Collateral Shocks

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We estimate a macroeconomic model on US data where banks lend to households and businesses and simultaneously adjust lending requirements on the two types of loans. We find that the collateral shock, a change in the ability of the financial sector to redeploy collateral, is the most important force driving the business cycle. Hit by this unique disturbance, our model quantitatively replicates the joint dynamics of output, consumption, investment, employment, and both household and business credit quantities and spreads. The estimated collateral shock generates accurate movements in lending standards and tracks measures of market sentiment. (*JEL* E32, E44, G21)

Business cycles are characterized by positive comovements among output, consumption, investment, and employment. To understand what drives these comovements, a branch of macroeconomics develops and estimates quantitative general equilibrium models where candidate forces compete to trigger responses that mimic actual business cycles. In the decade since the 2008 recession, a number of influential papers have come to the conclusion that financial shocks play a key role in driving economic fluctuations.[1] These findings are important because they are supported by other strands of the empirical literature and ultimately help us understand how crises come and go.[2]

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[1]See Gerali et al. (2010), Jermann and Quadrini (2012), Liu, Wang, and Zha (2013), Christiano, Motto, and Rostagno (2014), Gilchrist, Sim, and Zakrajšek (2014), Del Negro, Giannoni, and Schorfheide (2015), Iacoviello (2015), and Ajello (2016).

[2]Evidence using long-run time series includes Reinhart and Rogoff (2009) and Schularick and Taylor (2012). For vector autoregression evidence, see Gilchrist and Zakrajšek (2012), Bassett et al. (2014), Prieto, Eickmeier, and Marcellino (2016), Furlanetto, Ravazzolo, and Sarferaz (2017), and Cesa-Bianchi and Sokol (2019). For univariate forecasting specifications, see López-Salido, Stein, and Zakrajšek (2017). For micro data evidence, see Peek and Rosengren (2000), Ashcraft (2005), Amiti and Weinstein (2011), Derrien and Kecskés (2013), Chodorow-Reich (2014) and Benmelech, Meisenzahl, and Ramcharan (2017).

Despite the recent progress, none of these studies proposes a shock that generates the comovements observed in the data.[3] Typically, the main financial impulse drives a large share of the variance in output, investment, and hours worked, but has very little impact on the dynamics of consumption. Since actual consumption is both highly correlated with and about two thirds as volatile as output, these papers must resort to a distinct source, generally a preference shock, to explain the movements in consumption. This is not satisfactory because the financial and preference shocks need to be correlated to fit the data, a result at odds with their structural and independent nature.

In this paper, we identify a *single* disturbance that produces the comovements in all four aggregate variables, including consumption. This disturbance originates in the financial sector. In the United States, 80 percent of total private credit is bank-based; over half flows to households while the rest goes to businesses; most of it is secured by collateral. Though these facts are well known, we believe another basic feature of bank intermediation has been largely overlooked. When banks tighten or loosen their lending standards, they do so for the two types of borrowers—households and firms alike. Figure 1 illustrates this point clearly. It plots two measures of lending standards, one for consumer loans and the other for business loans. The two series exhibit the same pattern: standards tighten sharply before each recession, and subsequently ease.

Motivated by this preliminary evidence, we develop a macroeconomic model with two main ingredients. First, a banking sector extends loans to households and firms. Debt is backed by collateral—housing for households, capital for firms. Second, banks respond to exogenous events taking place in the financial system by simultaneously readjusting their lending requirements on the two types of loans. To obtain this reaction we assume that, in the event of a default, lenders cannot sell the collateral of their borrowers on the spot. They must first search for a potential buyer and negotiate over the price. This process of redeploying assets is costly and depends on market conditions.[4]

We refer to the change in cost paid by banks to redeploy foreclosed assets as

[3]Two dimensions matter for the comovements. The first one is qualitative: the candidate shock must cause output, consumption, investment, and employment to move in the same direction. The second dimension is quantitative: the candidate shock must generate movements of the same magnitude as in the data. In this paper we emphasize the latter because all the aforementioned papers struggle along this dimension for at least one variable—consumption.

[4]Our redeployment cost is inspired by Candian and Dmitriev (2020) who model time-varying liquidation costs in the nonfinancial business sector.

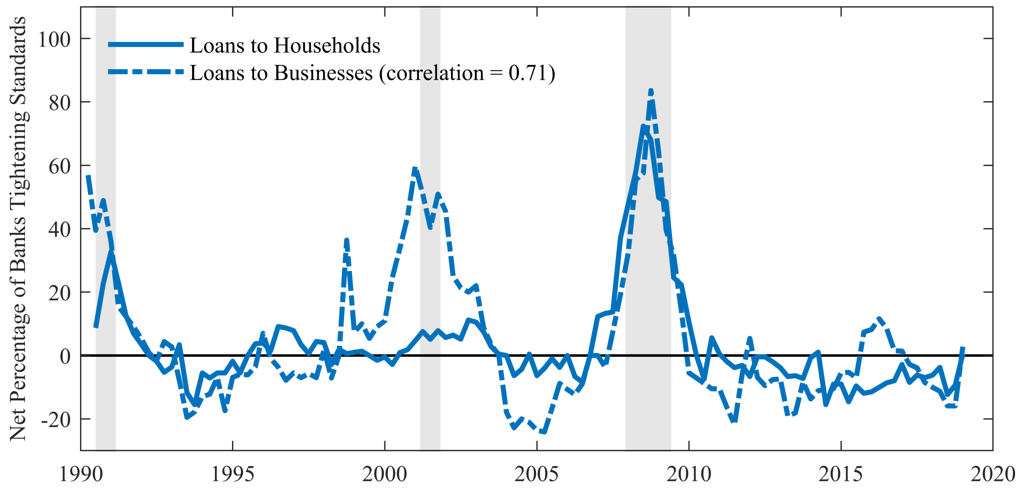

Figure 1: Bank Tightening

Note: Shaded bars indicate NBER recession dates. *Source:* Senior Loan Officer Opinion Survey on Bank Lending Practices (SLOOS), Board of Governors of the Federal Reserve System.

the *collateral shock*, which we denote by ν_t. This shock is meant to capture swings in the risk appetite of the financial system. For instance, a large share of total credit is intermediated by shadow banks through securitization of collateralized loans. In good times, buyers are plentiful and deem these asset-backed securities safe. Lenders find it easy to offload collateral and can afford to demand lower down payments from their borrowers. A sudden awareness to risk, however, turns the mood around. The securities are downgraded. Investors flee the wholesale funding market, banks have trouble finding buyers willing to acquire distressed assets, and borrowers end up with stricter lending requirements.[5]

We ask whether the collateral shock can generate dynamics that resemble US business cycles. The answer is yes. Using macroeconomic and financial data, we estimate our model with Bayesian techniques and find that the collateral shock is the main driver of economic fluctuations over the past decades. It accounts for the bulk of the variance in output, consumption, investment, employment, business credit, household and business credit spreads, and a sizable share of the variance in household credit. We believe this paper is the first to put forward

[5]Kiyotaki and Moore (2018), Ajello (2016), and Del Negro et al. (2017) emphasize liquidity shocks through a resaleability constraint. Our collateral shock encompasses their disturbance, as the drop in confidence in the early stage of the last crisis probably resulted from liquidity issues in wholesale credit markets. However, liquidity shocks in these papers affect only the financing of firms, and say nothing about household credit and house price dynamics, two central elements of the crisis.

a shock capable of explaining the movements in all four main macroeconomic variables as well as in various financial series.[6]

The reason why our collateral shock drives consumption on top of the other macro variables is simple. Imagine confidence in the financial sector slips and banks realize redeploying foreclosed assets is costlier—an adverse collateral shock. Their first reaction is to tighten collateral requirements on all their new loans, regardless of the type of borrower. Households and firms obtain less credit. On the corporate side, firms cut back on capital purchases, causing investment, employment, and output to fall. On the consumer side, borrowing households cut back on housing and goods purchases, causing consumption to fall. To see how critical this latter channel is to the story, we estimate a version of the model without borrowing households and household credit. We find that the collateral shock is still the economy's main impulse, but it no longer drives consumption. The preference shock fills the gap.

What does a collateral shock represent? We attempt to answer this question by running two out-of-sample exercises. We first confront the collateral requirements implied by our model to the data on bank lending standards presented in Figure 1. The series are highly correlated. Next, we show that the innovations to the estimated collateral shock track various indicators of financial stress. Thus, we interpret the collateral shock as a rough measure of sentiment in the financial sector, which has the consequence of shifting the supply of credit available to households and businesses.

Our paper contributes to the literature that builds quantitative models to uncover the sources of economic fluctuations. Angeletos, Collard, and Dellas (2020) motivate the search for a "main business-cycle shock" that causes strong comovements among most macro variables but is disconnected from inflation and TFP.[7] Justiniano, Primiceri, and Tambalotti (2010) claim that investment shocks explain a large chunk of the cycle, excluding consumption.[8] Christiano,

[6]Angeletos, Collard, and Dellas (2018) recently argue that agents' heterogeneous beliefs about their trading partners' future productivity generate dynamics that resemble business cycles. Their confidence shock explains a large share of the movements in the four main macroeconomic variables, but is silent on financial variables, as the authors abstract from financial frictions.

[7]Sargent and Sims (1977) and Giannone, Reichlin, and Sala (2004), among others, argue that US cycles are driven by two shocks, one for real variables and the other for nominal ones.

[8]These authors suggest financial factors might be at play. Jermann and Quadrini (2012) estimate a model where firms raise loans to finance working capital. They find that financial shocks are the most important factor driving US business cycles, excluding consumption. Pfeifer (2016) disputes their result and argues that a more reliable estimation reproduces the findings of

Motto, and Rostagno (2014, hereafter CMR) show that once they add a financial accelerator to this setup and estimate it with financial series, the influence of the investment shock nearly vanishes. Instead, shocks to the dispersion of firms' productivity, or risk shocks, become the main driver of the economy. The risk shock, however, does not account for much of the movements in consumption. Our approach builds on theirs and enables us to explain household consumption, credit, and spreads.

Our work is also related to a growing line of research arguing that changes in the credit supply by banks, unrelated to improvements in productivity or income, are the cause of debt booms and busts.[9] Some of these studies find evidence for the direct causal link between household credit and consumption that our model displays. Mian and Sufi (2011) show that in good times homeowners borrow vast quantities through refinancing and home equity loans, and use these funds to consume more. Mian, Rao, and Sufi (2013) establish that in bad times credit-constrained families are those that cut consumption by the widest margin.

The article is organized as follows. Section I provides intuition for the central mechanism of the paper. Section II lays out the model and Section III discusses the estimation procedure. In Section IV we present our main results. Section V offers external evidence on the collateral shock. Section VI concludes.

I. Intuition

Financial shocks have long been known to generate counterfactual implications for consumption and investment.[10] In this section we explain how a shock that originates from banks and simultaneously affects business and household loans can overcome the issue and generate the comovements observed in the data.

Consider the following business cycle model. There are two types of households, patient (superscript p) and impatient (superscript i).[11] Patient households are the ultimate lenders in the economy. Impatient households are net borrowers, they take on debt B_t^i to purchase housing H_t^i and consume. Firms (superscript e) take on debt B_t^e to invest in the capital stock K_t. A bank acts as an intermediate.

Justiniano, Primiceri, and Tambalotti (2010).

[9]Examples include Mian, Sufi, and Verner (2017), Justiniano, Primiceri, and Tambalotti (2018), and Rodano, Serrano-Velarde, and Tarantino (2018).

[10]Barro and King (1984) are the first to identify this puzzle for a large class of shocks.

[11]This designation comes from Iacoviello (2005).

It collects deposits D_t from patient agents and transforms them into loans for the two types of borrowers, $D_t = B_t^i + B_t^e$. To mitigate credit risk, the bank requires that the amount of debt be a fraction of the value of collateralized assets

$$B_t^i \leq \phi_t^i H_t^i, \tag{1}$$

$$B_t^e \leq \phi_t^e K_t, \tag{2}$$

where ϕ_t^i and ϕ_t^e are endogenous loan-to-value ratios.

The key friction is as follows. Whenever a borrower defaults, the bank must seize its collateral and redeploy it. That is, it must search for a buyer and negotiate a good price. As pointed out by Shleifer and Vishny (1992), selling assets is harder in bad times because industry peers are likely to be experiencing problems themselves and other banks are likely to be selling similar assets as more debtors go bankrupt. We model this phenomenon with a time-varying liquidation cost, in the spirit of Candian and Dmitriev (2020).[12] In particular, let $\Theta^i(\phi_t^i, \eta_t^i, \nu_t)$ and $\Theta^e(\phi_t^e, \eta_t^e, \nu_t)$ be the cost of redeploying housing and capital, respectively. These functions are increasing and convex in the share of pledged assets, ϕ_t^i and ϕ_t^e, and proportionally increasing in two sector-specific exogenous variables η_t^i and η_t^e and one common factor ν_t. The sectoral shocks capture events that arise independently in the housing and business capital markets. Residential real estate may be easier to value than specialized corporate assets, say, but more prone to contagion in a turmoil.

We assume that ν_t is stochastic and refer to it as the *collateral shock*. This variable reflects developments in financial markets that impact all sectors. For example, when market conditions deteriorate the pool of potential buyers shrinks as investors move their capital away from risky assets. Meanwhile, buyers willing to acquire distressed assets find it more difficult to raise funds to finance their purchase. Thus in general, ν_t represents the risk appetite in the financial sector.

In this context, the objective of the bank is to choose ϕ_t^i and ϕ_t^e to maximize revenue from selling defaulted assets net of the redeployment cost

$$\phi_t^i H_t^i + \phi_t^e K_t - \Theta^i(\phi_t^i, \eta_t^i, \nu_t) H_t^i - \Theta^e(\phi_t^e, \eta_t^e, \nu_t) K_t. \tag{3}$$

[12]These authors focus on the corporate sector exclusively. They assume that non-defaulting firms pay a cost to acquire and redeploy the assets of their failing competitors. The cost varies endogenously over the cycle, leading to fire-sale prices and empirically-plausible recovery rates.

The first-order conditions imply that the marginal revenue from one extra unit of collateral is equal to its marginal cost

$$\Theta^{i\prime}(\phi_t^i, \eta_t^i, \nu_t) = 1. \tag{4}$$

$$\Theta^{e\prime}(\phi_t^e, \eta_t^e, \nu_t) = 1. \tag{5}$$

What is the effect of adverse financial shocks in this economy? Start with the two sector-specific shocks. A rise in η_t^e makes capital costlier to liquidate, prompting the bank to cut ϕ_t^e and tighten the borrowing constraint of firms. Business credit and investment drop. Bar any large movement in the demand for labor, output responds relatively little at first, implying that consumption increase to satisfy the resource constraint. A rise in η_t^i, on the other hand, makes housing costlier to liquidate, prompting the bank to cut ϕ_t^i and tighten the borrowing constraint of impatient households. Impatient household credit and consumption drop. Market forces induce patient households to move their savings towards capital, while not affecting their consumption much. Investment goes up. To summarize, both financial shocks—on households and firms—produce opposite movements in consumption and investment and fail to generate the comovements.

Consider now an adverse collateral shock. A rise in ν_t increases the cost of redeploying all foreclosed assets. This prompts the bank to cut both ϕ_t^i and ϕ_t^e and hence tighten the borrowing constraints of impatient households and firms alike. On the corporate side, business credit and investment fall. On the consumer side, impatient household credit and consumption fall. With a large enough share of impatient households in the economy, aggregate consumption drops. Provided that prices are sticky and output is demand-driven, the demand for labor drops. To summarize, a collateral shock leads to a decline in output, consumption, investment, hours, and credit, and thus generates the desired comovements.

II. The Model

We enrich the model of the previous section with several elements. First, we introduce default a la Bernanke, Gertler, and Gilchrist (1999) for each type of borrower. This gives rise to endogenous credit spreads, which help us distinguish the collateral shock from other disturbances affecting loan demand.[13] The qualitative properties of our central mechanism remain intact. Second, we add a number of frictions and shocks widely used in the literature, as in Christiano, Eichenbaum, and Evans (2005), Smets and Wouters (2007), and CMR. The complete derivation of the model is in Online Appendix Section A1.

A. *Patient Households*

A representative patient household contains a large number of workers who supply differentiated labor $l^p_{k,t}$, $k \in [0,1]$. The household derives utility from consumption C^p_t and housing services H^p_t according to

(6)
$$E_0 \sum_{t=0}^{\infty} \beta^{p,t} \left\{ \zeta_{c,t} \ln(C^p_t - b^p_c C^p_{t-1}) + \ln H^p_t - \psi_l \int_0^1 \frac{l^{p,1+\sigma_l}_{k,t}}{1+\sigma_l} dk \right\}, \quad b^p_c, \psi_l, \sigma_l > 0,$$

where β^p is a discount factor and $\zeta_{c,t}$ is a preference shock. Housing services are provided one-for-one by the housing good $\bar{H}^p_t$ whose price is Q^h_t. The budget constraint of the patient household writes

$$(7) \qquad (1+\tau^c) P_t C^p_t + Q^h_t \bar{H}^p_t + P_t D_t \leq (1-\tau^l) \int_0^1 W^p_{k,t} l^p_{k,t} dk + R_t P_{t-1} D_{t-1} + Q^h_t \bar{H}^p_{t-1} + \Delta^p_t + T^p_t,$$

where τ^c and τ^l are consumption and labor tax rates, P_t is the price of final goods, and $W^p_{k,t}$ is the nominal wage of worker k. The patient household allocates its budget on consumption, housing, and bank deposits D_t. Its revenues come from labor income, previous-period deposits, the sale of previous-period housing, dividends from entrepreneurs Δ^p_t, and a transfer from the government T^p_t.

B. *Impatient Households*

A representative impatient household comprises three types of members. A large number of workers supply differentiated labor $l^i_{k,t}$, $k \in [0,1]$, consume, and choose housing services. A single real estate broker acquires housing goods and sells them to homeowners. Finally, a large number of homeowners borrow

[13] See Online Appendix Section A5 for a discussion.

from banks to purchase housing goods and rent them to the workers.[14] The reason we split the impatient household in three is to ensure that the problem of the borrowing agent—the homeowner—is linear in net worth, which facilitates aggregation. There is perfect insurance in consumption goods and housing services within the household.

Workers.—The impatient household has preferences similar to the patient one

$$(8)\qquad E_0 \sum_{t=0}^{\infty} \beta^{i,t} \left\{ \zeta_{c,t} \ln(C_t^i - b_c^i C_{t-1}^i) + \ln H_t^i - \psi_l \int_0^1 \frac{l_{k,t}^{i,1+\sigma_l}}{1+\sigma_l} dk \right\}, \quad b_c^i > 0.$$

We impose $\beta^i < \beta^p$ to guarantee that the impatient household is a net borrower in equilibrium. The budget constraint of workers is

$$(9)\qquad (1+\tau^c) P_t C_t^i + P_t r_t^h H_t^i \leq (1-\tau^l) \int_0^1 W_{k,t}^i l_{k,t}^i dk + \Delta_t^i + T_t^i,$$

where r_t^h is the rental rate of housing and Δ_t^i denotes aggregate housing dividends coming from homeowners.

Real Estate Brokers.—A representative, competitive real estate broker acts as a middleman. He purchases housing goods from housing producers (described below) and sells them to the homeowners. In the process of acquiring vast amount of real estate, the broker is subject to housing adjustment costs. These costs are important because they smooth the dynamics of housing and hence of household credit, which is an observable variable, and thus help our model fit the data. The problem of the real estate broker is to maximize profit

$$(10)\qquad E_0 \sum_{t=0}^{\infty} \beta^{i,t} \Lambda_{z,t}^i \left\{ Q_t^h \bar{H}_t^i - Q_t^h \bar{H}_t^i \left[1 + S^h(\zeta_{h,t} \bar{H}_t^i / \bar{H}_{t-1}^i) \right] \right\},$$

where $\Lambda_{z,t}^i$ is the impatient household's marginal utility of consumption, S^h is an increasing convex function defined below, and $\zeta_{h,t}$ is a housing shock.

[14]The separation of the impatient household program into workers and homeowners comes from Ferrante (2019).

C. Borrowers: Impatient Homeowners and Entrepreneurs

Impatient homeowners and entrepreneurs have similar programs and therefore we describe them jointly in this subsection.

There is a continuum $j \in [0,1]$ of borrowers of type $o \in \{i, e\}$, where $o = i$ if the type is homeowner and $o = e$ if the type is entrepreneur. In period t, borrower j of type o obtains a loan $B^o_{j,t}$ from the bank at interest rate R^o_t. She combines the loan with her net worth $N^o_{j,t}$ to purchase an asset $X_{j,t}$ at price Q^x_t, where $x \in \{h, k\}$. The asset is housing, $X_{j,t} = \bar{H}^i_{j,t}$ and $Q^x_t = Q^h_t$, if the borrower is a homeowner, or the asset is capital, $X_{j,t} = \bar{K}_{j,t}$ and $Q^x_t = Q^k_t$, if the borrower is an entrepreneur. Debt is risky, therefore the bank requires that the asset be pledged as collateral. The borrower can pledge only a fraction ϕ^o_t of her asset, chosen by the bank. In case of default the bank seizes this fraction, while the borrower gets to keep the non-pledged share $1 - \phi^o_t$.

At the beginning of period $t + 1$, borrower j is hit by an idiosyncratic shock $\omega^o_{j,t+1}$ that converts the value of her asset $Q^x_t X_{j,t}$ into $\omega^o_{j,t+1} Q^x_t X_{j,t}$.[15] We assume $\omega^o_{j,t+1}$ is a lognormal random variable distributed independently over time and across borrowers, with cumulative distribution function $F^o(\omega^o_{j,t+1})$, and $E_t \omega^o_{j,t+1} = 1$. After receiving the idiosyncratic shock, borrower j has the following net worth, which is simply the difference between assets and liabilities

$$N^o_{j,t+1} = R^x_{j,t+1} \omega^o_{j,t+1} Q^x_t X_{j,t} - R^o_{j,t} B^o_{j,t}, \quad o \in \{i, e\}, x \in \{h, k\}. \tag{11}$$

Here, $R^x_{j,t+1}$ is the return on asset $X_{j,t}$. Let us separate momentarily the two types of borrowers. Impatient homeowner j obtains a return $R^h_{t+1} \equiv Q^h_{t+1}/Q^h_t$ on her housing, common to all homeowners.[16] She allocates her resources on new housing purchases and dividends to her household. She draws funds from her net worth, rental income, and a new loan from the bank. Her budget constraint is

$$Q^h_{t+1} \bar{H}^i_{j,t+1} + \Delta^i_{j,t+1} = N^i_{j,t+1} + P_{t+1} r^h_{t+1} \bar{H}^i_{j,t+1} + B^i_{j,t+1}. \tag{12}$$

[15]In the case of housing, this reflects changes in the neighborhood such as local employment, public infrastructure, weather conditions, and crime. In the case of capital, the idiosyncratic shock reflects the fact that many firms end up in failure while others experience success.

[16]This return excludes rental income which we assume cannot be seized by the bank.

Entrepreneur j, for her part, obtains the following return on capital

(13)
$$R^k_{j,t+1} = \left[(1-\tau^k)[u_{j,t+1}r^k_{t+1} - a(u_{j,t+1})]\Upsilon^{-(t+1)}P_{t+1} + (1-\delta)Q^k_{t+1} + \tau^k\delta Q^k_t\right]/Q^k_t,$$

where τ^k is the tax rate on capital income. The entrepreneur chooses capital utilization rate $u_{j,t+1}$, pays utilization adjustment cost $a(u_{j,t+1})$, and rents out capital services $u_{j,t+1}\omega^e_{j,t+1}Q^k_t\bar{K}_{j,t}$ to intermediate firms at rental rate r^k_{t+1}. After production, she sells her depreciated capital to capital producers at price Q^k_{t+1}. Depreciated capital benefits from a tax deduction. The entrepreneur combines her net worth and the loan from the bank to purchase capital. Her budget constraint is

(14)
$$Q^k_{t+1}\bar{K}_{j,t+1} = N^e_{j,t+1} + B^e_{j,t+1}.$$

Objective.—We return to the generic borrower j of type $o \in \{i,e\}$. The goal of borrower j is to maximize dividends if she is a homeowner, or expected net worth if she is an entrepreneur. Optimization is subject to the budget constraint and a bank participation constraint, defined below. In Online Appendix Section A1, we show that the objective function of borrower j is linear in current net worth. As a result, each borrower receives a standard debt contract and strategically defaults whenever the cost of servicing debt exceeds the value of the assets she pledged to the bank as collateral. Let $\bar{\omega}^o_{j,t+1}$ be the default threshold, then

(15)
$$R^x_{t+1}\bar{\omega}^o_{j,t+1}\phi^o_t Q^x_t X_{j,t} = R^o_{j,t}B^o_{j,t}, \quad o \in \{i,e\}, x \in \{h,k\}.$$

D. Banks

A representative, competitive bank uses patient household deposits to extend loans to impatient households and entrepreneurs. For every borrower j of type $o \in \{i,e\}$, the bank requires a return equal to the nominal interest rate R_{t+1}. Thus, the following participation constraint is always satisfied in period $t+1$

(16)
$$[1 - F^o(\bar{\omega}^o_{j,t+1})]R^o_{j,t+1}B^o_{j,t} + (1-\mu^o)\int_0^{\bar{\omega}^o_{j,t+1}} \omega^o_{j,t+1}dF^o(\omega^o_{j,t+1})R^x_{t+1}\phi^o_t Q^x_t X_{j,t} \geq R_{t+1}B^o_{j,t}.$$

The left-hand side of this expression is the expected return, per borrower, on the loan, split between solvent (first term) and insolvent (second term) agents.

The bank pays μ^o to monitor defaulting borrowers. As explained earlier, ϕ_t^o represents the value of the underlying asset—housing or capital—against which the bank is willing to lend, and which is therefore able to recover in case of bankruptcy.

Redeploying seized assets is costly, as we discuss in Section I. We assume the cost function takes a quadratic form

$$\Theta^o(\phi_t^o, \eta_t^o, \nu_t) = \frac{(\phi_t^o)^2}{2} \eta_t^o \nu_t, \quad o \in \{i, e\}. \tag{17}$$

Again, η_t^i and η_t^e are sector-specific shocks to the redeployment cost of housing and physical capital, respectively. Up to first order, they are isomorphic to changes in the dispersion of impatient households' and entrepreneurs's idiosyncratic productivity, or risk shocks (η_t^e in particular is equivalent to CMR's risk shock σ_t). The collateral shock ν_t is a common cost shifter meant to capture economy-wide financial disturbances. Optimal housing and capital loan-to-value ratios are

$$\phi_t^i = (\nu_t \eta_t^i)^{-1}, \tag{18}$$

$$\phi_t^e = (\nu_t \eta_t^e)^{-1}. \tag{19}$$

Each of the three financial shocks makes reselling assets costlier and leads the bank to reduce the size of the loan it grants to borrowers for a given value of pledgeable assets. Only the collateral shock, though, affects the two lending constraints at once.

E. Production, Government, Aggregation, Adjustment Costs, and Shocks

Goods Production.—A representative, competitive final good firm combines intermediate goods $Y_{j,t}$, $j \in [0, 1]$, to produce final output Y_t using the technology

$$Y_t = \left[\int_0^1 Y_{j,t}^{\frac{1}{\lambda_{p,t}}} dj \right]^{\lambda_{p,t}}, \tag{20}$$

where $\lambda_{p,t} \geq 1$ is a markup shock. Each intermediate good j is produced by a monopolist according to the production function

$$Y_{j,t} = \max \left\{ \varepsilon_t (u_t K_{j,t-1})^{\alpha} (z_t l_{j,t})^{1-\alpha} - \theta z_t^* \; ; \; 0 \right\}, \quad \alpha \in (0, 1), \tag{21}$$

where $K_{j,t-1}$ denotes capital services, $l_{j,t}$ is a homogeneous labor input, u_t is the aggregate utilization rate of capital, ε_t is a stationary technology shock, and θ is a fixed cost. There are two sources of growth in the model. The first one is the trend rise in technology z_t. The second one is an investment-specific shock $\mu_{\Upsilon,t}$ that changes the rate at which final goods are converted into $\Upsilon^t \mu_{\Upsilon,t}$ investment goods, with $\Upsilon > 1$. In equilibrium the price of investment goods is $P_t/(\Upsilon^t \mu_{\Upsilon,t})$. As in CMR, the fixed cost θ is proportional to z_t^*, which combines the two trends, $z_t^* = z_t \Upsilon^{(\frac{\alpha}{1-\alpha})t}$. The intermediate good producer faces standard Calvo frictions. Every period, a fraction $1 - \xi_p$ of intermediate firms sets its price $P_{j,t}$ optimally. The remaining fraction follows an indexation rule $P_{j,t} = \pi^{\iota_p} \pi_{t-1}^{1-\iota_p} P_{j,t-1}$, where $\iota_p \in (0,1)$ and $\pi_t \equiv P_t/P_{t-1}$ is inflation. A variable without the subscript t denotes its steady-state value.

Labor Market.—A representative, competitive labor contractor aggregates specialized labor services $l_{k,t}^o$, where $k \in [0,1]$ and $o \in \{p, i\}$, into homogeneous labor l_t^o using the technology

$$(22) \qquad l_t^o = \left[\int_0^1 l_{k,t}^{o,\frac{1}{\lambda_w}} dk \right]^{\lambda_w}, \quad o \in \{p, i\}, \lambda_w \geq 1.$$

Aggregate labor input is then defined as

$$(23) \qquad l_t = l_t^{p,\kappa} l_t^{i,1-\kappa}, \quad \kappa \in (0,1].$$

The share κ of patient labor income in total labor income is a decisive parameter; if $\kappa = 1$ we are back to a representative agent model.

Suppose that each worker of type k is represented by a monopoly union that sets its nominal wage rate $W_{k,t}^o$, where $o \in \{p, i\}$. All monopoly unions are subject to Calvo frictions in a similar fashion to intermediate firms. A fraction $1 - \xi_w$ of monopoly unions chooses its wage optimally. The remaining fraction follows an indexation rule $W_{k,t}^o = \mu_{z^*} \pi^{\iota_w} \pi_{t-1}^{1-\iota_w} W_{k,t-1}^o$, where $o \in \{p, i\}$, $\iota_w \in (0,1)$, $\mu_{z^*} \equiv z^*/z_{-1}^*$ is the steady-state growth rate of the economy, and $\mu_{z^*,t}$ is a shock.

Capital and Housing Production.—A representative, competitive capital producer builds raw capital according to a standard technology

$$(24) \qquad \bar{K}_t = (1-\delta)\bar{K}_{t-1} + \left[1 - S^k(\zeta_{i,t} I_t / I_{t-1})\right] I_t, \quad \delta \in (0,1),$$

where I_t is investment, S^k is an increasing function defined below, and $\zeta_{i,t}$ is a shock to the marginal efficiency of investment. For simplicity, housing is in fixed supply and does not depreciate. The total housing stock is

$$\bar{H} = \bar{H}_t^p + \bar{H}_t^i, \quad \bar{H}_t^i = \int_0^1 \bar{H}_{j,t}^i dj. \tag{25}$$

Government.—The monetary authority follows a standard Taylor rule

(26)

$$R_t - R = \rho_p(R_{t-1} - R) + (1-\rho_p)\left[\alpha_\pi(E_t\pi_{t+1} - \pi) + \alpha_{\Delta y}(g_{y,t} - \mu_{z^*})\right] + \varepsilon_t^p, \rho_p \in (0,1),$$

where $\alpha_\pi, \alpha_{\Delta y} > 0$ are weights, $g_{y,t}$ is quarterly GDP growth in deviation from its steady state, and ε_t^p is a monetary policy shock. The fiscal authority collects taxes to finance public expenditures G_t and make lump-sum transfers T_t to households

$$G_t + T_t = ([u_t r_t^k - a(u_t)]\Upsilon^{-t} P_t - \delta Q_{t-1}^k) K_{t-1} \tau^k + (W_t^i l_t^i + W_t^p l_t^p)\tau^l + P_t C_t \tau^c. \tag{27}$$

Government spending is given by $G_t = z_t^* g_t$, where g_t is an exogenous-spending shock.[17] Transfers are distributed to both types of households according to their respective share in total labor income, $T_t = \kappa T_t^p + (1 - \kappa) T_t^i$.

Aggregation.—Impatient households and entrepreneurs receive idiosyncratic shocks. Perfect insurance within each agent class allows us not to keep track of individual outcomes. Online Appendix Section A1 provides details. We include an equity shock γ_t^e to the aggregate net worth of entrepreneurs. Aggregate consumption and debt are respectively

$$C_t = C_t^p + C_t^i; \qquad B_t = B_t^i + B_t^e. \tag{28}$$

Clearing in the goods market imposes

$$Y_t = G_t + C_t + \Upsilon^{-t} \mu_{\Upsilon,t}^{-1} I_t + a(u_t)\Upsilon^{-t} \bar{K}_{t-1} + D_t^b, \tag{29}$$

where D_t^b represents aggregate resources used by banks to monitor impatient households and entrepreneurs.

[17]This shock captures both changes in government expenditures and changes in net exports.

Adjustment Costs.—Adjustment costs on investment and housing are similar

(30)
$$S^o(x_t^o) = \exp\left[\sqrt{S^{o\prime\prime}/2}(x_t^o - x^o)\right] + \exp\left[-\sqrt{S^{o\prime\prime}/2}(x_t^o - x^o)\right] - 2, \quad o \in \{k, h\},$$

where $x_t^k \equiv \zeta_{i,t} I_t / I_{t-1}$ and $x_t^h \equiv \zeta_{h,t} H_t^i / H_{t-1}^i$. Note that $S^o(x^o) = S^{o\prime}(x^o) = 0$ for $o \in \{k, h\}$, and $S^{k\prime\prime}$ and $S^{h\prime\prime}$ are parameters. The utilization adjustment cost function is such that utilization in steady state is equal to one

$$a(u_t) = r^k(\exp[\sigma_a(u_t - 1)] - 1)/\sigma_a, \quad \sigma_a > 0. \tag{31}$$

Shocks.—We consider 13 shocks: ε_t, ε_t^p, g_t, γ_t^e, $\lambda_{p,t}$, $\mu_{\Upsilon,t}$, $\mu_{z^*,t}$, ν_t, η_t^i, η_t^e, $\zeta_{c,t}$, $\zeta_{h,t}$, and $\zeta_{i,t}$. All have the same structure and follow a standard AR(1) process. Let x_t be a generic shock, then

$$\ln(x_t/x) = \rho_x \ln(x_{t-1}/x) + \epsilon_t^x, \qquad \epsilon_t^x \sim N(0, {\sigma_x}^2). \tag{32}$$

To solve the model, we stationarize it and loglinearize it around the steady state. All equations of the model are listed in Online Appendix Section A2.

III. Estimation

This section describes the data and the inference about parameters.

A. Data

We estimate our model on US quarterly data covering the period from 1985Q1 to 2019Q1. These include seven standard macroeconomic variables: GDP, consumption, investment, hours worked, inflation, the federal funds rate, and the relative price of investment goods. In addition, we use four financial series: credit to households, credit to nonfinancial businesses, interest rate on household mortgage loans, and interest rate on business loans. The two rates enter as spreads relative to the federal funds rate. Online Appendix Section A3 gives a full description of the data and measurement equations.[18] We treat the series as follows. In the case of GDP, consumption, investment, household credit, and business credit we express in real, per capita terms and take the logarithmic first

[18]We use other data to calibrate parameters, match steady-state ratios, and perform out-of-sample exercises. See Online Appendix Tables A1 and A2.

difference. For the price of investment goods we express in real terms and take the log first difference. We express hours in log levels. We measure inflation, the federal funds rate, and the two spreads in levels. We demean all variables to prevent low frequency movements from interfering with the higher business cycle frequencies that interest us.

B. Calibrated and Estimated Parameters

The model has 58 parameters, including 33 structural ones and 25 related to shocks. We fix a number of them a priori based on our dataset and other sources and targets. We estimate the remaining 42 parameters using Bayesian methods.[19] Online Appendix Section A4 provides a complete discussion of the calibration, choice of priors, posterior estimates, and measures of model fit.

IV. The Collateral Shock

We begin this section by presenting evidence that suggests the collateral shock is a major driver of business cycles. We then explain the reasons behind this finding. Finally, we analyze what it is about our model that enables the collateral shock to account for the dynamics of consumption.

A. Quantifying the Role of the Collateral Shock

We start with our main result. Table 1 reports the percentage of the variance in key variables explained by the different shocks at business cycle frequency.

The collateral shock is the single most important force driving output, consumption, investment, and hours. It accounts for 45, 41, 43, and 34 percent of the variance in these macroeconomic variables, respectively. The collateral shock also explains a large chunk of the movements in financial variables. It is the main impulse behind business credit (37 percent of its variance), household and business spreads (62 and 85 respectively), and the second impulse behind household credit (16, after the housing shock at 68). As far as we know, this is the first paper in the DSGE literature that puts forward a disturbance able to drive simultaneously the four main macro variables as well as several financial series.

[19] All estimations are done using Dynare developed by Adjemian et al. (2018).

Table 1: Variance Decomposition at Business Cycle Frequency

	Collateral ν_t	Technology $\varepsilon_t, \mu_{z^*,t}, \lambda_{p,t}$	Investment $\zeta_{i,t}, \mu_{\Upsilon,t}$	Household $\zeta_{c,t}, \zeta_{h,t}, \eta_t^i$	Firm γ_t^e, η_t^e	Policy g_t, ε_t^p
Output	45	17	19	2	5	11
Consumption	41	21	6	19	4	10
Investment	43	14	31	0	6	5
Hours	34	27	21	3	4	11
Household Credit	16	9	0	72	0	1
Household Spread	62	1	1	32	0	4
Business Credit	38	16	9	0	36	2
Business Spread	86	0	1	0	11	2

Notes: The variance decomposition is computed at the posterior mode. Business cycle frequency encompasses periodic components with cycles of 6-32 quarters.

Another way to assess the importance of the collateral shock is to conduct the following experiment. We simulate our model with all the estimated shocks at once. By construction, this replicates the data exactly. Next, we simulate the model again but we shut down all shocks except the collateral shock. Figure 2 plots the outcome. In the case of investment, business credit, and the two spreads, the two lines track each other very closely. The match is also good for consumption and household credit, although the counterfactual series overshoot the actual ones in the first two recessions of the sample. The collateral shock is particularly influential during the 2008-2009 recession. Overall, this exercise confirms the leading role of the collateral shock on the economic and financial cycles of the past decades.[20]

B. Explaining the Dominance of the Collateral Shock

The reason why our empirical analysis singles out the collateral shock is the following. When hit by a collateral shock, our model generates responses that mimic actual business cycles. Let us consider an adverse realization, *i.e.* an increase in ν_t. We have in mind, for example, a sudden risk awareness in wholesale credit markets. This reduces liquidity in the financial sector and makes it harder, or costlier, to resell collateral. Banks react by tightening collateral requirements for all their borrowers—households and entrepreneurs

[20]We estimate our model from 1985Q1 to 2008Q3 to exclude the period when the nominal interest rate is at the zero lower bound (from December 2008 to December 2015). We find that the collateral shock drives 53, 27, 52, and 33 percent of the variance in output, consumption, investment, and hours, respectively.

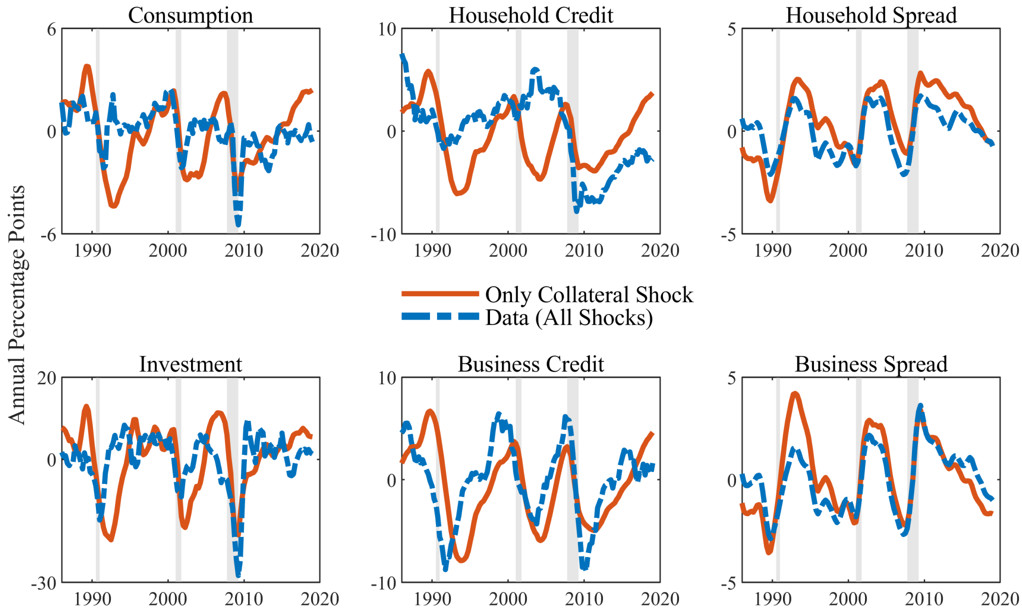

Figure 2: Isolating the Collateral Shock

Notes: The solid line is the result of simulating the model with only the estimated collateral shock, while shutting off all other shocks. The dashed line is the data.

alike. Figure 3 displays the responses of selected variables to such an event.

The first consequence is a fall in the volume of business loans (second row of Figure 3). This channel has been studied extensively in the literature. Entrepreneurs are forced to reduce their capital purchases. Investment and output drop, and intermediate firms respond by cutting down employment. The lower demand for capital generates a contraction in its price, reducing entrepreneurial net worth. This sets forth the standard financial accelerator. The fall in net worth causes a rise in leverage and makes entrepreneurs riskier. Banks charge them higher interest rates and the corporate spread shoots up. This, in turn, prevents entrepreneurs from borrowing, further reducing capital expenditures and output.

The second consequence of credit tightening is a fall in the volume of mortgage loans (third row of Figure 3). This channel has received less attention but is crucial in our story for the dynamics of consumption. Impatient households are forced to reduce their housing purchases. The price of housing falls and a second financial accelerator kicks in. As their net worth depreciates, impatient households become riskier. Banks charge them higher interest rates and the mortgage spread increases. This constrains borrowing even further: after an initial spike

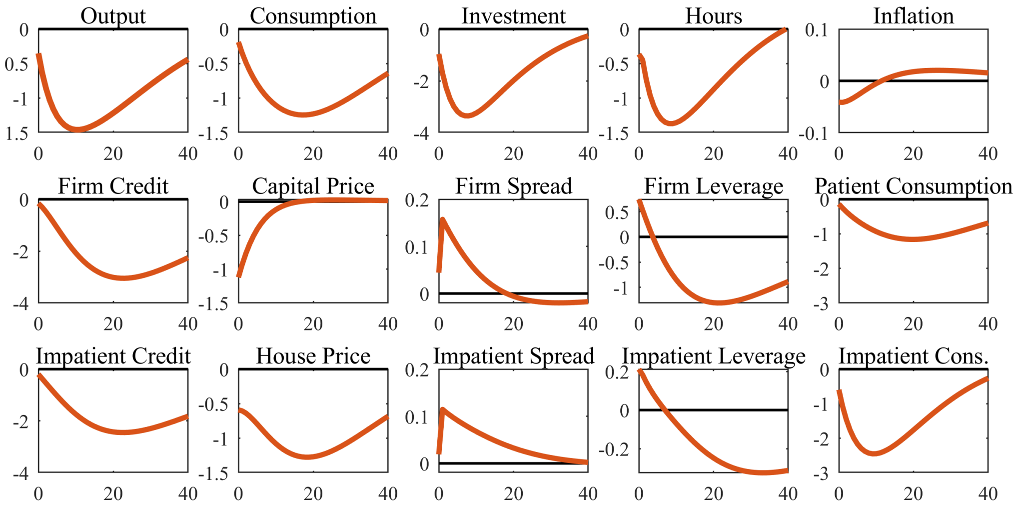

Figure 3: Response to an Adverse Collateral Shock

Notes: Impulse responses to a one standard-deviation shock. All variables are expressed in percentage deviation from their steady state. The horizontal axis is time, one period is a quarter.

in leverage, financially-constrained households are forced to deleverage.[21]

So what about consumption? The upshot is that indebted agents cut goods purchases drastically. On impact, their consumption drops by four times as much as that of patient households. The dynamics also differ: impatient consumption plunges faster than patient consumption. Aggregate consumption, as a result, falls steeply and nearly as fast as output.[22]

To sum up, the dynamics triggered by the collateral shock exhibit salient features of US business cycles: procyclical consumption, investment, employment, credit, and net worth; countercyclical credit spreads and leverage. This explains why the estimation procedure attributes such a large share of economic fluctuations to the collateral shock.

C. *The Collateral Shock and Consumption*

The main contribution of this paper is to propose a financial shock that accounts for the dynamics of consumption on top of other macroeconomic and financial variables. This result rests on one fundamental ingredient—the presence of indebted households whose access to credit varies over time. To see why, we estimate a version of the model without impatient households and thus

[21]The slow and painful debt deflation process is a stark feature of the last recession.
[22]Still, consumption falls less than output, as we observe in the data.

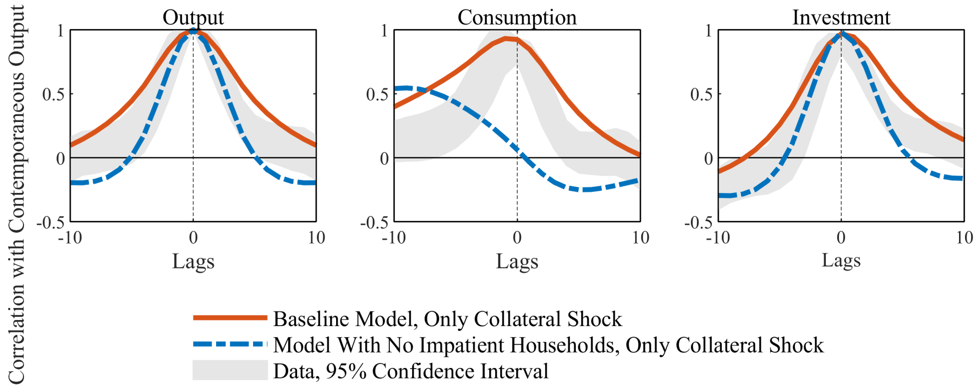

Figure 4: Cross Correlation with Output, Models Versus Data

without household credit (equivalent to setting $\kappa = 1$). In a world with only one credit channel from banks to entrepreneurs, the collateral shock becomes indistinguishable from the capital redeployment cost shock η_t^e.

We compute dynamic cross-correlations between GDP today and three variables, for $L \in [-10, 10]$, where L is the number of lags. Figure 4 plots the results. The grey area corresponds to a 95 percent confidence interval centered around the actual correlations in the data. The solid line is the correlation implied by the baseline model when only the collateral shock is active, and all other shocks are switched off. The dashed line is the correlation implied by the model without impatient households when only the collateral shock is active.

Two results emerge from Figure 4. First, in both models the collateral shock alone generates factual correlations for output and investment at almost every lag. The reason is simple. The shock reduces business credit, which causes investment to fall. Firms cut back on employment and output falls. These variables are thus highly correlated, as in the data. Second, in the model without impatient households the collateral shock fails dramatically on consumption. As explained in Section I, patient agents want to consume *more*, not less, after an adverse financial shock on firms. In the estimated model we find that counteracting general equilibrium effects dominate, in that a depressed economy with fewer hours and lower wages ultimately forces patient households to reduce consumption. But these effects are not strong enough, and consumption ends up being weakly correlated with output, unlike in the data. In our baseline specification, by contrast, the collateral shock has a direct effect on impatient household credit and consumption. This allows the model to match the procyclicality of aggregate consumption successfully.

V. Discussion

Our analysis assigns a large role in business cycles to changes in the capacity of banks to recycle collateral. In our opinion, these changes are intrinsically linked to spirits, and we view the collateral shock as a barometer of risk appetite in the financial sector. In this section we offer evidence supporting this interpretation. We start by examining lending requirements, which ought to be heavily influenced by banks' confidence about the economy. We then go one step deeper and compare the innovations of the collateral shock to several measures of financial stress. We emphasize that none of the data presented in this section was used in the estimation of the model.

A. Lending Standards

Following a positive realization of any of the three financial shocks η_t^i, η_t^e, and ν_t, banks face higher redeployment costs and respond by tightening collateral requirements on household loans ϕ_t^i, business loans ϕ_t^e, or both. To check whether this channel is relevant empirically, we plot the model's collateral requirements against actual bank lending standards. The data com from the Federal Reserve's Senior Loan Officer Opinion Survey on Bank Lending Practices (SLOOS), already discussed in the introduction. In the survey banks are asked in a given quarter if they have tightened or loosened loan requirements compared to the previous quarter. In the model collateral requirements are expressed in deviation from steady state. To make the two objects comparable, we take the cumulative sum of the survey series and remove their mean. Figure 5 shows the results. The observation period is shorter because the survey starts in 1990Q2.

The model and data series track each other very well. The correlation is 0.56 and 0.73 for household and business loans, respectively. Lending standards on firms tighten during each of the three recessions in our sample. Those on households harden in 1990, stay relatively stable during the mild 2001 recession, and tighten again dramatically in 2008. Thus, our model produces changes in lending conditions that are actually observed, regardless of the type of borrower. We see this test as an important one backing our story.

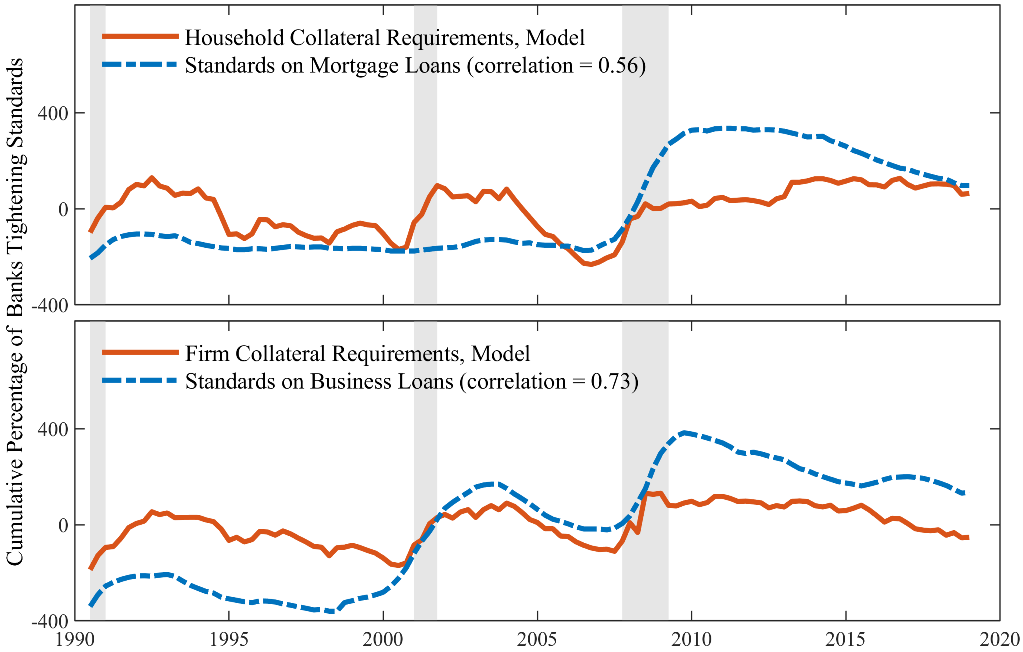

Figure 5: Bank Tightening, Model Versus Data

Notes: The solid lines plot the collateral requirements imposed by banks on households (top) and firms (bottom) in the model. The dashed lines are the cumulative sum of the net percentage of banks tightening standards for mortgage loans (top) and commercial and industrial loans to large and middle-market firms (bottom). These two data series are demeaned.

B. Financial Stress

Our second out-of-sample exercise looks at potential proxies for the collateral shock itself. We interpret the shock as the capacity of the financial sector to move collateral around. For the most part, this reflects the confidence of market participants, including investors, commercial banks, and shadow banks. Thus, in Figure 6 we confront the shock innovations to two measures of financial stress. The first one is the National Financial Conditions Index computed by the Chicago Fed. We are especially interested in the credit subindex, a composite of credit conditions. The second measure is the Gilchrist-Zakrajšek excess bond premium, an indicator of risk appetite in the corporate bond market.

The main takeaway is that our shock correlates well with these two measures. All three spike on the eve of each recession before receding in the recovery and expansion phases. A test of predictive causality indicates that the collateral shock Granger causes the two data series at the one percent confidence level, at up to five lags. We also look at the Volatility Index (VIX) implied by S&P 500

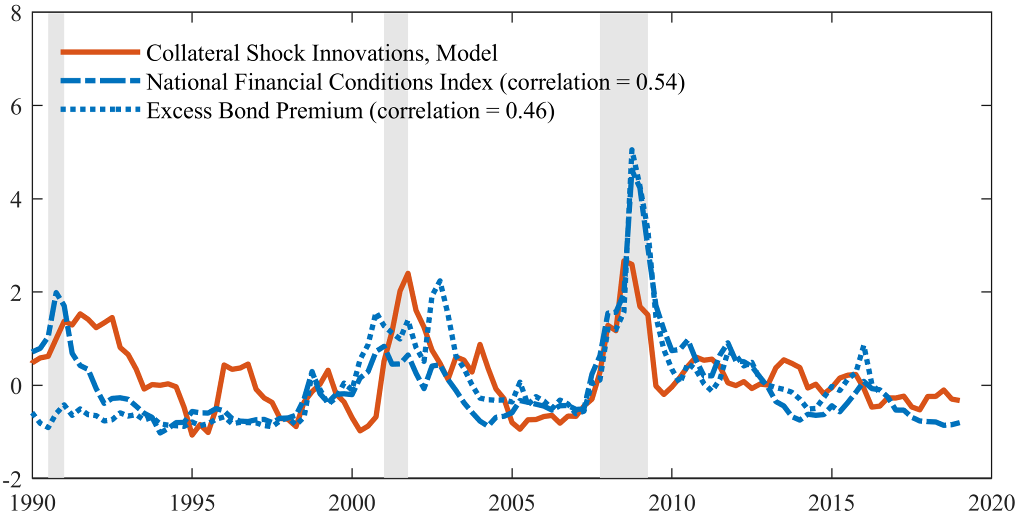

Figure 6: Financial Stress, Model Versus Data

Notes: The solid line represents the innovations to the estimated collateral shock. The dashed line is the Chicago Fed National Financial Conditions Credit subindex. The dotted line is the excess bond premium introduced by Gilchrist and Zakrajšek (2012).

index options and find very similar results: the collateral shock Granger causes the VIX at the one percent confidence level and the contemporaneous correlation is 0.46. We conclude that our theoretical object interprets reasonably as a gauge of investor sentiment.

VI. Conclusion

We study the impact of changes in lending requirements by banks on the economy. We build a macroeconomic model where banks find it costly to redeploy the collateral of their defaulting borrowers. That cost varies over time depending on market conditions, a phenomenon we refer to as the collateral shock. An adverse shock limits the amount of collateral the financial system is able to recycle and leads banks to restrict the supply of credit to households and businesses. We estimate our model on US data from 1985 to 2019 and find that the collateral shock is the most important driver of the business cycle. It accounts for the bulk of the variance in output, consumption, investment, employment, business credit, household and business credit spreads, and a sizable share of the variance in household credit. The reason why the model replicates the joint movements in consumption and other aggregates, when fed to a collateral shock, is because of its dual credit channel from banks to households and firms.

References

Adjemian, Stéphane, Houtan Bastani, Michel Juillard, Fréderic Karamé, Junior Maih, Ferhat Mihoubi, George Perendia, Johannes Pfeifer, Marco Ratto, and Sébastien Villemot. 2018. *Dynare: Reference Manual Version 4*. 1. CEPREMAP.

Ajello, Andrea. 2016. "Financial Intermediation, Investment Dynamics, and Business Cycle Fluctuations". *American Economic Review* 106.8, 2256–2303.

Amiti, Mary and David E. Weinstein. 2011. "Exports and Financial Shocks". *The Quarterly Journal of Economics* 126.4, 1841–1877.

Angeletos, George-Marios, Fabrice Collard, and Harris Dellas. 2018. "Quantifying Confidence". *Econometrica* 86.5, 1689–1726.

Angeletos, George-Marios, Fabrice Collard, and Harris Dellas. 2020. "Business Cycle Anatomy". Mimeo.

Ashcraft, Adam B. 2005. "Are Banks Really Special? New Evidence from the FDIC-Induced Failure of Healthy Banks". *American Economic Review* 95.5, 1712–1730.

Barro, Robert J. and Robert G. King. 1984. "Time-Separable Preferences and Intertemporal-Substitution Models of Business Cycles". *The Quarterly Journal of Economics* 99.4, 817–839.

Bassett, William F., Mary Beth Chosak, John C. Driscoll, and Egon Zakrajšek. 2014. "Changes in bank lending standards and the macroeconomy". *Journal of Monetary Economics* 62 (C), 23–40.

Benmelech, Efraim, Ralf R. Meisenzahl, and Rodney Ramcharan. 2017. "The Real Effects of Liquidity During the Financial Crisis: Evidence from Automobiles". *The Quarterly Journal of Economics* 132.1, 317–365.

Bernanke, Ben S., Mark Gertler, and Simon Gilchrist. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework". *Handbook of Macroeconomics*. Elsevier, 1341–1393.

Candian, Giacomo and Mikhail Dmitriev. 2020. "Default Recovery Rates and Aggregate Fluctuations". Mimeo.

Cesa-Bianchi, Ambrogio and Andrej Sokol. 2019. "Financial Shocks, Credit Spreads and the International Credit Channel". Mimeo.

Chodorow-Reich, Gabriel. 2014. "The Employment Effects of Credit Market Disruptions: Firm-level Evidence from the 2008-9 Financial Crisis". *The Quarterly Journal of Economics* 129.1, 1–59.

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy". *Journal of Political Economy* 113.1, 1–45.

Christiano, Lawrence J., Roberto Motto, and Massimo Rostagno. 2014. "Risk Shocks". *American Economic Review* 104.1, 27–65.

Del Negro, Marco, Marc P. Giannoni, and Frank Schorfheide. 2015. "Inflation in the Great Recession and New Keynesian Models". *American Economic Journal: Macroeconomics* 7.1, 168–196.

Del Negro, Marco, Gauti Eggertsson, Andrea Ferrero, and Nobuhiro Kiyotaki. 2017. "The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities". *American Economic Review* 107.3, 824–857.

Derrien, François and Ambrus Kecskés. 2013. "The Real Effects of Financial Shocks: Evidence from Exogenous Changes in Analyst Coverage". *The Journal of Finance* 68.4, 1407–1440.

Ferrante, Francesco. 2019. "Risky lending, bank leverage and unconventional monetary policy". *Journal of Monetary Economics* 101, 100–127.

Furlanetto, Francesco, Francesco Ravazzolo, and Samad Sarferaz. 2017. "Identification of Financial Factors in Economic Fluctuations". *The Economic Journal* forthcoming.

Gerali, Andrea, Stefano Neri, Luca Sessa, and Federico M. Signoretti. 2010. "Credit and Banking in a DSGE Model of the Euro Area". *Journal of Money, Credit and Banking* 42 (s1), 107–141.

Giannone, Domenico, Lucrezia Reichlin, and Luca Sala. 2004. "Monetary Policy in Real Time". *NBER Macroeconomics Annual* 19, 161–200.

Gilchrist, Simon, Jae W. Sim, and Egon Zakrajšek. 2014. "Uncertainty, Financial Frictions, and Investment Dynamics". NBER Working Papers, 20038.

Gilchrist, Simon and Egon Zakrajšek. 2012. "Credit Spreads and Business Cycle Fluctuations". *American Economic Review* 102.4, 1692–1720.

Iacoviello, Matteo. 2005. "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle". *American Economic Review* 95.3, 739–764.

Iacoviello, Matteo. 2015. "Financial Business Cycles". *Review of Economic Dynamics*. Money, Credit, and Financial Frictions 18.1, 140–163.

Jermann, Urban and Vincenzo Quadrini. 2012. "Macroeconomic Effects of Financial Shocks". *American Economic Review* 102.1, 238–271.

Justiniano, Alejandro, Giorgio E. Primiceri, and Andrea Tambalotti. 2010. "Investment shocks and business cycles". *Journal of Monetary Economics* 57.2, 132–145.

Justiniano, Alejandro, Giorgio E. Primiceri, and Andrea Tambalotti. 2018. "Credit Supply and the Housing Boom". *Journal of Political Economy* 127.3, 1317–1350.

Kiyotaki, Nobuhiro and John Moore. 2018. "Liquidity, Business Cycles, and Monetary Policy". *Journal of Political Economy* forthcoming.

Liu, Zheng, Pengfei Wang, and Tao Zha. 2013. "Land-Price Dynamics and Macroeconomic Fluctuations". *Econometrica* 81.3, 1147–1184.

López-Salido, David, Jeremy C. Stein, and Egon Zakrajšek. 2017. "Credit-Market Sentiment and the Business Cycle". *The Quarterly Journal of Economics* 132.3, 1373–1426.

Mian, Atif, Kamalesh Rao, and Amir Sufi. 2013. "Household Balance Sheets, Consumption, and the Economic Slump". *The Quarterly Journal of Economics* 128.4, 1687–1726.

Mian, Atif and Amir Sufi. 2011. "House Prices, Home Equity-Based Borrowing, and the US Household Leverage Crisis". *American Economic Review* 101.5, 2132–2156.

Mian, Atif, Amir Sufi, and Emil Verner. 2017. "Household Debt and Business Cycles Worldwide". *The Quarterly Journal of Economics* 132.4, 1755–1817.

Peek, Joe and Eric S. Rosengren. 2000. "Collateral Damage: Effects of the Japanese Bank Crisis on Real Activity in the United States". *American Economic Review* 90.1, 30–45.

Pfeifer, Johannes. 2016. "Macroeconomic Effects of Financial Shocks: Comment". Dynare Working Papers, 50.

Prieto, Esteban, Sandra Eickmeier, and Massimiliano Marcellino. 2016. "Time Variation in Macro-Financial Linkages". *Journal of Applied Econometrics* 31.7, 1215–1233.

Reinhart, Carmen M. and Kenneth S. Rogoff. 2009. "The Aftermath of Financial Crises". *American Economic Review* 99.2, 466–472.

Rodano, Giacomo, Nicolas Serrano-Velarde, and Emanuele Tarantino. 2018. "Lending Standards over the Credit Cycle". *The Review of Financial Studies* 31.8, 2943–2982.

Sargent, Thomas J. and Christopher A. Sims. 1977. "Business cycle modeling without pretending to have too much a priori economic theory". Working Papers 55, Federal Reserve Bank of Minneapolis.

Schularick, Moritz and Alan M. Taylor. 2012. "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008". *American Economic Review* 102.2, 1029–1061.

Shleifer, Andrei and Robert W. Vishny. 1992. "Liquidation Values and Debt Capacity: A Market Equilibrium Approach". *Journal of Finance* 47.4, 1343–1366.

Smets, Frank and Rafael Wouters. 2007. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach". *American Economic Review* 97.3, 586–606.