effects equals the expected value of a unit of bank net worth at the end of period t:

$$\Omega_t^c := (1 - \sigma) + \sigma \left\{ \upsilon_{st}^c/Q_t + \lambda_t^c \left(\upsilon_{st}^c/Q_t - \theta_c \right) \right\}. \tag{10}$$

Finally, by substituting equations (7a)–(7d) into the commercial bank Bellman equation, the time-varying coefficients in equation (6) can be found to be discounted expected returns on loans, the two types of ABS and deposits:

$$\mu_{st}^c = \mathrm{E}_t \Lambda_{t,t+1} \Omega_{t+1}^c \left(R_{s,t+1} - R_{m,t+1} \right), \tag{11a}$$

$$\mu_{mt}^c = \mathrm{E}_t \Lambda_{t,t+1} \Omega_{t+1}^c \left(R_{m,t+1}^{\mathrm{PT}} - R_{m,t+1}^{\mathrm{D}} \right), \tag{11b}$$

$$\upsilon_t^c = \mathrm{E}_t \Lambda_{t,t+1} \Omega_{t+1}^c R_{t+1}, \tag{11c}$$

$$v_{mt}^{\mathrm{D},c} = \mathrm{E}_t \Lambda_{t,t+1} \Omega_{t+1}^c R_{m,t+1}^{\mathrm{D}}, \tag{11d}$$

where the discount factor is seen to depend on Ω_{t+1}^c, the tightness of the bank's incentive constraint (see Appendix A in the Supporting Information for a statement of the solution method).

Shadow banks. There are many competitive shadow banks or "brokerage" firms, each owned and managed by household members called brokers. They hold loan pools composed of primary security bundles acquired from many originating commercial banks (other than the banks owned by their home household), financed by a combination of inside equity and ABS. In our model, securitized assets are held within the financial system, rather than being distributed to unlevered investors (households, in our model). As a result, aggregate risk is concentrated on the balance sheets of financial intermediaries. This idea is also present in the model of Gennaioli, Shleifer, and Vishny (2013), and the mechanisms by which financial institutions affected such concentration in the buildup to the subprime crisis are discussed in Acharya and Schnabl (2009).

The balance sheet identity of an individual broker (mnemonic b) at the end of period t is given by:

$$Q_t s_t^b = m_t^b + n_t^b, \tag{12}$$

where $m_t^b := q_t m_t^{\mathrm{PT},b} + m_t^{\mathrm{D},b}$ is the value of outstanding ABS in issue. A broker's internal equity is the accumulation of earnings retained from their securitization activities:

$$\begin{aligned} n_t^b &= R_{st} Q_{t-1} s_{t-1}^b - R_{mt}^{\mathrm{PT}} q_{t-1} m_{t-1}^{\mathrm{PT},b} - R_{mt}^{\mathrm{D}} m_{t-1}^{\mathrm{D},b} \\ &= (R_{st} - R_{mt}) m_{t-1}^b + R_{st} n_{t-1}^b \end{aligned} \tag{13}$$

with $R_m := \eta_t^b R_{mt}^{\mathrm{PT}} + (1 - \eta_t^b) R_{mt}^{\mathrm{D}}$ analogous to equation (2). We take securitization to be "frictionless" in the sense that loan bundles may move freely in and out of securitization pools. As a consequence, the prices of primary and secondary market loans are equalized.[17]

Brokers face the same random probability $1 - \sigma$ of being replaced by new management as do banks. As banks and brokers have identical exit rates and ownership

17. This assumption can be relaxed by introducing a bundling friction along the lines of Kiyotaki and Moore (2005). Formally, this is achieved by having a class of agents who purchase loans from banks, bundle them using a costly technology, and sell the bundles on to brokers in a competitive market. A wedge is then introduced between the price of an on balance sheet loan, and the price of a secondary market loan. However, the main dynamics of the model are little affected by introducing this friction; therefore, we omit it in the interests of parsimony.

structure, there are no differences between institutions because of impatience or risk aversion. The going concern value of the shadow bank is therefore

$$V_{t-1}^{b} = \mathrm{E}_{t-1}\Lambda_{t-1,t}\left[(1-\sigma)n_t^b + \sigma V_t^b\right].$$

As with commercial banks, brokers are able to transfer a fraction of assets under their control to the home household, which gives rise to an endogenous financing constraint. The main point of departure is that although commercial bank creditors are households, broker creditors are themselves financial institutions. It is reasonable to suppose that banks possess superior ability to monitor the quality of collateral held by brokers, and that the diversification inherent in creating a securitization pool itself enhances the pledgeability of broker balance sheets.[18] Both considerations lead to the presumption that the fraction of divertible assets be no higher for brokers than it is for banks. Shadow banks may then be regarded as the natural holders of bundled assets.

The broker's incentive constraint says that the going concern value of the enterprise should exceed a fraction θ_b of the value of the balance sheet the broker can divert:[19]

$$V_t^b \geq \theta_b\left(m_t^b + n_t^b\right), \tag{14}$$

and we will take it that $\theta_b < \theta_c$.

The broker's value function is linear in $\{v_{st}^b, v_{mt}^{\mathrm{PT},b}, v_{mt}^{\mathrm{D},b}\}$, which give the marginal values of each balance sheet item at each point in time. Define the excess values $\mu_{st}^b := v_{st}^b/Q_t - v_{mt}^{\mathrm{D},b}$ and $\mu_{mt}^b := v_{mt}^{\mathrm{PT},b}/q_t - v_{mt}^{\mathrm{D},b}$; then:

$$V_t^b = \left(\mu_{st}^b - \eta_t^b\mu_{mt}^b\right)m_t^b + \left(v_{st}^b/Q_t\right)n_t^b. \tag{15}$$

Let λ_t^b be the multiplier on the constraint given by equation (14). The first-order necessary conditions for $\{m_t^b, \eta_t^b, \lambda_t^b\}$ are:

$$\mu_{st}^b - \eta_t^b\mu_{mt}^b = \theta_b\tfrac{\lambda_t^b}{1+\lambda_t^b}, \tag{16a}$$

$$0 = \left(1+\lambda_t^b\right)\mu_{mt}^b m_t^b, \tag{16b}$$

$$0 = \left(\mu_{st}^b - \eta_t^b\mu_{mt}^b - \theta_b\right)m_t^b + \left(v_{st}^b/Q_t - \theta_b\right)n_t^b. \tag{16c}$$

It is immediate from equation (16b) that whenever the shadow bank issues ABS, $\mu_{mt}^b = 0$, and as a consequence, we have $v_{mt}^{\mathrm{PT},b}/q_t = v_{mt}^{\mathrm{D},b}$. With the condition $\mu_{mt}^b = 0$ in mind, we may rearrange equation (16c) to find the ABS supply function:

$$m_t^b = \frac{v_{st}^b/Q_t - \theta_b}{\theta_b - \mu_{st}^b}n_t^b. \tag{17}$$

18. The idea that diversification creates pledgeable income is explored in Tirole (2006, Chapter 4.2).

19. We consider the effect of a shock to the pledgeability of shadow bank assets in Section 3.3.

The expression shows that the supply of high-quality collateral depends on the financial condition of brokers. The term multiplying n_t^b on the right-hand side is the broker's leverage ratio minus unity. As their leverage is typically much larger than unity, ABS supply will be highly sensitive to changes in broker net worth.

The shadow value of broker net worth can be understood as follows. Whenever the broker is operational, $s_t^b > 0$, the Lagrange multiplier on the incentive constraint, equation (14), is

$$\lambda_t^b = \frac{\mu_{st}^b}{\theta_b - \mu_{st}^b}. \tag{18}$$

This tells us that the shadow value of a unit relaxation in the constraint is the leveraged increase in loans held $1/(\theta_b - \mu_{st}^b)$ multiplied by their value μ_{st}^b. To understand the expected value of a marginal unit of net worth at the end of period t, recall that it is consumed with probability $(1 - \sigma)$. Otherwise, with probability σ, the broker's constraint is relaxed by $v_{st}^b/Q_t - \theta_b$, which raises its value by λ_t^b times as much. There is a direct benefit of v_{st}^b/Q_t (since equity carries no charge), with the total increase in value being the sum of these effects:

$$\Omega_t^b := (1 - \sigma) + \sigma \left\{ v_{st}^b/Q_t + \lambda_t^b \left(v_{st}^b/Q_t - \theta_b \right) \right\}. \tag{19}$$

After plugging the first-order conditions into the broker's Bellman equation, the coefficients of the value function are found to be equal to the discounted expected returns on loan pools and ABS:

$$v_{st}^b/Q_t = \mathrm{E}_t \Lambda_{t,t+1} \Omega_{t+1}^b R_{s,t+1}, \tag{20a}$$

$$\mu_{st}^b = \mathrm{E}_t \Lambda_{t,t+1} \Omega_{t+1}^b \left(R_{s,t+1} - R_{m,t+1} \right), \tag{20b}$$

$$\mu_{mt}^b = \mathrm{E}_t \Lambda_{t,t+1} \Omega_{t+1}^b \left(R_{m,t+1}^{\mathrm{PT}} - R_{m,t+1}^{\mathrm{D}} \right), \tag{20c}$$

where similar to the commercial bank case, the effective discount factor depends on the tightness of the broker's incentive constraint through Ω_{t+1}^b.

2.2 *Equilibrium in the Asset-Backed Security Market*

Commercial banks and brokers trade in secondary markets for loans and in the market for ABS. We take it that securities markets always clear. In particular, the potential for an endogenous breakdown in the market for securitized assets, because of dynamic strategic complementarities or insufficient financial muscle, is not addressed in this paper (see, e.g., the papers referenced in Tirole 2011). As a prelude to the general equilibrium analysis of Section 3, the current section analyzes the behavior of the ABS market in isolation.

A graphical illustration of partial equilibrium in the ABS market is given in Figure 3. It takes as given intermediary net worth and the supply of funds by

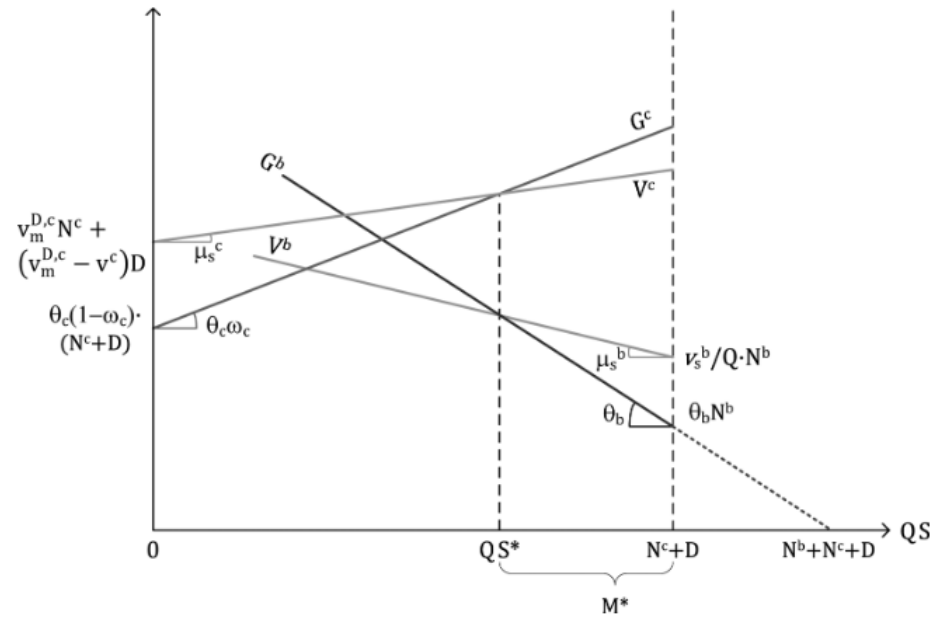

Fig. 3. ABS Market Partial Equilibrium.

Notes: A stylized representation of partial equilibrium in the ABS market, assuming N^c, N^b, and D are given. The vertical axis gives the going concern value V^τ and amount of divertible assets G^τ for each intermediary type. The horizontal axis gives loan holdings. Commercial bank loan holdings are read left-to-right, starting at the origin. Shadow bank loan holdings are read right-to-left, starting at $N^b + N^c + D$. The amount of securitized assets in issue is labeled M, and is the difference between shadow bank loan holdings and equity N^b.

households. On the horizontal axis, we measure asset amounts. We read from left to right to determine the on balance sheet loans of commercial banks, starting from 0; and from right to left to determine the holdings of loan pools by brokers, starting from $N^b + N^c + D$. The vertical axis registers the going concern value (V^τ) and the value of divertible assets (G^τ) for each institution type $\tau \in \{c, b\}$.

We start by asking what asset mix commercial banks would choose. As loans yield more than ABS, the commercial bank can always increase its value by switching from ABS into loans. However, ABS are less divertible than on balance sheet loans. The effect of switching a marginal unit of funds from ABS to loans is to tighten the incentive constraint by $\mu_s^c - \theta_c\omega_c$. The intersection of the V^c and G^c schedules gives the portfolio equilibrium condition, where the bank's incentive constraint is just binding. An amount QS^* of loans is held on balance sheet. The balance sheet identity implies that banks' demand for ABS is equal to the length of the interval $N^c + D - QS^*$.

Brokers mirror commercial banks in the figure. At the point $N^c + D$, brokers hold an amount N^b of loan pools. As we move leftward along the horizontal axis, they acquire additional loans by issuing ABS. As their balance sheet expands, each additional unit of loans purchased tightens their incentive constraint by $\mu_s^b - \theta_b$. The point at which the V^b and G^b schedules intersect determines the maximum size of the shadow bank sector. Total ABS issuance is given by M^*, which by the balance sheet identity determines their demand for loan bundles. (We need only consider total ABS issuance, since the two types are equally divertible.) Total intermediation in the economy, equal to the aggregate amount of loans held by commercial and shadow banks, is given by the length of the interval $[0, N^b + N^c + D]$.

In equilibrium, commercial bank demand for ABS must be met by supply from shadow banks. From any initial position of disequilibrium, the loan-ABS spread adjusts to clear the market. For example, taking loan returns and net worth as given, an excess demand for ABS is met with a decline in ABS yields that raises the spread, reducing bank demand (by making on balance sheet loans relatively attractive) and increasing broker supply (by relaxing their funding constraint).

2.3 *Households and Production*

The nonfinancial sectors of the economy closely resemble those of a standard DSGE model. There is a continuum of identical households, each composed of a contingent of workers, bankers, and brokers. Each household member consumes a final good (c_t) and enjoys perfect consumption insurance with the other household members. In every period, a fixed proportion of householders are assigned to act as bankers or brokers, whereupon they manage their respective financial institutions until exiting the industry at random (see sections "Risk-sharing and risk-taking securitization" and "Commercial banks"). Meanwhile workers sell a single type of labor (l_t) to goods producers, and likewise remit their wages (W_t) back to the household unit.

Our specification for household preferences follows Gertler, Kiyotaki, and Queralto (2012), and allows for internal habit persistence:

$$U_0 = \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t), \qquad u(c_t, l_t) = \ln\left\{(c_t - hc_{t-1}) - \frac{\chi}{1+\varphi} l_t^{1+\varphi}\right\}. \tag{21}$$

To effect transfers of resources across time, households acquire fixed (noncontingent) claims on commercial banks, called "deposits" for short.[20] Deposits promise to pay a gross interest rate R_t, which is known in advance. All household claims on firms, and therefore on the capital stock, are held indirectly through the financial system either as deposits, or as equity stakes in financial institutions that they manage. Finally, households may earn profits through their ownership of competitive capital goods producers (described below). They maximize equation (21) subject to the budget constraint:

$$c_t + d_t \leq W_t l_t + R_{t-1} d_{t-1} + \Pi_t - T_t,$$

where Π_t consists of nonlabor, noninterest income, and T_t are net government taxes (zero, except in Section 3.3).

20. All debt in our model can be thought of as collateralized. Fixed claims on commercial banks can be thought of as deposits, or as short-term secured funding such as repurchase agreements (repos).

Competitive firms employ labor and capital K_{t-1} to produce final goods Y_t, using identical constant returns technologies:

$$Y_t = e^{a_t} K_{t-1}^{\alpha} L_t^{1-\alpha}, \tag{22}$$

where a_t is the (logarithm) of total factor productivity (TFP), which follows an exogenous autoregressive process. Capital depreciates at a constant rate per period, such that:

$$K_t = I_t + (1-\delta)K_{t-1} \tag{23}$$

is the amount remaining at the end of period t. Firms must purchase capital from specialized producers prior to use. They finance their purchases by issuing primary market securities, which are claims on the cash flows generated by the asset. Following Gertler and Kiyotaki (2011), we assume that commercial banks are costlessly able to enforce payment on primary securities, and as a result, there are no financing frictions between firms and banks.

Competitive capital producers transform final goods into new capital goods, which they sell to final goods firms. As in Christiano, Eichenbaum, and Evans (2005), there are increasing convex costs $f(I_t/I_{t-1})$ to adjusting the rate of investment.[21] The adjustment cost function satisfies $f(1) = f'(1) = 0$ and the inverse elasticity of investment is defined by $\varepsilon := f''(1) > 0$. Capital producers maximize profits by equating the price of new capital goods Q_t with their marginal cost, which gives rise to an upward-sloping supply function:

$$Q_t = 1 + f\left(\frac{I_t}{I_{t-1}}\right) + \left(\frac{I_t}{I_{t-1}}\right) f'\left(\frac{I_t}{I_{t-1}}\right) - \mathrm{E}_t \Lambda_{t,t+1} \left(\frac{I_{t+1}}{I_t}\right)^2 f'\left(\frac{I_{t+1}}{I_t}\right). \tag{24}$$

As is standard, this specification guarantees that the deterministic steady state of the economy (the steady state in which exogenous shocks have zero variance) is independent of ε, while first-order dynamics depend on this parameter alone.

Letting Z_t denote the marginal product of capital, we may define the return on primary securities as

$$R_{st} = \frac{Z_t + (1-\delta)Q_t}{Q_{t-1}}. \tag{25}$$

Finally, returns on pass-through ABS depend on the cash flows from the underlying assets held by shadow banks according to:

$$R_{mt}^{\mathrm{PT}} = \frac{Z_t + (1-\delta)\, q_t}{q_{t-1}}. \tag{26}$$

21. These authors argue that second-order costs to adjusting investment enable the model to better account for observed investment and output dynamics than does a first-order adjustment cost specification.

2.4 Aggregation, Market Clearing, and Competitive Equilibrium

To find aggregate intermediary net worth, we sum across the mass σ of continuing and $1-\sigma$ of entering financiers. The net worth of continuing intermediaries at time t consists of the net earnings on their accumulated stocks of assets. Assume that households supply a fraction ξ_τ of the total assets of each intermediary type $\tau \in \{c, b\}$ to new financiers of each type, each period. Then, the laws of motion for traditional and shadow bank net worth, including total net transfers from households, are, respectively,

$$N_t^c = (\sigma + \xi_c)\left\{R_{st} Q_{t-1} S_{t-1}^c + R_{mt} M_{t-1}^c\right\} - \sigma R_t D_{t-1}, \tag{27}$$

$$N_t^b = (\sigma + \xi_b)\, R_{st} Q_{t-1} S_{t-1}^b - \sigma R_{mt} M_{t-1}^b. \tag{28}$$

The model is closed with market clearing conditions for primary securities, ABS, deposits, and labor. The primary securities markets clear when total demand from traditional and shadow banks is equal to total issuance by firms:

$$S_t^c + S_t^b = K_t. \tag{29}$$

Clearing in the ABS market similarly occurs when total demand by banks and total supply by brokers are equated:

$$M_t^c = M_t^b \tag{30}$$

with identical shares of pass-through ABS:

$$\eta_t^c = \eta_t^b.$$

Total deposits are given by the balance sheet identity of commercial and shadow banks as the residual funding requirement, given intermediary equity:

$$D_t = Q_t\left(S_t^c + S_t^b\right) - \left(N_t^c + N_t^b\right). \tag{31}$$

Aggregate labor supply is given by

$$W_t u_{c,t} = \chi L_t^{\varphi}\left[(C_t - hC_{t-1}) - \chi \frac{1}{1+\varphi} L_t^{1+\varphi}\right]^{-1}. \tag{32}$$

Finally, the aggregate resource constraint is

$$Y_t = C_t + \left[1 + f\left(\frac{I_t}{I_{t-1}}\right)\right] I_t. \tag{33}$$

The model has 33 endogenous variables, of which 9 are prices (Q_t, q_t, R_{st}, R_{mt}, R_{mt}^{PT}, R_{mt}^{D}, R_t, W_t, Z_t), 10 are shadow prices (Λ_t, λ_t^c, Ω_t^c, λ_t^b, Ω_t^b, μ_t^c, υ_{mt}^c, υ_t^c, μ_t^b, υ_{mt}^b), and 14 are quantities (Y_t, C_t, I_t, K_t, L_t, D_t, M_t^c, η_t^c, N_t^c, S_t^c, M_t^b, η_t^b, N_t^b, S_t^b), jointly determined by the 33 equations (B.1)–(B.33) given in Appendix B in the Supporting Information.

Steady-state return on ABS. For the case of a deterministic steady state, the return on ABS is given by the following intuitive result.

PROPOSITION 1 (Equilibrium ABS spread). *In deterministic steady state, the return on pass through (R_m^{PT}) and debt-like (R_m^D) varieties of ABS are equalized. Their common return R_m depends on the return on primary securities and the risk-free rate:*

$$R_m = (1 - \omega_c)R_s + \omega_c R,$$

where ω_c parameterizes the relative pledgeability of ABS. It follows immediately that the equilibrium ABS spread is related to the "gross financial wedge," $R_s - R$, by

$$R_m - R = (1 - \omega_c)(R_s - R),$$

that is, the ABS spread is decreasing in its pledgeability.

PROOF. See Appendix C in the Supporting Information. □

Proposition 1 gives some useful insights into the effect of changing ABS pledgeability. When ABS is no more pledgeable than on balance sheet loans, $\omega_c = 0$, then their returns are equalized, $R_s = R_m$. The intuition for this result is that if ABS has no collateral value, then commercial banks would sell it whenever $R_s > R_m$. That would have the effect of pushing down its price, and pushing up its return (commercial banks would not hold loans if $R_s < R_m$, and selling loans would push up their yield). If ABS can never be diverted, $\omega_c = 1$, and the return on ABS is the same as on a safe claim, $R_m = R$. Intuitively, if $R_m > R$, then commercial banks would earn a spread on every unit of ABS they acquired, and because ABS is not divertible, their creditors would permit them to purchase ABS without limit. The price of ABS is therefore driven up, and its yield is driven down, until $R_m = R$ (commercial banks would not hold ABS if $R_m < R$).

3. QUANTITATIVE ANALYSIS

We turn now to an analysis of the log-linear dynamics of our model economy around the deterministic steady state. Section 3.1 discusses how the main parameter values were chosen for numerical solutions. Section 3.2 analyzes the business cycle properties of the model, and explains how we use the data to pin down the extent of risk sharing within the financial system. Sections 3.3 and 3.4 analyze the effects of a securitization crisis, and the effectiveness of possible government responses, under the same calibration employed in Section 3.2.

TABLE 1

Parameter Values used in Simulations

Parameter	Value	Description
α	0.3	Share of capital in production
β	0.99	Household discount factor (quarterly)
δ	0.025	Capital depreciation rate (quarterly)
h	0.70	Habit persistence in consumption
χ	0.7276	Disutility of labor
φ	0.30	Inverse labor supply elasticity
ε	4.0	Elasticity of investment
ρ_a	1.0	Persistence of productivity shocks
σ	0.90	Survival probability for financiers
θ_b	0.1474	Divertibility of broker loans
ω_c	0.25	Relative divertibility of ABS
ξ_b	0.0095	Fraction of assets transferred to new brokers
θ_c	0.2599	Divertibility of bank loans
ξ_c	0.0154	Fraction of assets transferred to new banks

3.1 Calibration

Values for the parameters that we use when we simulate the model are given in Table 1. The parameters fall into two groups. The first group consists of eight parameters that govern key macroeconomic quantities familiar from other studies. The second group consists of six parameters specific to the financial system (with subscript b for shadow banks, and c for commercial banks). We choose parameters that allow the model to reproduce the main features of a financial system roughly comparable to that of the United States in the decade-and-a-half or so preceding the subprime crisis.

Among the macroeconomic parameters, we use conventional values for the discount factor β, the capital share α, and the depreciation rate δ. For the elasticity of investment ε, and households' degree of habit persistence h and labor supply elasticity φ, we adopt values taken from estimates readily available in the literature. Households' disutility of labor χ is set so that one-third of their time endowment is spent in work in steady state.[22]

Among the parameters specific to the financial system, we fix the per-period survival probability for bankers and brokers, σ, to generate a mean survival time of ten quarters (one could also think of this as a payout rate of 10%). We then calibrate the remaining five parameters $(\theta_c, \xi_c, \omega_c, \theta_b, \xi_b)$ to match the average values of five financial variables in steady state. These are the gross financial wedge $R_s - R$, the ABS spread $R_m - R$, the share of assets held in securitized form M/S^c, the loan to equity ratio of commercial banks S^c/N^c, and the asset to equity ratio of shadow banks S^b/N^b.

The steady-state risk-free rate is β^{-1} implying $R \approx 4.1\%$ per annum. We set the steady-state gross financial wedge $(R_s - R)$ to 100 basis points, which is roughly equal to the spread between the yields on good-quality long-term corporate and

22. Estimates of ρ_a are discussed in Appendix D.3 in the Supporting Information.

government bonds. The 2000–07 average ABS spread over comparable swap rates for high-quality securitizations varied from around seven basis points for credit card and auto receivables, to 25 basis points for large equipment and 70 basis points for nonconforming mortgages. We adopt a value of 25 basis points for the steady-state ABS spread ($R_m - R$) as most representative of the class of asset captured by the model. Using Proposition 1, it can be seen that the value of ω_c required to match this spread may be found by computing:

$$\omega_c = \frac{R_s - R_m}{R_s - R}.$$

The aggregate ratio of commercial bank loans to equity S^c/N^c is four times, which is close to the median ratio of total loans and leases to the sum of tiers 1 and 2 capital at commercial banks in the call report data.[23] We set the share of securitized assets M^c/S^c at 30%, based on call report data on bank assets sold and securitized. Together, these two ratios imply that the deposit-equity ratio $D/N^c = 4.2$. Using this information, the value of ξ_c may be set according to:

$$\xi_c = \frac{1 - \sigma R_m - \sigma(R_m - R)(D/N^c) - \sigma(R_s - R_m)(S^c/N^c)}{(R_s - R_m)(S^c/N^c) + R_m(1 + D/N^c)}.$$

We take a value of shadow banks' asset to equity ratio S^b/N^b of eight times, based on data on the leverage in MBS securitizations and flow of funds data on broker dealers.[24] The value for ξ_b may then be found from:

$$\xi_b = \frac{1 - \sigma R_m}{R_s}\frac{N^b}{S^b} - \sigma\frac{R_s - R_m}{R_s}.$$

Last, the asset divertibility parameters θ_c and θ_b may be found by computing:

$$\theta_c = \frac{\beta(1-\sigma)(R_s - R_m)}{\omega_c - \beta\sigma[R_m - (1-\omega_c)R_s](1+\lambda^c)}\frac{1+\lambda^c}{\lambda^c}, \tag{34}$$

$$\theta_b = \frac{\beta(1-\sigma)(R_s - R_m)}{(1 - \beta\sigma R_m) - \beta\sigma R_m\lambda^b}\frac{1+\lambda^b}{\lambda^b}, \tag{35}$$

23. Reports of Condition and Income ("Call Reports") are filed by U.S. regulated financial institutions on a quarterly basis, and are made available online by the Federal Deposit Insurance Corporation.

24. It is not straightforward to measure leverage for the shadow banking system as a whole for a number of reasons. Foremost is the diversity of institutional arrangements that come under the shadow banking umbrella. To get a sense for the range of values that could be adopted, some entities, such as ABCP (Asset Backed Commercial Paper) conduits, held effectively zero equity, as they had backup contingent credit lines from commercial banks (in the event that investors failed to roll over their holdings, see Acharya, Schnabl, and Suarez 2013). Others, such as securities brokers and dealers, had leverage ratios of 30 or 40 times, but as their name suggests much of their activity was not shadow banking. But restricting attention to credit market instruments, and computing net worth as total financial assets *less* total financial liabilities give a mean ratio for "real economy leverage" close to 6. Further discussion of the data used in calibration can be found in Appendix D in the Supporting Information.

TABLE 2
Steady-State Values

Variable	Value	Description
R	4.1%	Real interest rate (annual rate)
R_s	5.1%	Return on loans (annual rate)
R_m	4.35%	Return on ABS (annual rate)
S^c/N^c	4.0	Commercial bank loan-to-equity ratio
M^c/N^c	1.2	Commercial bank ABS-to-equity ratio
S^b/N^b	8.0	Shadow bank loan pool-to-equity (leverage) ratio
L	0.33	Labor hours
Y/K	0.125	Output-to-capital ratio
C/Y	0.8	Consumption-to-output ratio
I/Y	0.2	Investment-to-output ratio

where

$$\lambda^c = \beta(R_s - R_m)\left[\frac{S^c}{N^c} + \frac{1-\omega_c}{\omega_c}\left(1 + \frac{D}{N^c}\right)\right] \quad \text{and} \quad \lambda^b = \beta(R_s - R_m)\frac{S^b}{N^b},$$

which, given the values assigned to the financial ratios and yield spreads described above, implies $\theta_b < \theta_c$ as anticipated by the discussion in Section 2.1. The steady-state values of the model's principal financial and real variables are summarized in Table 2.

3.2 Traditional and Shadow Banking over the Business Cycle

In this section, we examine the ability of the model laid out in Section 2 to generate realistic business cycle comovements. We focus on two dimensions: the comovement between traditional and shadow bank credit, as shown in Figure 1; and that between separate credit aggregates and output. In evaluating our model along these dimensions, a difficulty must be overcome: Although correlations computed from the model condition upon a particular source of disturbance—those arising from shifts in total factor productivity–correlations computed from the data are unconditional.[25] We now describe an empirical approach that overcomes this difficulty, and extends previous results in the literature (see, inter alia, den Haan and Sterk 2010, Nelson, Pinter, and Theodoridis 2015).

To compute conditional correlations in the data, we assume that the total factor productivity series measured by Fernald (2012) is a good approximation to the economy's true underlying quarterly productivity growth rate, and treat it as exogenous. As standard unit root tests cannot reject the null that the levels series is a random walk, changes in Fernald's series are taken to be shocks to productivity (ν_t^a).[26] In

25. We condition on productivity shocks as, in the absence of nominal rigidities, they allow the model to reproduce the comovement of output, hours, investment, and consumption seen in the aggregate data.

26. Results from augmented Dickey–Fuller tests on the log-level TFP series are reported in Appendix D.3.

TABLE 3

CONDITIONAL AND UNCONDITIONAL OUTPUT-CREDIT CORRELATIONS

	Corr(S^c, S^b)	Corr(Y, S^c)	Corr(Y, S^b)
Data (unconditional)	−0.06	0.37	−0.29
	[−0.23,0.09]	[0.26,0.48]	[−0.38, −0.17]
Data (TFP)	−0.35	0.67	−0.30
	[−0.41, −0.26]	[0.51,0.74]	[−0.41, −0.23]
Model (TFP)	−0.35	0.96	−0.54

NOTE: The table compares sample correlation coefficients between year-on-year output (Y) growth, traditional bank loan (S^c) growth, and shadow bank loan (S^b) growth over the period 1990:1–2007:3 (all in real GDP-deflated terms). Row 1 reports the unconditional sample correlation computed from the VAR given by equation (D.1). Row 2 reports the sample correlation, conditioned on shocks from the Fernald TFP series. Row 3 reports the sample correlation between data series simulated from the model by feeding in shocks to measured total factor productivity taken from Fernald (2012), when the portfolio shares parameter $\eta = 0.701$. In rows 1 and 2, the numbers in brackets indicate the minimum and maximum point correlation estimates as the number of lags p in the VAR is varied from 1 through 5 (see Table D.2).
Data sources: Macroeconomic data are from the NIPA. See note to Figure 1 for definitions of credit aggregates and their sources.

order to summarize the conditional comovements in the data, we estimate a vector autoregression (VAR) over the period 1990:1–2007:3 that spans the precrisis securitization era. No identifying assumptions are required, as the shocks upon which the correlations are conditioned are given externally. The VAR includes the productivity shock and annual growth rates of real output, real traditional bank, and real shadow bank credit, such that the vector of modeled variables is $\mathbf{z}_t' = (\nu^a, g_Y, g_{S^c}, g_{S^b})_t$.[27] The conditional correlation between variables is then a function of the impulse responses of the endogenous variables in $\mathbf{z}_t$ to a change in productivity (Appendix D.3 provides details of our approach to computing conditional correlations from the VAR).

To obtain comparable conditional sample correlations from the model, we feed in the same sequence of observed productivity changes ν_t^a as used in the VAR, and calculate correlations between the growth rates of model variables corresponding to those in $\mathbf{z}_t$. Consistent with the arguments advanced in Section 2.1, we choose to take the share of pass-through securities in issue (η) as being determined by forces outside the model. In practical terms, the approach we take in the simulation exercise is to pin down the portfolio risk sharing parameter η so as to match the correlation between credit aggregates conditional on productivity disturbances.[28] We can then evaluate the model on the basis of its predictions for correlations between output and credit variables.

Table 3 summarizes the correlations computed from the data and the model. In the data, the conditional correlation between traditional and shadow bank credit is firmly negative at −0.35. This contrasts to the low unconditional correlation

27. Including the change in productivity as an endogenous variable in the VAR acknowledges the possibility that the series may be measured with error. However, our results do not change when ν_t^a is treated as an exogenous regressor. Further details on the VAR may be found in Appendix D.3.

28. An alternative approach to determining the portfolio share parameter η, suggested by an anonymous referee, is to use second-order approximations to the portfolio equilibrium conditions in equations (11b) and (20c), as proposed by Devereux and Sutherland (2011), to determine an optimal value. The results of our investigation into this alternative approach are reported in Appendix F in the Supporting Information.

between (growth rates of) the two series. Credit extended by traditional banks moves strongly with the business cycle. Again, the unconditional correlation is smaller than the conditional correlation, indicating a preponderance of nonproductivity shocks affecting traditional bank lending. Shadow bank credit is moderately countercyclical. For our model, setting $\eta = 0.701$ allows us to reproduce precisely the correlation between traditional and shadow banks measured in the data. The implied conditional correlations between credit and real activity are of the correct sign and remarkably close in magnitude to our estimates. Further information on the comovement between macroeconomic aggregates, ABS spreads, and credit flows can be found in Appendix E in the Supporting Information.

3.3 The Macroeconomic Effects of a Securitization Crisis

Having assessed the business cycle properties of our model economy, we turn now to its behavior in a securitization crisis. Using the model developed above, we simulate the effect of a shock affecting financial intermediaries. Its aim is to capture, albeit in a somewhat reduced form way, the idea that the collateral value of assets held or issued by the shadow banking system became impaired at the onset of the subprime crisis. The crisis scenario we consider is triggered by a persistent exogenous tightening of financial constraints.[29] Our experiment captures two distinct aspects of the crisis. The first is that assets held by the shadow banking system become less effective for raising secured funding. We model this as an unanticipated shock that increases θ_b by a factor ε^{θ}. The second aspect of the crisis is that shadow bank liabilities become less valuable as collateral for commercial banks. We model this as an unanticipated shock that decreases ω_c by a factor ε^{ω}.

Of course, the absence of housing and mortgages from the model complicates its correspondence with the data. But Gorton and Metrick (2012a) explain how a small amount of subprime risk impacted unrelated asset classes via heightened counterparty risk. These spillovers were as important for the run experienced by shadow banks as the direct effect arising from the subprime category alone. We therefore proceed as if the trigger for the generalized run on shadow banks provided by subprime risk is captured by the shocks in our model, and gauge its implications for aggregate activity.

The data we aim to match in our calibration are given in the top panel of Table 4, which also details our sources. There are two targets: real loans held by traditional banks and real securitized loans held by shadow banks. In each case, we measure the change between the onset of recession in 2007Q4, and the implementation of policy measures aimed at easing credit conditions in 2008Q4.[30] As the table shows, commercial bank assets underwent an expansion as the crisis began to bite, even as

29. The experiment therefore resembles the liquidity shock in Del Negro et al. (2011), although their model does not explicitly include financial intermediaries. The mean lag of the shock process in our model is set to be a little over three-quarters to give the flavor of a persistent shift away from securitization.

30. Focusing on the initial phase of the crisis provides us with the best chance of capturing the economy's response to a credit shock without the contaminating influence of central bank asset purchases, although anticipated interventions may well have been important in practice.

TABLE 4

THE SECURITIZATION CRISIS

Calibration targets		
Series	Data	Model
Commercial bank assets	3.7%	5.5%
Shadow bank assets	−18.4%	−17.5%
Model predictions		
Series	Data	Model
Output	−3.5%	−3.7%
Investment	−14.9%	−13.8%
Consumption	−3.6%	−1.2%
ABS spreads	12.0%	13.3%

NOTE: Asset and macroeconomic data are in real (GDP price deflator) terms. Figures quoted under "Data" are the percentage change in each variable between 2007Q4 and 2008Q4 (percentage point change for ABS spreads). Figures for "Model" are impact responses to shocks that alter (θ_b, ω_c) by factors of (1.4, 0.17) under the calibration in Table 1 and an ABS share $\eta = 0.701$.
Data sources: ABS spreads are the rates on A-rated ABS on large industrial equipment minus the relevant swap rate, collected from JP Morgan DataQuery. For other sources, see notes to Table 3.

shadow bank assets collapsed. We choose $(\varepsilon^{\theta}, \varepsilon^{\omega}) = (1.4, 0.17)$ so as to generate model responses that best reproduce the sign and magnitude of these movements.[31]

Having calibrated the securitization crisis to data on commercial and shadow bank credit, we examine the model's predictions for the behavior of other aggregate quantities and spreads. As the bottom panel of Table 4 shows, model responses closely replicate the patterns of falling output, investment, and consumption, and wider spreads, seen in the data. In particular, the model produces a fall in output of 3.7%, compared to 3.5% in the data. The consumption response is somewhat underpredicted, which is likely to be related to the absence of credit constraints on households in the model. As accompanying Appendix G in the Supporting Information shows, these predictions are robust to altering the persistence of the shock and the degree of shadow bank risk taking.

The intuition for the credit responses is straightforward. An immediate consequence of the shock to θ_b is to reduce the supply of securitized assets by tightening the broker incentive constraint. Referring back to Figure 3, it can be seen that the G^b schedule, describing the value of assets the broker can divert, becomes steeper and shifts upward. Commercial banks take loans back onto their balance sheets, but forced selling by shadow banks pushes down capital prices, which impairs the net worth of both sectors. The relatively higher leverage of brokers makes their balance sheet contraction large relative to banks, and works toward reducing securitization activity.

The shock to ω_c has twin effects. Because it directly impacts the bank incentive constraint, making ABS less pledgeable, to obtain a given amount of funding the

31. We calibrate the securitization crisis scenario by choosing $(\varepsilon^{\theta}, \varepsilon^{\omega})$ so as to minimize the squared distance between the impact response of credit variables in the model to the securitization shock, and the data in the top panel of Table 4. Appendix G provides additional information on the calibration exercise.

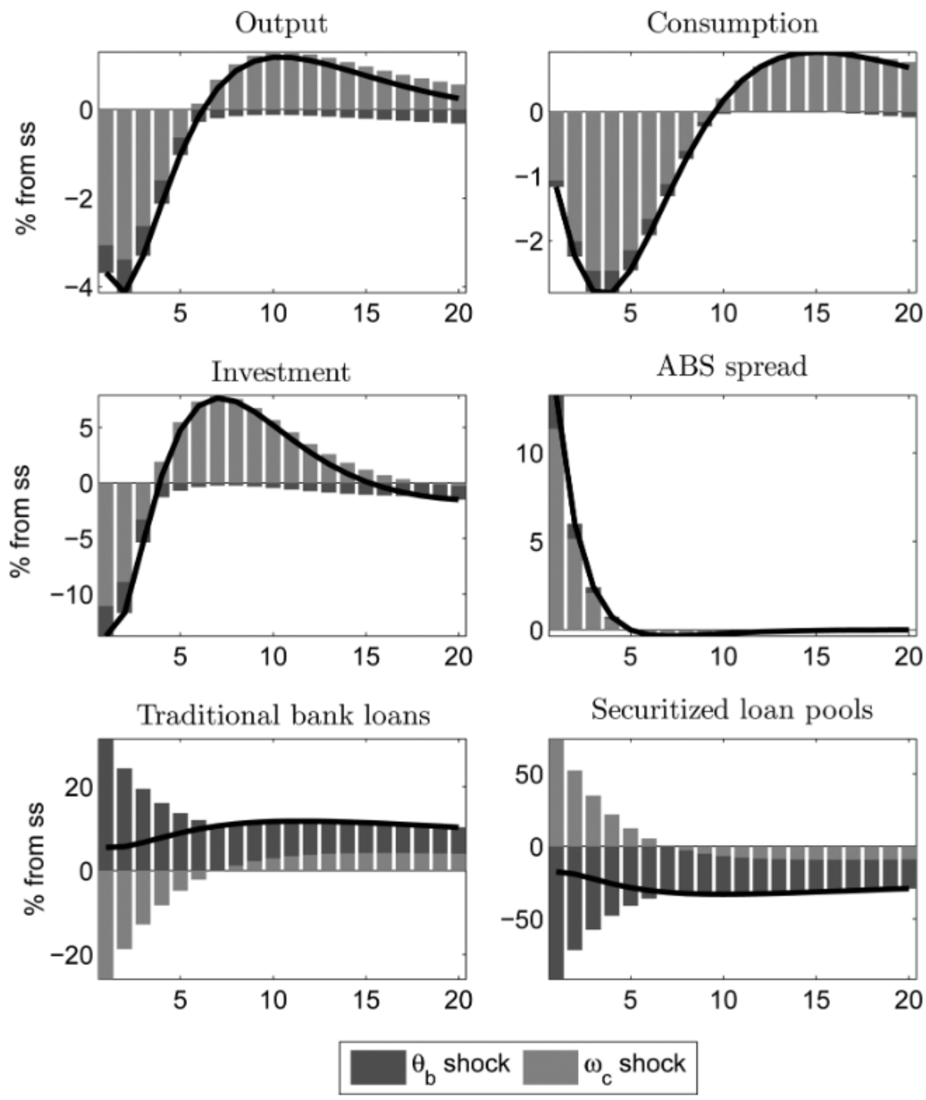

FIG. 4. The Impact of a Securitization Crisis on Macroeconomic and Financial Variables.

NOTES: In each panel, the height of bars shows the response of the indicated variable to shocks affecting the collateral value of shadow bank assets (θ_b) and the collateral value of ABS (ω_c), respectively. The solid black line indicates the effect of a securitization crisis, and is the sum of the two preceding effects. Table 4 quotes the impact values (time 1 impulse responses) of selected variables.

commercial bank now has to hold more of it in its asset portfolio. At the same time, a unit of ABS is relatively less attractive compared to loans, so banks would prefer to hold less. In terms of Figure 3, the former effect shifts the G^c schedule upward, whereas the latter effect flattens it.

Figure 4 shows how these effects play out. The ABS spread is mainly driven by the collateral value of ABS to commercial banks, as Proposition 1 indicates. The impact effect of a lower ABS collateral value is positive for the quantity of ABS in issue, as indicated by the lighter colored bars in the fifth and sixth panels of the figure: commercial banks tilt their portfolios away from loans and toward ABS in a forced bid to acquire collateral. On the other hand, the decline in the collateral value of securitized loans has a strong negative effect on shadow bank assets, as indicated by the darker bars in the figure. The effect is large enough to produce a net result in which aggregate commercial bank loans rise, and aggregate securitized loans fall, as in the data. The main impact on real quantities is felt from the decline in the collateral value of ABS. This reflects the fact that the shock to ω_c is larger than the shock to θ_b—it falls by a factor of 0.17 versus an increase in θ_b by a factor of 1.4—and that its impact is felt directly by the commercial banks, who raise their loan rate, choking off investment.

3.4 Shadow Banking with Government Backstops

The problems experienced in credit and interbank markets at the onset of the subprime crisis in August 2007 were swiftly followed by government actions, including cuts in official interest rates and enhanced provision of liquidity. As the crisis intensified, the scope of these actions was considerably broadened, with the number of announced crisis measures exceeding 150 across the major advanced economies by 2009 (see International Monetary Fund 2009). In the United States, official backstops for the shadow banking system were a prominent component of the policy response (Pozsar et al. 2010). These included a policy of providing long-term liquidity through the TALF (Term Asset-Backed Securities Loan Facility), and outright purchases of Agency MBS and debt funded by central bank reserves.[32,33]

We revisit the effects of the securitization crisis studied in Section 3.3, but supposing that the consolidated government sector purchases assets from the private sector financed by issuance of government debt. Government debt is held by households, who regard it as substitutable for bank deposits. The government may either purchase loans directly (equivalently, pools of loans), acting as an intermediary between households and firms; or it may purchase assets in securitized form as ABS, acting as an intermediary between households and shadow banks.[34] The rationale for government intermediation policies is that in contrast to private actors, it does not face financing

32. In the United Kingdom, the SLS (Special Liquidity Scheme) was also aimed at long-term liquidity provision. It allowed banks to undertake swaps of securitized assets for Treasury bills, which could then be used as collateral to obtain secured funding in wholesale markets.

33. Central bank asset purchases in jurisdictions other than the United States were mainly restricted to commercial paper, corporate bonds, covered bonds, and government securities, rather than securitized assets over the 2007–09 period. As Pozsar et al. (2010) remark, the Federal Reserve was able to undertake purchases of Agency liabilities without creating new facilities as such securities were already considered to be eligible collateral for the purpose of open market operations.

34. A third option is to lend to banks by purchasing deposits. However, it is straightforward to show that this policy has no effect, $G_t = T_t = 0$, so long as the resource cost parameter τ is zero, and the government lends on the same terms as other creditors, meaning there are no changes to banks' incentive constraints. Christiano and Ikeda (2011) discuss the failure of irrelevance conditions such as this in various types of models with financial frictions.

constraints. As a result, the composition of its balance sheet will not matter for its cost of funding, which is always at the risk-free rate.[35]

The government budget constraint takes the form:

$$G_t + Q_t S_t^g + M_t^g + R_t D_{t-1}^g = T_t + D_t^g + R_{st} Q_{t-1} S_{t-1}^g + R_{mt} M_{t-1}^g,$$

where D_t^g denotes 1 period government bonds, and lump sum taxes on households T_t adjust to ensure budget balance. After substituting the financing policy, the constraint becomes:

$$G_t - T_t = (R_{st} - R_t) Q_{t-1} S_{t-1}^g + (R_{mt} - R_t) M_{t-1}^g. \tag{36}$$

We assume that there is a real resource cost associated with government asset purchases, which represent its relative lack of specialization in managing investments, and which gives rise to nonzero public expenditure, parameterized by τ, which we set to 0.002, or 2 tenths of a cent on the dollar:

$$G_t = \tau \left(S_t^g + M_t^g \right). \tag{37}$$

Finally, the market clearing conditions equations (29) and (30) are altered to read:

$$S_t^c + S_t^b + S_t^g = K_{t+1} \tag{38}$$

and

$$M_t^c + M_t^g = M_t^b. \tag{39}$$

Government is taken to purchase a fraction φ_t^i of the steady-state stock of each asset type i. The policy response to the crisis takes the form of a simple feedback rule on the spreads (a star denotes steady-state values) as in Gertler, Kiyotaki, and Queralto (2012), with the parameter γ_{1i} determining the strength of the response:

$$\varphi_t^s = \gamma_{0s} + \gamma_{1s}\{\mathrm{E}_t(R_{s,t+1} - R_{t+1}) - (R_{s*} - R_*)\}, \tag{40}$$

$$\varphi_t^m = \gamma_{0m} + \gamma_{1m}\{\mathrm{E}_t(R_{m,t+1} - R_{t+1}) - (R_{m*} - R_*)\}. \tag{41}$$

The parameter γ_{0i} determines the steady-state fraction of assets held by the consolidated government sector, which we set at 2.5%. The rules given by equations (40) and (41), which are anticipated by the public, capture the idea that the principal goal of intervention is to bring down borrowing rates.

35. The policy described here differs from the Federal Reserve's large-scale asset purchase (LSAP) program, which has taken the form of purchases of federal government and agency liabilities funded by central bank reserves. In our model, the purchase of one type of consolidated government liability funded by issuing another type of government liability would have no effect. The effect of the policy on bank deposits also differs. Under the LSAP program, purchases of MBS from the public result in higher deposits at banks, who hold correspondingly higher reserve balances at the Fed. In the model, debt and deposits are substitutes in the household asset portfolio, so when the government's balance sheet expands, bank deposits decline. The effects of a debt-funded expansion of intermediation in a model with monetary policy are discussed in Gertler and Karadi (2011).

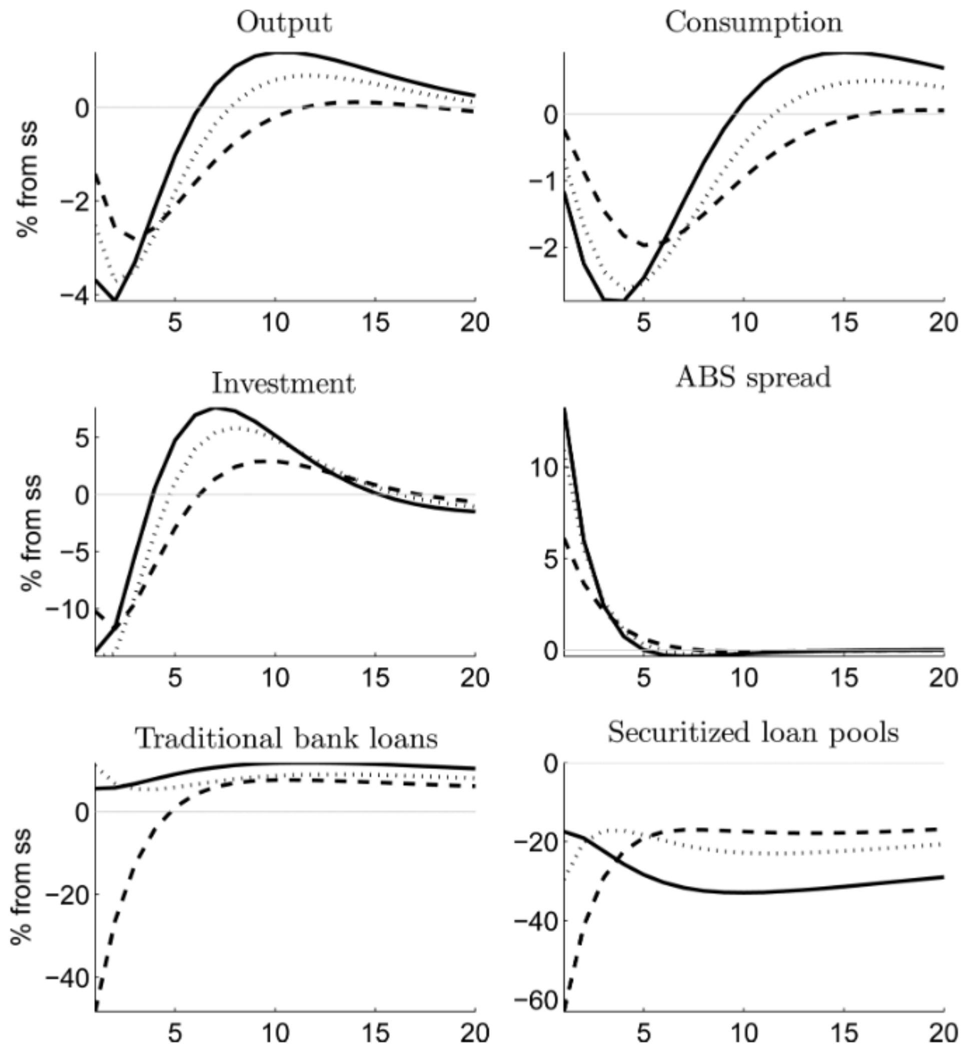

FIG. 5. The Impact of Government Backstops during a Securitization Crisis.

NOTES: Figure compares the effects of a securitization crisis: without a policy response (—); with government purchases of primary securities (- -); and with government purchases of asset backed securities (···). Details of the shock are given in the main text. The ex-intervention response is equal to the solid line in Figure 4. Credit policies are calibrated so as to produce an identical initial increase in the ratio of government debt to GDP.

We once again subject the economy to the securitization shock described in Section 3.3. To gauge the "bang per buck" of the policy alternatives—direct asset purchases versus ABS purchases—we set the γ_{1i} parameters to produce identical on-impact rises in government borrowing, relative to GDP, in each case. This experiment is informative about the effectiveness of a given dollar of intermediation services provided by the government. Figure 5 compares the responses of the economy with and without government intervention. The solid lines reproduce the responses in

Figure 4, where there was no intervention; dash lines correspond to loan purchases, with $\gamma_{1s} = 2.51$; dotted lines to ABS purchases with $\gamma_{1m} = 1.37$. We consider the effects of each intervention in turn.[36]

First, as the government purchases loans, the value of primary securities stabilizes, relative to the case without intervention. Revaluation is helpful because it protects the net worth of all intermediaries. But there is an offsetting effect arising from a compression in lending spreads. When prices rise, the returns that intermediaries expect to earn in the transition back to steady state are lower, tightening their incentive constraint. Profit growth for both traditional and shadow banks is also very slow, keeping their net worth low for a protracted period. Intermediaries of both types therefore see their balance sheets shrink. As a result, although investment is somewhat less volatile, the reduction in output volatility apparent in the figure is driven principally by consumption.

Second, it can be seen that a policy of outright ABS purchases is less effective in reducing ABS spreads than an equivalent-sized loan purchase policy. Moreover, the total quantity of ABS issued by shadow banks is, on impact, lower than in the no-intervention case, as are loan pools. The reason for this seemingly perverse effect can be explained as follows. Holding returns constant, the incentive constraint of the shadow banking system is unaffected by the government's purchases. As their constraint is binding, they cannot expand their balance sheets to meet the increased demand for ABS. The first-round effect of the government's purchases is therefore to reduce commercial bank holdings of ABS, while at the same time, commercial bank deposits fall as households substitute into government debt. The key to understanding the response can be seen from equation (8), which tells us that lower deposits translate into lower demand for ABS from commercial banks; indeed, so long as $\omega_c < 1$, ABS demand falls more than one-for-one with the loss of deposits as commercial banks require less pledgeable collateral to support their reduced leverage. As a consequence, total demand for ABS summing across banks and the government is actually lower than in the absence of intervention. To clear the market as in equation (39), the loan-ABS spread must fall. A lower spread hurts profits, and triggers reductions in net worth and a second-round tightening of financial constraints for both intermediary types, see equations (3) and (13), leading private-sector intermediation to remain persistently impaired.

In summary, the results in this section imply that a policy that raises asset values through direct loan purchases is more effective at bringing down spreads and reducing macroeconomic volatility than a policy that supports the price of ABS, reducing funding costs for shadow banks. Intuitively, by diverting household saving into government bonds, the policies incentivize commercial banks to retain loans, which works with the policy of loan purchases, but against the policy of ABS purchases. The results also point to the importance of combining asset purchases with

36. The message of our analysis is not altered by considering much larger values of γ_{1m}; the result of raising γ_{1m} is larger initial declines in securitized loan pools, and more protracted declines in real activity, in response to government ABS purchases.

recapitalizations, which would counteract the effects of the protracted margin squeeze intermediaries face.

4. CONCLUDING REMARKS

In this paper, we developed a simple dynamic general equilibrium model in which a traditional commercial banking sector and a "shadow" banking sector interact through the market for securitized assets. We examined the consequences of "securitized banking" for aggregate activity, credit supply, and credit spreads under business cycle disturbances and financial shocks.

We report that the model we construct is able to reproduce the cyclical behavior of output and credit aggregates in response to productivity shocks. We used the model to argue that liquidity shocks affecting the collateral value of shadow bank assets and liabilities are capable of explaining the patterns of credit supply and real activity over the financial crisis of 2007–08. We further showed that in response to a securitization crisis, lending to shadow banks by purchasing ABS would, in our environment, be a much less effective policy per unit of public expenditure than direct government intermediation between households and firms. These findings underline the importance for successful policy design of anticipating spillovers within the financial system.

In conclusion, shadow banking remains an important piece of the financial system even if it is, at the time of writing, far diminished. Interest in reform of shadow banking continues to be an active area of development in postcrisis financial regulation (Financial Stability Board 2015). This paper provides a framework, albeit a somewhat stylized one, for thinking about the economy-wide implications that such reforms may entail.

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