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HYLTON HOLLANDER AND GUANGLING LIU

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HYLTON HOLLANDER
DEPARTMENT OF ECONOMICS
UNIVERSITY OF STELLENBOSCH
PRIVATE BAG X1, 7602
MATIELAND, SOUTH AFRICA
E-MAIL: HOLLANDER03@GMAIL.COM

GUANGLING LIU
DEPARTMENT OF ECONOMICS
UNIVERSITY OF STELLENBOSCH
PRIVATE BAG X1, 7602
MATIELAND, SOUTH AFRICA
E-MAIL: DAVEGLIU@GMAIL.COM

UNIVERSITEIT STELLENBOSCH UNIVERSITY

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Credit spread variability in U.S. business cycles: the Great Moderation versus the Great Recession

Hylton Hollander*†and Guangling Liu ‡

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Abstract

This paper establishes the prevailing financial factors that influence credit spread variability, and its impact on the U.S. business cycle over the Great Moderation and Great Recession periods. To do so, we develop a dynamic general equilibrium framework with a central role of financial intermediation and equity assets. Over the Great Moderation and Great Recession periods, we find an important role for bank market power (sticky rate adjustments and loan rate markups) on credit spread variability in the U.S. business cycle. Equity prices exacerbate movements in credit spreads through the financial accelerator channel, but cannot be regarded as a main driving force of credit spread variability. Both the financial accelerator and bank capital channels play a significant role in propagating the movements of credit spreads. We observe a remarkable decline in the influence of technology and monetary policy shocks over three recession periods. From the demand-side of the credit market, the influence of LTV shocks has declined since the 1990−91 recession, while the bank capital requirement shock exacerbates and prolongs credit spread variability over the 2007−09 recession period. Across the three recession periods, there is an increasing trend in the contribution of loan markup shocks to the variability of retail credit spreads.

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Keywords: Financial intermediation, credit spreads, financial frictions, Great Recession

*Department of Economics, University of Stellenbosch, Stellenbosch, 7602, South Africa. E-mail address: hollander03@gmail.com

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‡Corresponding author: Department of Economics, University of Stellenbosch, Stellenbosch, 7602, South Africa. Tel: +27 21 808 2238 fax: +27 21 808 4637. E-mail address: davegliu@gmail.com

1 Introduction

The objective of this paper is to establish the prevailing financial factors that influence credit spread variability, and the mechanisms through which shocks impact credit spread variability over the Great Moderation and Great Recession periods. We specifically look at demand- and supply-side credit market frictions, the equity market and bank balance sheet adjustments. Furthermore, we investigate whether there are any contributing financial factors to credit spread variability in the recent 2007−09 Great Recession that can be distinguished from the 1990−91 and 2001 recessions during the Great Moderation. By answering these questions we gain insight into the key financial factors that propagate and amplify financial stress to the real economy.

One notable recurring characteristic of financial stress in recessions is the widening of credit spreads. Since the financial crisis reared its head in August 2007, systemic disruptions to financial intermediation have shown how large variations in credit spreads dislocate the interaction between short-term interest rates and real economic activity. The recent crisis has also called into question the lack of a prominent role for financial intermediation and multiple interest rates in dynamic macroeconomic models, and subsequently, the effectiveness of the interest-rate policy of central banks (Woodford, 2010; Gertler and Kiyotaki, 2011). Similarly, the role of the equity market cannot be ignored. As pointed out by Brunnermeier (2009) and Adrian and Shin (2011), both credit spreads and equity markets exhibited significant financial stress during the Great Recession of 2007−09, and both significantly affected real economic activity and the business cycle (see, Castelnuovo and Nisticò, 2010; Gilchrist and Zakrajšek, 2012). In fact, the 1990−91 and 2001 recessions during the Great Moderation exhibited similar financial stress through widening credit spreads and collapsing equity prices. Farmer (2012) goes further and argues that it is the stock market crash of 2008, triggered by a collapse in house prices, that caused the Great Recession.

Collapsing equity prices and widening credit spreads tend to occur at the same time. To illustrate the behavior of credit spread variability and equity prices, Figure 1 plots the logarithm of the S&P500, two retail credit spreads (the difference of the mortgage loan rate and the 3-month Treasury Bill rate and the difference of the Baa corporate bond rate and the 3-month Treasury Bill rate) and the interbank credit spread (the difference of the Fed funds rate and the 3-month Treasury Bill rate). Two observations are worth noting here. Firstly, the recessions (grey areas) of 1990−91, 2001 and 2007−09 coincided with equity price collapses of 14.7% (1990−91), 29.36% (2001) and 50.82% (2007-09), respectively. Secondly, significant credit spread widening occurred during all three recession periods.[1]

Equity plays an important role in bank capital accumulation too. Figure 2 shows the composition of bank capital over the sample period of 1982−2012.[2] Over the period 1982Q2−2003Q4 the total bank capital structure of all commercial banks in the U.S. consistently comprised of, approximately, 45% capital surplus and 44% retained earnings. However, since 2003Q4 the ratios diverged considerably, with capital surplus peaking at 77.2% and retained earnings declining to 18.8% by the end of 2009. This simple exercise shows a significant structural shift towards greater common equity capital leverage in U.S. commercial banks.

[1]Data source: Federal Reserve Bank of St. Louis's FRED database.
[2]Data source: Federal Deposit Insurance Corporation (FDIC, 2012).

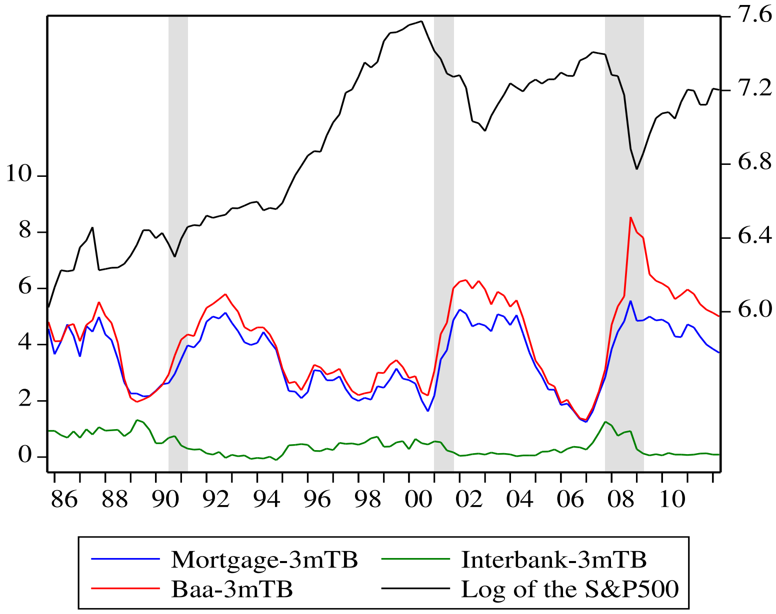

Figure 1: Financial markets and the U.S. business cycle

A volume of research on financial factors emphasizes both credit demand- and supply-side restrictions that exacerbate the business cycle. For example, creditworthiness and net worth constrain the borrowing ability of households and firms (Bernanke et al., 1999; Iacoviello, 2005), while bank capital requirements, interest rate stickiness and value-at-risk constraints impose frictions in financial intermediaries (Gerali et al., 2010; Adrian and Shin, 2011). Although demand-side factors are important for financial accelerator effects, the consensus highlights the importance of financial intermediaries in propagating financial instability to real economic activity—through both the composition of balance sheet aggregates and the widening of credit spreads. Some studies focus on how to curtail the effects of credit market frictions or bank balance sheet adjustments on real economic activity through either conventional or unconventional monetary policies. Cúrdia and Woodford (2010) use a basic New-Keynesian model with credit frictions and minimal financial intermediary structures to investigate the interaction between credit spread variability and monetary policy. Adrian and Shin (2011) and Gertler and Kiyotaki (2011) centralize the role of financial intermediation in macroeconomic models to conform more closely to current institutional realities. While these two studies successfully highlight potential causes and consequences of the recent U.S. credit cycle, their frameworks have yet to be fully adapted to the New-Keynesian framework. It is clear though, there have been significant changes in financial intermediation over the last three decades. What is unclear is whether the transmission mechanism of financial intermediation has evolved over the Great Moderation and Great Recession periods (Ireland, 2011, p.52).

To understand the sources of credit spread variability, and the mechanisms through which they impact credit spread variability, we develop a New-Keynesian dynamic stochastic general equilibrium (DSGE) model with a central role for financial intermediation and equity markets. On the one hand, the model captures how financial intermediaries adjust interest rates in response to their own balance sheet adjustments and

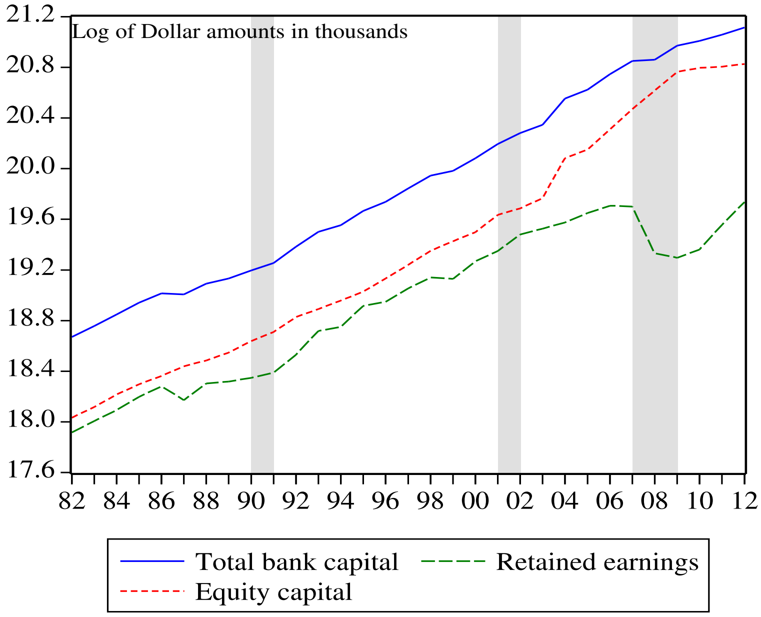

Figure 2: Composition of bank capital for all U.S. commercial banks

that of nonfinancial borrowers. This is along the lines of Bernanke and Gertler (1995), in which the authors argue that the balance sheet channel (financial accelerator channel) is one of the two important mechanisms through which monetary policy affects the size of the external finance premium in credit markets and, hence, real economic activity.[3] On the other hand, the model reveals an important role of equity prices in affecting real economic activity through the financial accelerator channel and the bank capital channel.

The contribution of our paper is two-fold. Firstly, it synthesizes recent milestones in the New-Keynesian DSGE literature on financial intermediation (e.g., Cúrdia and Woodford, 2009; Gerali et al., 2010) and the fundamental factors of the Great Recession in the U.S. economy (e.g., Ireland, 2011; Farmer, 2012). That said, we present a centralized framework of financial intermediaries' interest rate setting behavior in the transmission of nominal, real and financial shocks. In terms of the model setup, this paper contributes to the DSGE literature by introducing a role for the equity market in households, firms and banks' resource allocation. For our second contribution, we investigate whether financial factors that affect credit spread variability and their behavior have fundamentally changed over the the Great Moderation and the Great Recession periods.

The results show that supply-side factors are the primary source of credit spread variability, which is along the lines of Gilchrist and Zakrajšek (2012). That is, retail loan markups account for more than half of the variability of retail credit spreads and sticky rate adjustments significantly alter the path of retail loan rates relative to the policy rate. Monetary policy has a strong influence on the short-term interbank rate, whereas the effectiveness of interest-rate policy on long-term nonfinancial loan rates is much weaker. Equity prices exacerbate movements in credit spreads through the financial accelerator channel, but cannot be regarded as a main driving force of credit spread variability. Both the financial accelerator and bank capital channels play

[3]The other mechanism is the bank lending channel.

a significant role in propagating the movements of credit spreads. In contrast to Ireland (2011), we observe a remarkable decline in the influence of technology and monetary policy shocks over three recession periods. From the demand-side of the credit market, the influence of LTV shocks has declined since the 1990−91 recession, while the bank capital requirement shock exacerbates and prolongs credit spread variability over the 2007−09 recession period. Moreover, across the three recession periods, there is an increasing trend in the contribution of loan markup shocks to the variability of retail credit spreads.

The rest of the paper is organized as follows. Section 2 defines the credit spread transmission mechanism of financial intermediation. Section 3 develops the New-Keynesian DSGE model with financial market interactions, and Section 4 presents the Bayesian estimation results. Sections 5.1 investigates financial factors that affect credit spread variability, and Section 5.2 compares the influence of financial factors on credit spread variability over the Great Moderation and Great Recession periods. Section 5.3 provides a robustness analysis of the baseline model. Section 6 concludes.

2 The transmission mechanisms of credit spread variability

In this section we define the four transmission mechanisms of credit spread variability in the DSGE model with credit and banking. On the supply side of the credit market we have bank market power and bank balance sheet adjustments. On the demand side, we have the creditworthiness of nonfinancial borrowers (the financial accelerator channel). The fourth transmission mechanism is the equity price channel.

Credit supply factors fall under two types of banking operations. On the one hand, commercial banks are monopolistically competitive, and supply long-term loans to nonfinancial borrowers (households and entrepreneurs) in the retail market. Credit spread variability arises from interest-rate stickiness and stochastic retail rate markups. This bank market power is the mechanism by which long-term retail loan rates adjust disjointedly to short-term interest rates. Investment banks, on the other hand, provide short-term funding to commercial banks in the interbank market, and finance their interbank lending with deposits and bank capital.

In the interbank market, bank capital-asset requirements influence the adjustment of the effective interbank rate. Because investment bank assets are subject to a bank capital-asset requirement, for a given quantity of bank capital, the supply schedule for interbank funds will be upward sloping (Woodford, 2010, p.31-32). In contrast, the downward sloping demand schedule for interbank funding depends on the quantity of available interbank funds at any given retail credit spread. The intersection of the supply and demand schedules determines the equilibrium quantity of interbank funds and the prevailing credit spreads. Shocks to bank funding (either bank capital) therefore directly affect the supply of liquidity to liquidity to nonfinancial borrowers. As a result, financial intermediation in the interbank market and in the retail credit market has a direct impact on the efficient allocation of resources in real economic activity (Woodford, 2010, p.29-35).

The financial accelerator channel captures the demand side transmission mechanism of credit spread variability. Here, household creditworthiness and entrepreneur net worth influence the external finance premium.[4] That is, the ability of borrowers to collateralize their external financing is inversely related to the cost of credit (Bernanke and Gertler, 1995, p.35). As a result, low net worth or collateral during recessions causes credit spreads to widen. Conversely, during boom phases improved creditworthiness causes credit spreads to narrow.

We identify the equity price channel as a separate transmission mechanism in credit spread variability. The price of equity is determined by households' demand for equity investment. To generate the strong correlation between equity prices and credit spreads (Figure 1) we provide a role for equity in nonfinancial borrowers' creditworthiness and bank capital. As a result, the equity price channel influences credit spreads through both the financial accelerator channel and the bank capital channel. For example, an equity price collapse reduces borrower creditworthiness which puts upward pressure on retail credit spreads from the demand side. On the supply side, a fall in the bank capital-asset ratio induces financial distress in over-leveraged banks, which widens the interbank spread.

3 Model economy

To begin with, the credit spreads in this study are defined as follows. The spread between the policy rate and the interbank rate is the interbank credit spread, whereas the spread between the interbank rate and the long-term retail loan rate is the retail credit spread.[5]

Households borrow bank loans to finance their consumption, hold safe assets (e.g., bank deposits and government bonds), and invest in the equity market. Entrepreneurs demand homogenous labor to produce wholesale goods. Monopolistically competitive branders in the retail goods sector introduce Calvo-type sticky prices, whereas unions aggregate labor supply and introduce the Calvo-type sticky wages in the model. The model is closed by assuming that the monetary authority follows the conventional Taylor-type monetary policy rule.

3.1 Financial intermediation

There is a continuum of bank units, where each bank $j \in [0, 1]$ consists of an investment bank and a commercial bank. We assume that the commercial bank is a wholly-owned subsidiary of the investment bank, and the consolidated profits are used as retained earnings at the end of each period (see, Gerali et al., 2010).

3.1.1 Investment Bank

The investment bank chooses household safe assets (B_t) and the amount of interbank lending to commercial banks (L_t^c) to maximize periodic discounted cash-flows:

[4] The external finance premium is the difference between the cost of external financing (equity or debt) and internal financing (retained earnings).

[5] In the literature, the net interest spread is the difference between the rates at which banks borrow and lend. Cúrdia and Woodford (2009) refer to the net interest spread as the credit spread, while Adrian and Shin (2011, p.602) refer to it as the term spread.

$$E_0 \sum_{t=0}^{\infty} \beta_B^t \left[i_t^c L_t^c - i_t B_t - \frac{\kappa_k}{2} \left(\frac{K_t^B}{L_t^c} - \tau_t \right)^2 K_t^B \right] \tag{1}$$

subject to the binding balance sheet identity

$$L_t^c = K_t^B + B_t, \tag{2}$$

where K_t^B is the total bank capital. The coefficient κ_k captures the quadratic adjustment cost of the deviation of the current capital-assets ratio (K_t^B/L_t^c) from a target capital requirement ratio (τ_t), according to the Basel regulations. τ_t follows an exogenous AR(1) process. This banking sector setup allows for interbank credit spread variability emanating from capital-asset ratio adjustments relative to exogenous innovations in τ_t. For example, when financial stress hits the interbank market banks raise their desired capital requirement, which immediately raises the interbank spread. As banks are accumulating larger capital buffers and the capital-asset ratio is converging towards the target τ_t, the interbank credit spread becomes narrower.

The bank capital accumulation equation is as follows:

$$K_t^B = (1 - \delta_B) K_{t-1}^B + \phi_\psi (Q_t^\psi - Q_{t-1}^\psi) \Psi^B + \Pi_{\psi,t-1}^B. \tag{3}$$

We assume that the initial stock of bank equity (Ψ^B) remains unchanged. What matters here is the market capitalization of bank equity ($Q_t^\psi \Psi^B$). As the market value of bank equity increases, bank capital accumulates and, in turn, the feasible credit supply increases (i.e. a rightward shift of the credit supply schedule). ϕ_ψ measures the pass-through effect of equity price changes on total bank capital. δ_B is the bank capital depreciation rate, capturing management costs for banks. Retained earnings ($\Pi_{\psi,t-1}^B$) are bank profits net of dividend payments.

We assume no frictions between short-term safe asset classes, and the investment bank has access to unlimited funds from the central bank at the policy rate i_t. Therefore, arbitrage implies that investment banks remunerate household safe assets at i_t. Conversely, for the supply of interbank funds, the commercial bank remunerates investment bank assets at i_t^c. Combining the first order conditions for B_t and L_t^c gives the interbank credit spread between the interbank loan rate and the policy rate,

$$i_t^c = i_t - \kappa_k \left(\frac{K_t^B}{L_t^c} - \tau_t \right) \left(\frac{K_t^B}{L_t^c} \right)^2. \tag{4}$$

3.1.2 Commercial bank

Commercial bank j differentiates $L_{j,t}^c$ at zero cost and sells them to households and entrepreneurs at their individual markups. All commercial banks $j \in [0,1]$ apply a symmetrical objective function for all loan types indexed $z = e, h$, described as the following:

$$\max_{\{i_{j,t}^z\}} E_0 \sum_{t=0}^{\infty} \beta_B^t \left[i_{j,t}^z L_{j,t}^z - i_t^c L_{j,t}^c - \frac{\kappa_z}{2} \left(\frac{i_{j,t}^z}{i_{j,t-1}^z} - 1 \right)^2 i_t^z L_t^z \right]$$

subject to loan demand schedules (indexed $z = e, h$) from households and entrepreneurs

$$L^z_{j,t} = \left(\frac{i^z_{j,t}}{i^z_t}\right)^{-\varepsilon^z_t} L^z_t. \tag{5}$$

We assume that the interbank market determines the feasible quantity of loans in the retail sector, therefore, $L^c_{j,t} = L_{j,t} = L^h_{j,t} + L^e_{j,t}$ (see also, Gerali et al., 2010; Woodford, 2010). Risk on the quality of commercial bank assets enters through a value-at-risk constraint: $(1 + i^c_t)L^c_{j,t} \leq \nu_B(1 + i^z_{j,t})L^z_{j,t}$. Where ν_B is the interbank loan-to-value ratio.[6]

In the symmetric equilibrium the first order conditions give household and entrepreneur loan rates. Under flexible interest rates ($\kappa_z = 0$) and no value-at-risk constraint, retail loan rates i^z_t are a markup over marginal cost i^c_t:

$$i^z_t = \frac{\varepsilon^z_t}{\varepsilon^z_t - 1} i^c_t. \tag{6}$$

Subsequently, we define the retail rate markup over i^c_t as the retail credit spread. Therefore, for each loan type z, the sum of the interbank credit spread and retail credit spread gives the net interest spread (as in Cúrdia and Woodford (2009)) between i^z_t and i_t.

Using the log-linearized equations for loan rate setting, we derive the retail credit spread S^z_t:

$$S^z_t = \hat{i}^z_t - \hat{i}^c_t = \frac{\kappa_z}{\kappa^*_z}\hat{i}^z_{t-1} + \frac{\beta_B\kappa_z}{\kappa^*_z}E_t\hat{i}^z_{t+1} + \frac{(1+\nu_B)(\varepsilon^z - 1) - (1+\beta_B)\kappa_z}{\kappa^*_z}\hat{i}^c_t + \frac{(1-\nu_B)(\varepsilon^z - 1)}{\kappa^*_z}\mu_{z,t}, \tag{7}$$

where $\mu_{z,t}$ is the stochastic process for retail rate markups imposed by commercial banks, and $\kappa^*_z = (1 - \nu_B)(\varepsilon^z - 1) + (1 + \beta_B)\kappa_z$. Eq. 7 shows that entrepreneur and household loan rate setting depends on: the stochastic markup, past and expected future loan rates, and the marginal cost of the loan branch $(\hat{i}^c_t)$ which depends on the policy rate and the balance sheet position of the bank. A positive adjustment of the interbank rate puts upward pressure on retail loan rates. As ν_B tends to one, the influence of the interbank rate over retail rate setting increases, while the influence of the stochastic markup decreases. In contrast, a higher adjustment cost (κ_z) smoothes the adjustment of retail loan rates and, hence, retail credit spreads.

3.2 Households

We adopt the conventional consumption-based asset pricing framework for equity. The demand driven equity price is market determined by contemporaneous wealth effects on households' intertemporal consumption choices, capital gains (or losses) and dividend payments. Moreover, equity is redeemable as collateral for bank loans.

The representative household derives utility from consumption and leisure choices, and financial wealth services in the form of safe assets (see also, Iacoviello, 2005; Christiano et al., 2010). Households maximize expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t_h \left[\frac{(C_t - \phi C_{t-1})^{1-\gamma}}{1-\gamma} - \frac{(H_t)^{1+\eta}}{1+\eta} + \xi_{b,t} ln \frac{B_t}{P_t}\right], \tag{8}$$

[6] See Woodford (2010, p.32) and Adrian and Shin (2011, p.608-9). Our technical appendix discusses the setup in more detail.

where β_h^t is the discount factor. The coefficient of relative risk aversion γ measures the curvature of the household's utility function with respect to its argument $C_t - \phi C_{t-1}$, where C_t is real consumption at time t and habit formation is parameterized by ϕ. η is the Frisch elasticity of labor supply with respect to hours worked (H_t). Households' preferences are subject to a demand shock $\xi_{b,t}$ on real safe asset balances (B_t/P_t).

The representative household's budget constraint is as follows:

$$C_t + \frac{B_t}{P_t} + \xi_{\psi,t}\frac{Q_t^\psi}{P_t}\Psi_t + \frac{I_{t-1}^h L_{t-1}^h}{P_t} = \frac{W_t}{P_t}H_t + \frac{I_{t-1}B_{t-1}}{P_t} + \frac{L_t^h}{P_t} + \frac{(Q_t^\psi + \Pi_{\psi,t})}{P_t}\Psi_{t-1}. \tag{9}$$

The household allocates periodic wage income ($W_t H_t$), gross return on safe assets ($I_{t-1}B_{t-1}$), capital gains/losses ($Q_t^\psi \Psi_{t-1}$), real dividends ($\Pi_{\psi,t}$) and new loans (L_t^h) to current consumption, new asset holdings and the repayment of previous loans ($I_{t-1}^h L_{t-1}^h$). $\xi_{\psi,t}$ is an equity price shock. The dividend policy is defined as a proportion ζ_ψ (the steady-state dividend yield) of the value of each household's equity holdings. In addition to the budget constraint, the household also faces a borrowing constraint

$$I_t^h L_t^h \leq \nu_{h,t}\big[\phi_w W_t H_t + (1-\phi_w)Q_t^\psi \Psi_t\big]. \tag{10}$$

The household's wage income together with her investment in the equity market serve as a measure of creditworthiness, where $0 \leq \phi_w \leq 1$ is the weight on wage income. $\nu_{h,t}$ is a stochastic loan-to-value ratio and, correspondingly, in cases of default $1 - \nu_{h,t}$ can be interpreted as the proportional transaction cost for bank's repossession of borrower's collateral. Following the literature (e.g., Iacoviello, 2005), we assume the size of shocks is small enough so that the borrowing constraint is always binding.

The representative household's first order conditions for hours worked, household loans, safe assets and equity are as follows:

$$\frac{W_t}{P_t} = \frac{(H_t)^\eta}{\Lambda_t} - \lambda_t \Lambda_t^{-1}\nu_{h,t}\phi_w \frac{W_t}{P_t}, \tag{11}$$

$$\Lambda_t = \beta_h E_t\left[\Lambda_{t+1}\frac{I_t^h}{\Pi_{t+1}}\right] + \lambda_t I_t^h, \tag{12}$$

$$a\xi_{b,t}\left(\frac{B_t}{P_t}\right)^{-1} = \Lambda_t - \beta_h E_t[\Lambda_{t+1}R_t], \tag{13}$$

$$1 = \beta_h E_t\left[\left(\frac{\Lambda_{t+1}}{\Lambda_t}\right)\left(\frac{Q_{t+1}^\psi + \Pi_{\psi,t+1}}{\xi_{\psi,t}Q_t^\psi}\right)\frac{1}{\Pi_{t+1}}\right] - \lambda_t\Lambda_t^{-1}\nu_{h,t}(1-\phi_w), \tag{14}$$

where $\Lambda_t = (C_t - \phi C_{t-1})^{-\gamma}$ is the marginal utility of consumption and the Lagrangian multiplier of the household's budget constraint. The Lagrangian multiplier λ_t is the marginal utility of an additional unit of loans. Eq. 11 is the household's labor supply schedule. Eq. 12 is the consumption Euler equation. Eq. 13 indicates that the demand for assets depends on households' consumption and the real return to safe assets (R_t), where $R_t < R_t^h \; \forall \, t$.[7] Eq. 14 gives the consumption-based asset pricing equation for equity investment. Specifically, the resulting equilibrium market price for equity incorporates demand-side wealth effects on consumption.

[7] $R_t^h = I_t^h/\Pi_{t+1}$ is the real return on household loans.

3.3 Retailers

The retail sector, characterized by monopolistically competitive branders, introduces Calvo-type sticky prices into the model (see, Bernanke et al., 1999; Iacoviello, 2005). Retailers purchase intermediate goods $Y_{j,t}$ from entrepreneurs at the wholesale price $P^W_{j,t}$ in a competitive market, and differentiate them at no cost into $Y_{k,t}$. Each retailer sells $Y_{k,t}$ with a mark-up over $P^W_{j,t}$ at price $P_{k,t}$, taking into account their individual demand curves from consumers. Following Calvo (1983), we assume that the retailer can only adjust the retail price with probability $(1-\theta_R)$ in each period. Therefore, the decision problem for the retailer is

$$\max_{\{P^*_{k,t}\}} E_t \sum_{z=0}^{\infty} \theta_R^z \Lambda^R_{t,z} \left[P^*_{k,t} Y_{k,t+z} - P^W_{j,t+z} X Y_{k,t+z} \right] \tag{15}$$

subject to the consumer demand schedule for goods

$$Y_{k,t+z} = (\frac{P^*_{k,t}}{P_{t+z}})^{-\varepsilon^p_t} Y_{t+z}, \tag{16}$$

where $\Lambda^R_{t,z} = \beta^z(\Lambda_{t,z}/\Lambda_t)$ is the consumption-based relevant discount factor. $P^*_{k,t}$ denotes the optimal sales price set by the retailers, who are able to adjust the price in period t. $X_t \equiv P_t/P^W_t$ is the aggregate markup of the retail price over the wholesale price. In steady state, $X = \varepsilon^p/(\varepsilon^p - 1)$, where ε^p is the steady state price-elasticity of demand for intermediate good $Y_{j,t}$.

The aggregate price level is determined by

$$(P_t)^{1-\varepsilon^p_t} = \theta_R(\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_p} P_{t-1})^{1-\varepsilon^p_t} + (1-\theta_R)(P^*_t)^{1-\varepsilon^p_t}, \tag{17}$$

where γ_p determines the degree of price indexation for non-optimizing retailers. Solving and linearizing the optimization problem and combining it with Eq. 17 gives the forward-looking New-Keynesian Phillips curve, as in the literature.

3.4 Entrepreneurs

The representative entrepreneur produces the intermediate good $Y_{j,t}$ using a standard Cobb-Douglas production function

$$Y_{j,t} = \xi_{z,t} K^{\alpha}_{j,t-1} H^{1-\alpha}_{j,t}, \tag{18}$$

where $0 < \alpha < 1$. $K_{j,t-1}$ is physical capital and $\xi_{z,t}$ is an exogenous technology shock for total factor productivity. The representative entrepreneur faces the following borrowing constraint

$$I^e_{j,t} L^e_{j,t} \leq \nu_{e,jt}[\phi_k Q^k_{j,t} K_{j,t-1} + (1-\phi_k) Q^{\psi}_{j,t} \Psi^e_j], \tag{19}$$

where $\phi_k \in (0,1)$ is the weight on physical capital stock. $Q^k_{j,t}$ is the nominal price of physical capital, $\nu_{e,jt}$ is an exogenous stochastic loan-to-value ratio, and $I^e_{j,t}$ is the gross nominal interest rate on entrepreneur bank loans ($L^e_{j,t}$). The market value of physical capital ($Q^k_{j,t} K_{j,t-1}$) and the initial stock of entrepreneur equity

$(Q^{\psi}_{j,t}\Psi^e_j)$ serve as a measure of creditworthiness.[8] The equity market is introduced into the production sector in such a way that it has an impact on the entrepreneur's resource allocation and, in turn, the productivity of the economy.

Following Iacoviello (2005), we assume that in each period the representative entrepreneur chooses the desired amount of physical capital, labor and bank loans to maximize

$$E_0 \sum_{t=0}^{\infty} \beta_e^t \left[\frac{(C^e_{j,t})^{1-\gamma^e}}{1-\gamma^e} \right] \tag{20}$$

subject to the production technology (Eq. 18), borrowing constraint (Eq. 19) and the following flow of funds constraint

$$\frac{Y_{j,t}}{X_{j,t}} + \frac{L^e_{j,t}}{P_t} = C^e_{j,t} + \frac{I^e_{j,t-1}L^e_{j,t-1}}{P_t} + \frac{W_t}{P_t}H_{j,t} + V_{j,t} + Adj^e_{j,t} + \Pi^e_{\psi,jt}. \tag{21}$$

Adj^e_t captures capital adjustment costs:

$$Adj^e_{j,t} = \kappa_v(\frac{V_{j,t}}{K_{j,t-1}} - \delta_e)^2 \frac{K_{j,t-1}}{(2\delta_e)}, \tag{22}$$

where $V_{j,t}$ is the investment used to accumulate capital, $K_{j,t} = (1-\delta_e)K_{j,t-1} + V_{j,t}$, and κ_v is the variable capital adjustment cost parameter. $\Pi^e_{\psi,t} = (\zeta_\psi Q^\psi_t \Psi^e_j)/P_t$ is the real dividend paid out. We assume entrepreneurs are more impatient than households ($\beta^t_e < \beta^t_h$) and, therefore, γ^e should be less than γ. Iacoviello (2005) adopts log utility ($\gamma^e = 1$) for entrepreneurs. This implies that entrepreneurs are not risk neutral, but rather lie between being extremely risk averse and risk neutral. here, we add the risk aversion coefficient to capture the degree of impatience of entrepreneurs, while the usual binding constraint conditions must hold $(1/I^e - \beta_e) > 0)$.

The first order conditions for hours worked, bank loans and physical capital are the following:

$$\frac{W_t}{P_t} = \frac{(1-\alpha)Y_{j,t}}{H_{j,t}X_{j,t}}, \tag{23}$$

$$(C^e_{j,t})^{-\gamma^e} = \beta_e E_t \left[(C^e_{j,t+1})^{-\gamma} \frac{I^e_{j,t}}{\Pi_{t+1}} \right] + \lambda_{j,t} I^e_{j,t}, \tag{24}$$

$$\begin{aligned} Q^k_{j,t} = \; & \beta_e E_t \Bigg[\frac{1}{(C^e_{j,t+1})^{\gamma^e}} \left(\frac{\kappa_v}{\delta_e} \left(\frac{V_{j,t+1}}{K_{j,t}} - \delta_e \right) \frac{V_{j,t+1}}{K_{j,t}} - \frac{\kappa_v}{2\delta_e} \left(\frac{V_{t+1}}{K_{j,t}} - \delta_e \right)^2 \right) \\ & + Q^k_{j,t+1}(1-\delta_e) + \frac{\alpha Y_{j,t+1}}{(C^e_{j,t})^{\gamma^e} X_{j,t+1} K_{j,t}} \Bigg] + \lambda_{j,t}\nu_{e,jt}\phi_k Q^k_{j,t}, \end{aligned} \tag{25}$$

where $\lambda^e_{j,t}$ is the Lagrangian multiplier of the borrowing constraint. Eq. 25 is the investment schedule, where the shadow price of physical capital is defined as $Q^k_{j,t} = (C^e_{j,t})^{-\gamma^e}(1 + \kappa_v/\delta_e(V_{j,t}/K_{j,t-1} - \delta_e))$. The investment schedule states that the shadow price of capital must equal the expected marginal product of capital plus the discounted expected shadow price and capital adjustment costs. Eq. 23 is the standard labor demand schedule. Eq. 24 gives the entrepreneur consumption Euler equation.

[8] In other words, they serve as a market-based signal for entrepreneurs' net worth and hence collateral.

3.5 Labor supply decisions and the wage-setting equation

The wage-setting equilibrium stems from the work of Gali et al. (2007). Monopolistically competitive unions set the optimal wage at the prevailing labor demand equilibrium. There is a continuum of unions, each union represents workers of a certain type τ uniformly distributed across all households.

The unions' problem is to choose $\{W_t^\tau\}_{t=0}^{\infty}$ to maximize the consumption-weighted wage income of their workers. However, following Calvo (1983), in each time period only a random fraction $1-\theta_w$ of unions have the opportunity to reset the optimal wage (W_t^*) for its workers, whereas those unions that cannot reset wages simply index to the lagged wage rate, as in Christiano et al. (2005) and Smets and Wouters (2007). Therefore, the wage index is given by

$$(W_t)^{1-\varepsilon^w} = \theta_w(\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_w} W_{t-1})^{1-\varepsilon^w} + (1-\theta_w)(W_t^*)^{1-\varepsilon^w}, \tag{26}$$

where γ_w is the degree of wage indexation, and the objective function for the optimal wage is as follows:[9]

$$\max_{\{W_t^*\}} E_t \sum_{i=0}^{\infty} (\theta_w \beta_h)^i \left[\left(\frac{W_t^* H_{t+i}^\tau}{P_{t+i}\tilde{C}_{t+i}} - \frac{(H_{t+i}^\tau)^{1+\eta}}{1+\eta}\right)\right],$$

subject to the the labor demand schedule

$$H_{t+i}^\tau = \left(\frac{W_t^*}{W_{t+i}}\right)^{-\varepsilon_t^w} H_{t+i}.$$

Assuming a constant wage elasticity of substitution ($\varepsilon_{t=0}^w$), the first order condition for W_t^* is

$$E_t \sum_{i=0}^{\infty} (\theta_w \beta_h)^i \left[\frac{W_t^*}{P_{t+i}}\left(\frac{1}{MRS_{t+i}}\right)\right] = E_t \sum_{i=0}^{\infty} (\theta_w \beta_h)^i \left[\mu^w \left(\frac{W_t^*}{W_{t+i}}\right)^{-\varepsilon^w \eta}\right],$$

where $MRS_{t+i} = \tilde{C}_{t+i} H_{t+i}^\eta$ is the marginal rate of substitution between consumption and leisure for households and $\mu^w = \varepsilon^w/(\varepsilon^w - 1)$ is the steady-state wage markup.

Log-linearizing and solving for w_t^* gives the optimal wage equation

$$w_t^* = \frac{(1-\theta_w\beta_h)}{(\varepsilon^w\eta + 1)} E_t \sum_{i=0}^{\infty} (\theta_w\beta_h)^i \Big(\chi mrs_{t+i} + \varepsilon^w \eta w_{t+i} + p_{t+i}\Big), \tag{27}$$

where $\chi \equiv W/MRS\mu^w$.

Combining Eq. 27 with the log-linearized aggregate wage index (26) gives the aggregate sticky wage equation

$$\begin{aligned} w_t = {} & \Phi w_{t-1} + \Phi\beta_h E_t w_{t+1} + \Phi^*(\varepsilon^w \eta w_t + \chi mrs_t) \\ & + \Phi\beta_h E_t \pi_{t+1} - \Phi\pi_t - \Phi\theta_w\beta_h\gamma_w\pi_t + \Phi\gamma_w\pi_{t-1}, \end{aligned} \tag{28}$$

where $\Phi^* = (1-\theta_w)(1-\theta_w\beta_h)/(1+\theta_w^2\beta_h)(1+\varepsilon^w\eta)$ and $\Phi = \theta_w/(1+\theta_w^2\beta_h)$.

[9] Here $\tilde{C}_{t+i}$, defined as $\tilde{C}_{t+i} = (C_{t+i} - \phi C_{t+i-1})^\gamma$, captures households' consumption preferences.

3.6 Monetary policy and market clearing conditions

The monetary authority follows a Taylor-type interest-rate policy

$$I_t = (I_{t-1})^{\kappa_i} \left(\frac{\Pi_t}{\Pi^{target}} \right)^{\kappa_\pi (1-\kappa_i)} \left(\frac{Y_t}{Y_{t-1}} \right)^{\kappa_y (1-\kappa_i)} \xi_{i,t}, \tag{29}$$

where κ_i is the weight on the lagged policy rate, κ_π is the weight on inflation, and κ_y is the weight on output growth. $\xi_{i,t}$ is the monetary policy shock following an AR(1) stochastic process.

The market clearing conditions are as follows. The aggregate resource constraint for the economy is

$$Y_t = C_t + C_t^e + V_t + \delta_B \frac{K_{t-1}^B}{\Pi_t}, \tag{30}$$

where $\delta_B K_{t-1}^B$ represents the banks' management cost in terms of bank capital. Similar to Iacoviello (2005), we close the model by including the entrepreneur flow of funds constraint (21).

In the equity market, the aggregate demand for equity shares across a continuum of households implies that $\Psi_t \equiv \Psi$. Market clearing in the equity market therefore requires the assumption of a constant total stock of equity shares in the whole economy. Given this assumption, entrepreneurs and banks do not issue new shares and $\Psi^e + \Psi^b = \Psi$. The usual market clearing aggregation applies for consumption and loans.

3.7 Exogenous shocks

In the model, there are ten exogenous shocks that follow AR(1) processes with independent and identically distributed standard deviations. The three core New-Keynesian shocks are the technology shock ($\xi_{z,t}$), the price markup shock (ε_t^p) and the monetary policy shock (ξ_t^i). We introduce seven additional shocks in the financial sector. On the supply side of credit, we have a capital requirement shock (τ_t) in the interbank market and two retail loan rate markup shocks to household loans ($\mu_{h,t}$) and entrepreneur loans ($\mu_{e,t}$). On the demand side of credit, household loans and entrepreneur loans are subject to loan-to-value shocks $\nu_{h,t}$ and $\nu_{e,t}$, respectively. Households' intertemporal consumption decisions are subject to an exogenous shock to households' safe-asset holdings ($\xi_{b,t}$). Finally, an equity price shock ($\xi_{\psi,t}$) contemporaneously affects consumption, production and bank lending activities.

4 Estimation

We estimate the model with Bayesian techniques using U.S. data over the sample period 1982Q2−2012Q3. The full sample covers the recession periods of 1990Q3−1991Q2, 2001Q1−2001Q4 and 2007Q4−2009Q2, and we define the Great Moderation period as of 1982Q2−2006Q4.[10] Since the model has a total of 10 shocks, our data set contains 10 observable variables: output, inflation (GDP deflator), equity price, household loans, entrepreneur loans, household assets, 3-month Treasury Bill rate, Fed funds rate, mortgage rate, and

[10]NBER U.S. recession data is available at http://www.nber.org/cycles/cyclesmain.html. For the initial structural break of the Great Moderation see, for example, Stock and Watson (2003, p.173) and Farmer (2012, p.397). The model is estimated using Dynare developed by Michel Juillard and his collaborators at CEPREMAP.

Baa corporate bond rate. All variables except inflation and interest rates are converted into real terms by dividing the GDP deflator. Prior to estimation, we take the log-difference of real per capita variables.

A few points are worth noting in terms of the observable variables used for estimation. Firstly, monetary authority funds plus household deposits (similar to the monetary base plus M2 money supply) make up aggregate household safe assets. The motivation for this aggregation is two-fold. This satisfies the arbitrage assumption in the model setup (Section 3.1.1) from unlimited access to monetary authority funds. On the empirical side, it accommodates the recent surge in monetary authority funds between 2008−2011, resulting from the large-scale recapitalization of the banking sector, which largely offset the significant shortage of during that time (see also, Woodford, 2010). Therefore, it would be misleading to view household s as the sole measure of bank household deposits as the sole measure of bank liabilities (or to observe the transmission mechanism of financial intermediation. Secondly, as a consequence of this assumption, we use the 3-month Treasury Bill rate as the short-term safe-asset rate (i.e. the policy rate). Lastly, by the end of 2009, outstanding financial commercial paper stood at $1.7 trillion. To capture this additional financial stress on the effective interbank rate, which was not exhibited in the Great Moderation period, we derive the interbank rate by averaging the effective Fed funds rate with the 3-month AA financial commercial paper rate. paper rate.

4.1 Calibrated parameters

Table 1 lists the parameters that are calibrated prior to estimation. In the first block, discount factors $\{\beta_h, \beta_e, \beta_B\}$ fall in the interval $[0.95, 0.99]$ (see also, Iacoviello, 2005, p.751). We derive the discount factors from the reciprocal of their relevant steady-state markups over the steady-state quarterly safe asset rate ($R = 1.01$). For example, using a steady-state quarterly gross real return to entrepreneur loans $R_e = 1.0383$, and satisfying the binding borrowing constraint condition $(1/R_e - \beta_e) > 0$, we set $\beta_e = 0.955$. This ensures a similar value for both the household and entrepreneur binding constraint conditions. The inverse of the Frisch elasticity η is set to 1. The capital-output share α is set to 0.33, and the physical capital depreciation rate δ_e is set to 0.025. A steady-state gross markup of $X = 1.10$ implies a price elasticity of demand for differentiated retail goods (ε^p) of 11. The price elasticity of demand for different types of labor ε^w is fixed at 5, implying a steady-state wage markup (μ^w) of 25%. Lastly, based on well-established estimates (e.g., Smets and Wouters, 2003, 2007), we assume a high degree of wage indexation (0.8) and let the probability of resetting an optimal wage $(1 - \theta_w)$ approximate an average length of wage contracts of one year.

The second block reports the steady-state aggregate ratios and the relevant U.S. banking sector conditions. The elasticities of substitution for household loans (ε^h) and entrepreneur loans (ε^e) equal 1.441 and 1.353, respectively. The target capital requirement ratio τ equals 11%, reflecting the recent U.S. banks' balance sheet condition. The bank capital depreciation rate δ_B equals 0.1044.[11] Parameter ϕ_ψ captures the pass-through effect of equity price changes on bank capital accumulation. We set ϕ_ψ to 0.25, based on our preliminary estimations. Shares of household and entrepreneur loans to total bank loans, the consumption-

[11] We assume that there are no undivided profits in the steady-state equilibrium, and therefore derive the value from the net income data of all U.S. commercial banks (FDIC, 2012).

Table 1: Calibrated parameters

Parameter	Description	Value
β_h	Household discount factor	0.97
β_e	Entrepreneur discount factor	0.955
β_B	Bank discount factor	0.986
η	Inverse of the Frisch elasticity	1
α	Capital share in the production function	0.33
δ_e	Capital depreciation rate	0.025
ε^p	Price elasticity of demand for goods	11
ε^w	Price elasticity of demand for labor	5
θ_w	Wage stickiness	0.75
γ_w	Degree of wage indexation	0.8
τ	Capital requirement ratio	0.11
ε^h	Elasticity of substitution for household loans	1.441
ε^e	Elasticity of substitution for entrepreneur loans	1.353
δ_B	Sunk costs for bank capital management	0.1044
ϕ_ψ	Equity price pass-through on total bank capital	0.25
L^h/L	Households' share of total loans	0.46
L^e/L	Entrepreneurs' share of total loans	0.54
C/Y	Consumption-output ratio	0.679
K^B/Y	Total bank capital-output ratio	0.171
ϕ_w	Weight on wages in borr. constraint	0.8
ϕ_k	Weight on physical capital in borr. constraint	0.8

output ratio, and the total bank capital-to-output ratio are calculated from the data means over the sample period. We restrict any other steady-state ratios in the banking sector to be consistent with the balance sheet definition and capital requirement. Finally, based on stable preliminary estimations, the weights on wages (ϕ_w) and physical capital (ϕ_k) in the borrowing constraints are set to 0.8. This implies that, for example, a negative 10% shock to equity prices will directly reduce household and entrepreneur creditworthiness by 2%.

4.2 Prior distributions and posterior estimates

The prior distribution of the structural parameters are reported in columns 3−5 in Tables 2 and 3. We assume that the household's coefficient of relative risk aversion (RRA) γ follows an inverse-gamma distribution with a mean of 3 and a standard deviation of 0.5. Meanwhile, the entrepreneur's RRA is assumed to be much less than the household's RRA ($\gamma_e = 0.9$), which implies a preference for current period consumption gains. Both RRA values roughly correspond with estimates of its reciprocal (the intertemporal elasticity of substitution in consumption) in the micro literature (e.g., Vissing-Jorgensen, 2002). The prior on habit formation parameter ϕ is set at 0.65 with a standard deviation of 0.03 (e.g., Christiano et al., 2005). Parameters in the Phillips curve are based on the estimates from Smets and Wouters (2003) and Christiano et al. (2010). The parameters describing the monetary policy reaction function are chosen within the context of financial frictions literature, based on the estimates of Christiano et al. (2010). We choose a reasonable value of 0.6 as the prior mean for both the households' LTV ratio (ν_h) and the entrepreneur's LTV ratio (ν_e). We set the prior mean of the interbank LTV ratio (ν_B) to 0.5 with a standard deviation of 0.05. The interest rate adjustment cost parameters $\{\kappa_k, \kappa_h, \kappa_e\}$ are assumed to follow a gamma distribution with a mean of 5 and a standard deviation of 2 (see also, Gerali et al., 2010). Analogous to the entrepreneur investment schedule in Iacoviello

Table 2: Structural parameters

	Parameter	Prior Distribution Type	Mean	Std.dev	Posterior Distribution Mean	2.5%	Median	97.5%
Preferences								
γ	Household RRA	Inv.Gamma	3	0.5	4.910	4.088	4.866	5.659
γ_e	Entrepreneur RRA	Inv.Gamma	0.9	0.1	1.087	0.888	1.073	1.279
ϕ	Habit formation	Beta	0.65	0.03	0.708	0.672	0.707	0.749
Prices								
θ_R	Price stickiness	Beta	0.8	0.03	0.923	0.914	0.924	0.932
γ_p	Degree of price indexation	Beta	0.5	0.03	0.511	0.464	0.510	0.554
Monetary policy rule								
κ_i	Coefficient on lagged policy rate	Beta	0.65	0.05	0.615	0.570	0.616	0.661
κ_π	Coefficient on inflation	Gamma	1.5	0.05	1.612	1.529	1.612	1.697
κ_y	Coefficient on output change	Beta	0.25	0.02	0.261	0.228	0.260	0.292
Credit and banking								
ν_h	Households' LTV ratio	Beta	0.6	0.03	0.580	0.531	0.580	0.630
ν_e	Entrepreneurs' LTV ratio	Beta	0.6	0.03	0.722	0.693	0.722	0.752
ν_B	Interbank LTV ratio	Beta	0.5	0.05	0.424	0.361	0.423	0.485
κ_h	HH loan rate adjust. cost	Gamma	5	2	15.22	11.87	15.07	18.51
κ_e	Entrep. loan rate adjust. cost	Gamma	5	2	6.890	5.720	6.890	8.072
κ_k	Leverage deviation cost	Gamma	5	2	1.255	1.038	1.254	1.443
Physical capital								
κ_v	Capital adjust. costs	Gamma	2	0.5	2.292	1.847	2.263	2.689
K^e/Y	Capital-output ratio	Gamma	10.7	0.2	10.78	10.46	10.78	11.11

(2005, p.752), we set the prior mean of the physical capital adjustment cost parameter κ_v to 2. The prior mean of the capital-output ratio is set to 10.7 based on its steady-state value. Lastly, the prior distributions for the AR(1) coefficients and the standard deviations of the shocks are reported in columns 3−5 in Table 3.

The estimated posterior statistics for the structural parameters are reported in columns 6−9 in Tables 2 and 3. Parameters for preferences, prices, and the monetary policy rule all conform well within the literature consensus. Shocks for monetary policy, loan rate markups to households and entrepreneurs, and the price markup are not persistent, while the rest are strongly persistent. The LTV ratio for households (0.58) is lower than that of entrepreneurs (0.72), which suggests that entrepreneurs can more easily collateralize their loans (see also, Iacoviello, 2005, p. 752). In fact, high estimates for ν_h and ν_e implies that changes to household creditworthiness and entrepreneur net worth have strong and persistent effects on aggregate demand and output. An estimated interbank LTV of 0.42 highlights the importance of bank market power by giving a large weight to retail loan rate markups (see Eq. 7). Corresponding to the observed persistence of retail credit spread movements, large posterior means for the entrepreneur and household loan rate adjustment cost parameters ($\kappa_e = 6.89$ and $\kappa_h = 15.22$) implies a large degree of retail loan rate stickiness. Furthermore, $\kappa_e < \kappa_h$ confirms the recent relatively sharper changes to the entrepreneur credit spread in the data (see also, Gerali et al., 2010, p.124). A value of 1.255 for the leverage deviation cost, on the other hand, is significantly smaller. However, this value is based on the close relationship between the short-term policy rate and the short-term interbank rate. As shown in our results in Section 5, and contrary to Gerali et al. (2010) for the Euro area, we find a clear role for the sticky-rate structure in commercial banking for both business cycle dynamics and credit spread variability.

Table 3: Exogenous processes

	Parameter	Prior Distribution Type	Mean	Std.dev	Posterior Distribution Mean	2.5%	Median	97.5%
AR coefficients								
ρ_z	Technology	beta	0.98	0.005	0.981	0.979	0.981	0.984
ρ_i	Monetary policy	beta	0.2	0.05	0.431	0.347	0.433	0.513
ρ_b	Household asset	beta	0.97	0.005	0.970	0.967	0.971	0.973
ρ_e	Entrep. loan markup	beta	0.3	0.05	0.422	0.352	0.423	0.493
ρ_h	Household loan markup	beta	0.2	0.05	0.269	0.180	0.268	0.347
ρ_{ν_h}	Households' LTV	beta	0.95	0.005	0.951	0.943	0.951	0.960
ρ_{ν_e}	Entrepreneurs' LTV	beta	0.55	0.05	0.618	0.561	0.620	0.680
ρ_ψ	Equity	beta	0.8	0.05	0.871	0.835	0.872	0.906
ρ_p	Price markup	beta	0.3	0.05	0.373	0.292	0.373	0.461
ρ_t	Capital requirement	beta	0.85	0.05	0.782	0.722	0.782	0.843
Standard deviations								
ϵ_z	Technology	Inv.Gamma	0.02	inf	0.016	0.014	0.016	0.017
ϵ_i	Monetary policy	Inv.Gamma	0.01	inf	0.008	0.007	0.008	0.009
ϵ_b	Household asset	Inv.Gamma	0.01	inf	0.008	0.007	0.008	0.009
ϵ_e	Entrep. loan markup	Inv.Gamma	0.08	inf	0.114	0.086	0.114	0.144
ϵ_h	Household loan markup	Inv.Gamma	0.08	inf	0.210	0.153	0.206	0.273
ϵ_{ν_h}	Households' LTV	Inv.Gamma	0.03	inf	0.021	0.019	0.021	0.024
ϵ_{ν_e}	Entrepreneurs' LTV	Inv.Gamma	0.03	inf	0.029	0.023	0.028	0.034
ϵ_ψ	Equity	Inv.Gamma	0.01	inf	0.005	0.004	0.005	0.006
ϵ_p	Price markup	Inv.Gamma	0.002	inf	0.001	0.001	0.001	0.001
ϵ_t	Capital requirement	Inv.Gamma	0.015	inf	0.012	0.010	0.012	0.014

5 Results

In this section, we use the DSGE model developed in Section 3 (hereafter, the baseline model) to determine the main financial factors that impact credit spread variability over the Great Moderation and Great Recession periods. Firstly, we establish the prevailing financial factors in credit spread variability over the full sample period (1982Q2−2012Q3). Using the historical shock decomposition of each credit spread we show how structural shocks predict the cyclical pattern of credit spreads in the U.S. business cycle. Secondly, we compare U.S. recession episodes over the Great Moderation and Great Recession periods. To do this, we re-estimate the baseline model with three sub-sample periods covering the 1990−91, 2001 and 2007−09 recessions. We determine whether factors that impact credit spreads have changed over time; and whether there are any clear difference in transmission mechanisms of credit spread variability during the Great Moderation and Great Recession periods. We conclude this section with a robustness analysis of the baseline model.

5.1 Impact factors on credit spread variability

Figure 3 provides the historical shock decomposition of the interbank and retail credit spreads. Here, we focus on how the structural shocks predict cyclical patterns of credit spreads over the Great Moderation and Great Recession periods. On the demand side, LTV shocks contribute significantly to interbank credit spread variability. For instance, a negative entrepreneur LTV shock reduces bank assets, and raises the capital-asset ratio—narrowing the interbank credit spread. This clearly corresponds with the post-recession credit slumps of 1992−1995, 2002−2004 and 2009−2012, observed in the data. Conversely, we see a similar

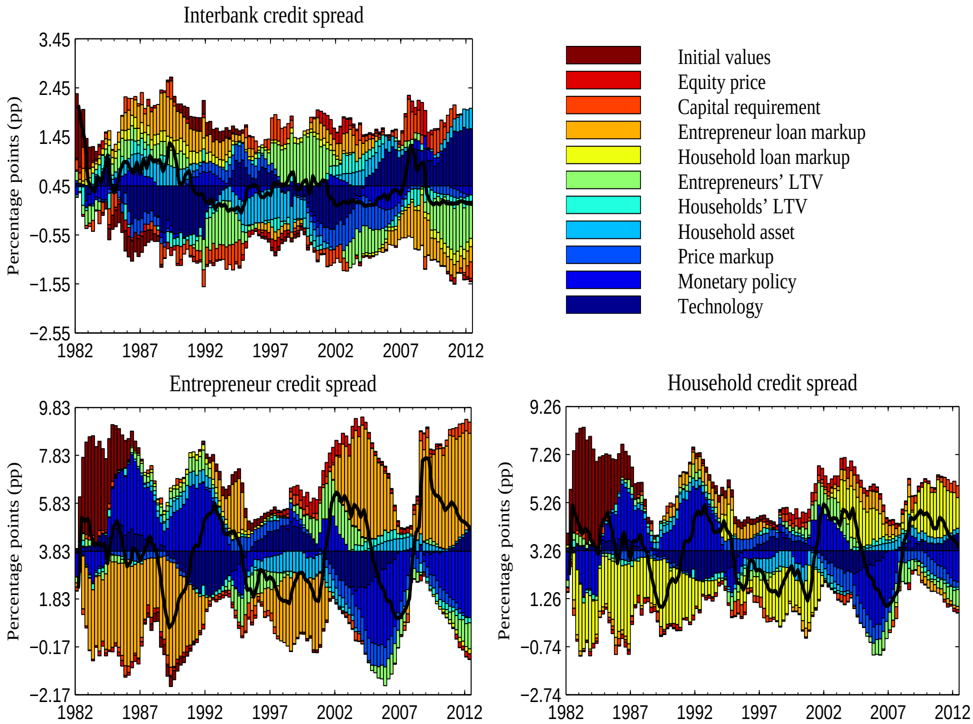

Figure 3: Historical decomposition of credit spreads (full-sample)

effect for the large credit boom period between 1997 and 2001. On the supply-side, we observe a significant impact of the bank capital requirement shock on interbank credit spread variability in 2007−09 recession. Furthermore, the collapse of the equity market during the 2001 and 2007−09 recession periods created some additional financial stress. Both the technology shock and the monetary policy shock do not contribute significantly to interbank credit spread variability during all three recession periods.

The persistence of retail credit spread widening or narrowing is driven by bank market power over retail loan rate markups. There is, however, one exception. Leading up to the August 2007 crisis, monetary policy has an extremely persistent effect on narrowing retail credit spreads—more than offsetting the loan rate markups. This observation gives credence to the evidence that monetary authorities kept the policy rate too low from 2002 to 2005 (Taylor, 2007), inadvertently creating the incentive for banks to seek larger profit margins by increasing risky portfolios. The widening of retail credit spreads occurs at the peak of each recession period (1990Q3−1991Q2, 2001Q1−2001Q4 and 2007Q4−2009Q2). This reflects the observation from the interest rate data that credit spreads become increasingly narrow towards the end of boom phases of the business cycle, and conversely widen in recession periods (see, Gilchrist and Zakrajšek, 2012, p.1696).

In terms of the relationship between equity prices and credit spread variability, the impact of the equity price shock on credit spread variability is small. Yet, we observe the recurring pattern of falling equity prices and widening credit spreads during U.S. recessions, the 2007Q4−2009Q2 recession in particular.

Although a technology shock produces a negative correlation between equity prices and net credit spreads (see Figure 6), it is unlikely that a single large fundamental shock is able to generate systemic financial stress in both equity and credit markets. Rather, it is more likely due to a combination of financial shocks and real shocks.

In summary, we observe bank market power as the primary source of credit spread variability. This is along the lines of Gilchrist and Zakrajšek (2012), in which the authors find that it is the supply-side factors of financial intermediation that dominate the demand-side factors in driving credit spread variability. By borrowing on short-term rates and lending on long-term rates banks carry balance sheet risk, but also large profit-making margins. Financial intermediaries exert their market power over net interest margins between their assets and liabilities, to the extent that they impose a measure of risk or desired profitability on interest rates charged. On the demand side, the financial accelerator channel plays a significant role in driving interbank credit spread variability only. Finally, the equity price channel exacerbates movements in credit spreads, but cannot be regarded as main driving force of credit spread variability.

5.2 Great Moderation verse Great Recession

In this section, we investigate: first, whether factors that impact the variability of credit spreads differs in the three recession periods; second, whether there are any clear shift in the driving forces behind credit spread variability across the three recession periods. To do so, we re-estimate the baseline model with three sub-sample periods. Each sub-sample period includes a maximum of twenty quarters before and after each recession's peak and trough: 1985Q3−1996Q2; 1996Q1−2006Q4; and 2002Q4−2012Q3.

Although the recessions of 1990−91 and 2001 were milder than the 2007−09 one, a comparative study by Peter Ireland (2011) shows that the pattern of shocks has not changed significantly throughout the Great Moderation and Great Recession periods. In fact, Ireland (2011) finds that all three recessions were caused by a similar combination of exogenous demand and supply shocks, where the notable difference for the Great Recession is that these adverse shocks were deeper, and lasted longer. The author argues that while expansionary monetary policy helped in cushioning the 1990−91 and 2001 recessions, the zero lower bound on the policy rate created a *de facto* contractionary policy in 2009. This constraint contributed to both the duration and deepness of the recession. Similarly, Stock and Watson (2003), Sims and Zha (2006) and Smets and Wouters (2007) find that the start of the Great Moderation cannot be attributed to changes in structural parameters—that is, the endogenous transmission mechanism of shocks—but rather a reduction in the volatility of a similar combination of exogenous shocks.

Table 4 reports the contribution of the structural shocks to the variance of credit spreads at 1-quarter, 1-year, and 5-year horizons. We find that supply-side financial factors account for a great part of credit spread variability in the 2007−09 recession period. In addition, the impact of technology shocks and monetary policy shocks has fallen considerably during all three recession periods. The parameter estimates for each of the U.S. recession sub-samples reveal little evidence of significant changes in the structural parameters.[12] In contrast, the posterior means for the standard deviations of household's and entrepreneur's LTV shocks (ϵ_{ν_h} and ϵ_{ν_e}) have declined since the 1990−91 recession, while the standard deviation for the entrepreneur loan markup shock (ϵ_e) has steadily increased. This indicates a shift from demand-side to supply-side credit

[12] Results are not reported here, but are available upon request.

Table 4: Variance decomposition of credit spreads for the U.S. recession periods

Interbank spread

	2007−09: Horizons			2001: Horizons			1990−01: Horizons		
Shocks	1-quart.	1-year	5-years	1-quart.	1-year	5-years	1-quart.	1-year	5-years
ϵ_z	0.086	0.063	0.613	0.110	0.109	0.521	0.120	0.107	0.384
ϵ_i	0.039	0.046	0.015	0.055	0.072	0.032	0.065	0.091	0.057
ϵ_p	0.007	0.007	0.055	0.003	0.004	0.028	0.001	0.002	0.023
ϵ_b	0.001	0.003	0.023	0.001	0.002	0.034	0.000	0.001	0.027
ϵ_{ν_h}	0.288	0.233	0.070	0.244	0.236	0.088	0.317	0.292	0.183
ϵ_{ν_e}	0.086	0.070	0.061	0.208	0.181	0.145	0.054	0.055	0.069
ϵ_h	0.003	0.013	0.006	0.001	0.012	0.010	0.001	0.007	0.008
ϵ_e	0.073	0.068	0.022	0.097	0.094	0.032	0.020	0.019	0.013
ϵ_t	0.320	0.403	0.107	0.209	0.235	0.088	0.325	0.353	0.178
ϵ_ψ	0.099	0.093	0.030	0.073	0.055	0.020	0.097	0.072	0.057

Household credit spread

	2007−09: Horizons			2001: Horizons			1990−01: Horizons		
Shocks	1-quart.	1-year	5-years	1-quart.	1-year	5-years	1-quart.	1-year	5-years
ϵ_z	0.024	0.011	0.041	0.038	0.021	0.095	0.087	0.096	0.374
ϵ_i	0.245	0.154	0.148	0.311	0.195	0.179	0.412	0.284	0.255
ϵ_p	0.002	0.004	0.026	0.001	0.003	0.010	0.001	0.001	0.006
ϵ_b	0.001	0.001	0.001	0.001	0.001	0.002	0.000	0.000	0.002
ϵ_{ν_h}	0.080	0.038	0.025	0.050	0.025	0.018	0.088	0.049	0.027
ϵ_{ν_e}	0.048	0.021	0.015	0.091	0.039	0.028	0.024	0.013	0.017
ϵ_h	0.495	0.721	0.697	0.420	0.674	0.632	0.270	0.488	0.262
ϵ_e	0.035	0.016	0.011	0.038	0.018	0.013	0.011	0.008	0.007
ϵ_t	0.055	0.026	0.031	0.034	0.017	0.017	0.073	0.041	0.031
ϵ_ψ	0.015	0.007	0.005	0.016	0.008	0.007	0.034	0.020	0.018

Entrepreneur credit spread

	2007−09: Horizons			2001: Horizons			1990−01: Horizons		
Shocks	1-quart.	1-year	5-years	1-quart.	1-year	5-years	1-quart.	1-year	5-years
ϵ_z	0.023	0.018	0.096	0.033	0.023	0.128	0.100	0.134	0.444
ϵ_i	0.152	0.088	0.120	0.232	0.147	0.155	0.423	0.305	0.254
ϵ_p	0.001	0.002	0.027	0.001	0.002	0.009	0.001	0.001	0.006
ϵ_b	0.001	0.000	0.001	0.001	0.000	0.002	0.000	0.000	0.003
ϵ_{ν_h}	0.053	0.024	0.018	0.038	0.019	0.016	0.091	0.054	0.028
ϵ_{ν_e}	0.031	0.013	0.012	0.069	0.031	0.026	0.024	0.016	0.020
ϵ_h	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000
ϵ_e	0.693	0.833	0.692	0.588	0.758	0.641	0.248	0.421	0.197
ϵ_t	0.035	0.016	0.028	0.026	0.013	0.015	0.076	0.045	0.031
ϵ_ψ	0.011	0.005	0.004	0.013	0.007	0.006	0.037	0.023	0.018

Note: see Table 3 for shock parameter descriptions.

market shocks.

Capital requirement shocks have the largest influence (approximately 30% over the forecast horizon) on interbank credit spread variability for both the 2007−09 and 1990−01 recession periods. Compared to the 1990−01 recession period, however, the results show that the entrepreneur loan markup shock accounts for 5% more of the interbank spread variance than the capital requirement shock over 20-quarters during the 2007−09 recession period. On the demand-side, the influence of the household's LTV shock (ϵ_{ν_h}) is strong over 1-quarter and 1-year horizons for each U.S. recession period. The entrepreneur's LTV shock (ϵ_{ν_e}) only plays a significant role in explaining interbank credit spread variability during the 2001 recession. As such, the interbank credit spread in the 2001 recession period seems to be less rooted in supply-side factors. Comparing all three recession periods, we find that the impact of technology shocks has fallen steadily over shorter horizons, while the impact of monetary policy has fallen significantly over all horizons. As a result, interbank credit spread variability in the recent recession is more strongly rooted in supply-side financial factors.

Bank market power plays a dominant role in explaining the variability of both retail credit spreads. Across the three recession periods, there is an increasing trend in the contribution of loan markup shocks (ϵ_e and ϵ_h) to the variability of both retail credit spreads at all horizons. In contrast, the contribution of LTV shocks (ϵ_{ν_h} and ϵ_{ν_e}) are small and ambiguous across the three recession periods. Analogous to the interbank credit spread, we observe a remarkable decline in the influence of technology and monetary policy shocks over three recession periods. These findings suggest a shift towards a greater influence of supply-side financial factors in the 2007−09 recession.

Two important observations are worth noting in the historical shock decomposition of the entrepreneur credit spread in Figure 4.[13] Firstly, from the demand-side of the credit market, the influence of LTV shocks has declined since the 1990−91 recession, while the bank capital requirement shock exacerbates and prolongs credit spread variability over the 2007−09 recession period. Secondly, for each recession period, policy rate adjustments consistently lead movements in the spread, which are prolonged by entrepreneur loan markups (bank market power). For the 1990−91 and 2001 recessions, the entrepreneur credit spread returns to its steady state after approximately three years, whereas it takes much longer to converge to steady state during the 2007−09 recession. After the 1990−91 and 2001 recessions the policy rate continues to fall for a number of quarters, which sharply reduces the spread. However, from 2010 onwards, we see that the zero lower bound prevents the policy rate from counteracting the persistence of retail loan markups and higher capital requirements. As a result, the influence of the policy rate on nonfinancial long-term rates is completely ineffective over the 2007−09 recession period.

5.3 Robustness analysis

In this section, we perform robustness analysis for the model developed in the paper. We compare the baseline model with three variant versions of the model. We first compare the dynamics of variant models

[13] For the sake of space, we only report the results for the entrepreneur credit spread here. Results for the household credit spread follow a similar pattern, and are available upon request.

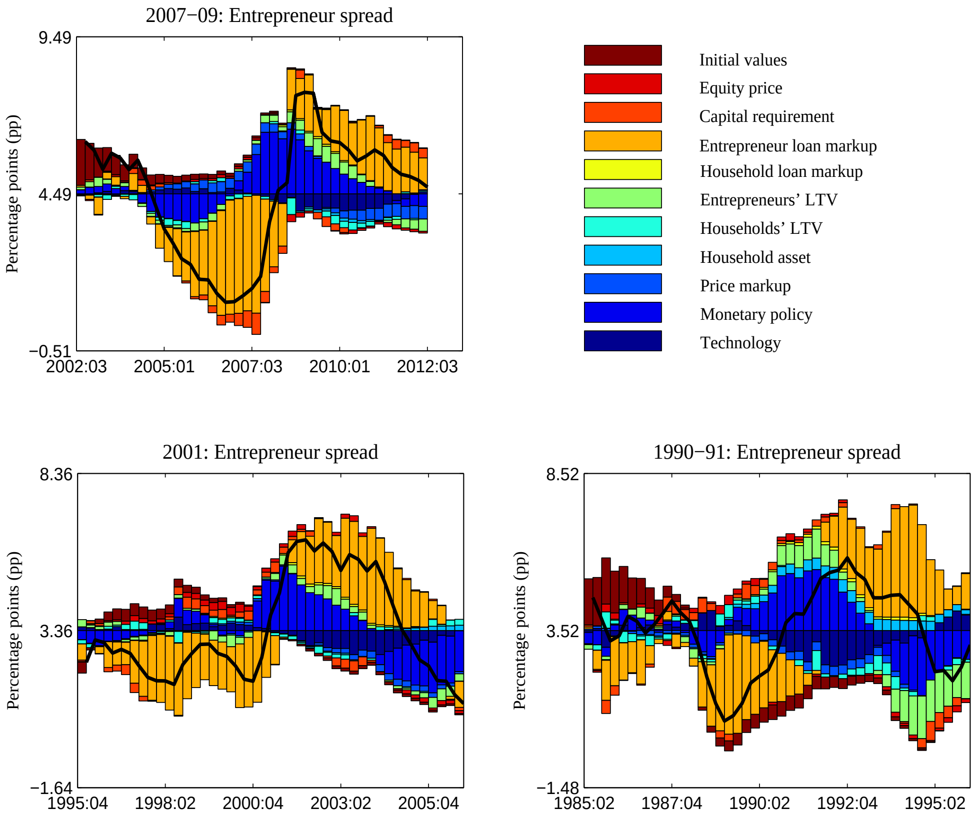

Figure 4: Historical decomposition for entrepreneur credit spread: 2007−09 recession (top-left); 2001 recession (bottom-left); 1990−91 recession (bottom-right)

in response to monetary and technology shocks. We then compare the parameter estimates across models. The robustness analysis also provides more valuable insights for analysis on credit spread variability.

The three variant models serve to highlight three key issues. For the first variant model (FI hereafter) we assume flexible rate adjustments on retail loan rate setting. That is, there are no quadratic retail loan rate adjustment costs ($\kappa_h = \kappa_e = 0$). The comparison analysis between the baseline model and the flexible interest rate model highlights the role of bank market power through sticky retail rate adjustment. For the second variant version (TB hereafter) we use the 10-year Treasury Bill as the observed data for the interbank rate. Introducing the interbank spread between the 3-month and 10-year Treasury Bill rates highlights the influence of monetary policy over long-term interest rates. By doing so, we are able to test the robustness of the credit spread transmission mechanisms, as defined in Section 2. For the third variant version (NI hereafter), we re-estimate the model without the observed variable for the interbank rate. In addition, we drop the capital requirement shock to match nine shocks with the remaining nine observed variables. As this NI model is in line with the estimated models with multiple interest rates in the literature (e.g., Gerali et al., 2010), it serves a useful reference for the baseline model.

5.3.1 Nominal and real shocks

Figure 5 shows the impulse responses of the observed variables to a contractionary monetary policy shock.[14] Comparing the baseline model to the FI model, reveals an important role for sticky rate adjustments: during a recession (or boom), imperfect bank competition will stifle efforts of monetary authorities to stimulate (or attenuate) aggregate demand through the conventional interest-rate policy. Without sticky rate adjustments, the decline in total loans and output is much more severe in response to a contractionary monetary policy. The dynamics of the TB model and the NI model follow a similar pattern as that of the baseline model. There are some uninformative differences in credit spreads and equity prices though; as the difference in the impact of monetary policy on output, inflation and balance sheet quantities is negligible among the three models. More importantly, the influence of monetary policy on the interbank spread in the TB model (i.e., the 10-yr Treasury Bill) provides no distinct advantage in the results. Similarly, compared to the baseline model and the NI model, the pass-through onto retail credit spreads is only slightly improved. In other words, the influence of the conventional monetary policy on long-term interest rates is not robust.

Figure 6 shows the impulse responses of the observed variables to a positive technology shock. For the baseline model, the effect of the technology shock on output is strong and persistent. The positive financial wealth effect on household consumption subsequently fuels the equity price boom (see also, Castelnuovo and Nisticò, 2010, p.1720). The bullish equity market improves both the demand and supply of the credit market. On the demand side, borrower's creditworthiness increases the feasible amount of loans. The improved credit demand and widen bank profit margins propagate the dynamics of the model through both financial accelerator and bank capital channels (see, Christiano et al., 2010, p.55-58). On the supply side, increased market value of bank equity increases bank funding and, therefore, shifts the credit supply schedule upward. Conversely, the policy rate increases in response to higher output and inflation. Higher interest

[14] For simplicity, we aggregate household loans and entrepreneur loans, and label it total loans. We also include the response of the capital-asset ratio.

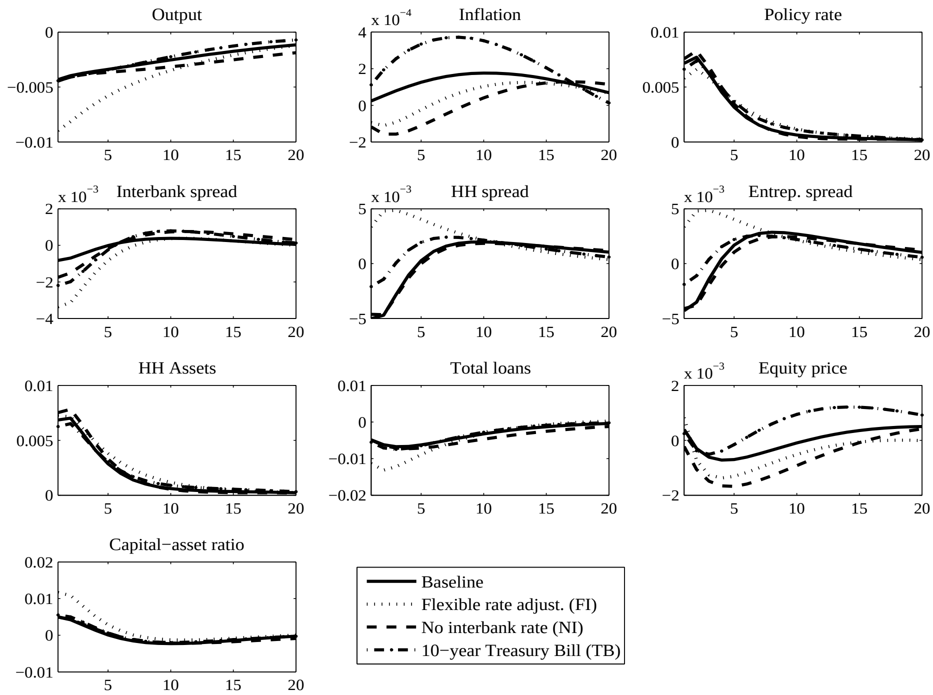

Figure 5: IRFs to a contractionary monetary policy shock

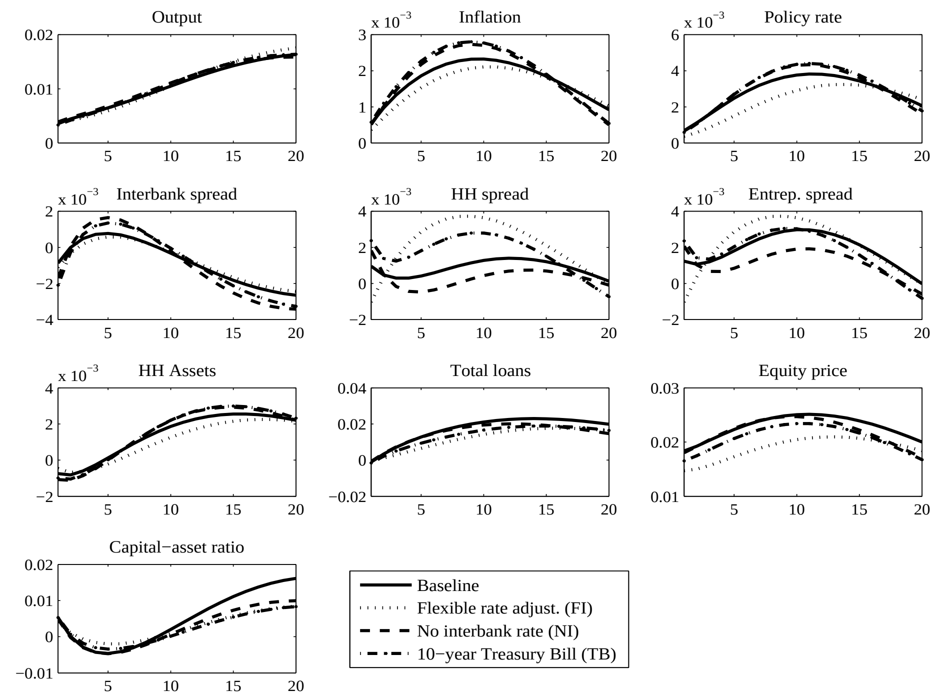

Figure 6: IRFs to a positive technology shock

rates dampen credit demand, and raise households' demand for safe assets in the medium- to long-term. There is little variation in the dynamics among variant models in response to the technology shock, except for retail credit spreads. For the FI model, responses of retail credit spreads are exacerbated. This reiterates the importance of sticky retail rate adjustment in the banking sector.

In summary, based on the model comparison, we find that the baseline model is robust to alternative versions of the model. The dynamics of the model in response to both monetary and technology shocks conform with the established literature evidence. Indeed, as shown in Section 5.3.2 below, the comparison of the estimated parameters between variant models reinforces these findings.

5.3.2 Alternative model parameter estimates

Table 5 compares the posterior estimates of the structural parameters for each alternative model. Overall, the parameter estimates are mostly consistent across models, indicating our results are robust. The most notable variations occur in some of the parameters in the banking sector, which reiterates the importance of the supply-side factors in determining credit spread variability. Compared to the baseline model, the FI model predictably gives more weight to stochastic markup shocks in retail loan rate setting since sticky retail loan rate adjustment falls away. This is indicated by a decline of the estimated interbank LTV ratio (ν_B) from 0.424 to 0.158. As discussed in Section 3.1.2, $1 - \nu_B$ captures the weight of the stochastic markup in retail loan rate setting. At the same time, zero sticky retail rate adjustment is now compensated for by a significant jump in the persistence of stochastic markup shocks (ρ_e, ρ_h). Comparing all three alternative versions of the model to the baseline model, a larger leverage deviation cost parameter (κ_k) creates additional imperfect rate adjustment by magnifying the influence of the capital-asset ratio on the interbank rate and, hence, long-term retail loan rates. This suggests that the baseline model represents the influence of leverage deviation costs more accurately.

The shocks and frictions considered in each estimated model determine its ability to fit the data. The relative importance of the baseline model can therefore be measured by comparing its marginal data density (measured in log points) to that of each alternative model.[15] For flexible rate adjustment, the marginal density of the FI model falls from 4357 to 4155. This highlights the importance of sticky retail rate adjustment for capturing credit spread data. For the TB model, the marginal density falls from 4357 to 4332. This suggests that the model setup is less suited to explain variability between the 3-month and 10-year Treasury Bill rates and, hence, misspecification due to the capital requirement shock is less likely in the baseline model. Therefore, the structural relationship in the baseline model (between bank balance sheet adjustments and the short-term interbank rate) is empirically preferable to that of the TB model.

6 Concluding remarks

This paper develops a New-Keynesian DSGE model with a central role for financial intermediation and equity assets to assess the influence of financial factors on credit spread variability. Large movements in

[15] The exception being the NI model: given the same prior distributions, one less observable variable means that the marginal data density will always be lower than the baseline model.

Table 5: Alternative model parameter estimates

	Posterior distribution means					Posterior distribution means			
	Baseline	Flexible (FI)	No interbank rate (NI)	10-yr Treasury Bill (TB)		Baseline	Flexible (FI)	No interbank rate (NI)	10-yr Treasury Bill (TB)
Marginal density	4357	4155	3765	4332					
Parameters									
γ	4.910	4.578	4.806	4.543	ρ_z	0.981	0.987	0.981	0.981
γ^e	1.087	0.878	1.117	0.872	ρ_i	0.431	0.337	0.433	0.409
ϕ	0.708	0.713	0.705	0.708	ρ_b	0.970	0.973	0.970	0.970
θ_R	0.923	0.924	0.907	0.908	ρ_e	0.422	0.868	0.449	0.549
γ_p	0.511	0.500	0.520	0.523	ρ_h	0.269	0.919	0.276	0.583
κ_i	0.615	0.765	0.642	0.669	ρ_{ν_h}	0.951	0.952	0.951	0.952
κ_π	1.612	1.580	1.598	1.591	ρ_{ν_e}	0.618	0.617	0.609	0.591
κ_y	0.261	0.272	0.264	0.262	ρ_ψ	0.871	0.896	0.881	0.877
ν_h	0.580	0.581	0.584	0.487	ρ_p	0.373	0.377	0.440	0.411
ν_e	0.722	0.701	0.690	0.682	ρ_t	0.782	0.861	-	0.847
ν_B	0.424	0.158	0.321	0.063	ϵ_z	0.016	0.016	0.015	0.015
κ_k	1.255	2.176	2.629	3.005	ϵ_i	0.008	0.006	0.008	0.007
κ_e	6.890	-	8.024	6.208	ϵ_b	0.008	0.008	0.008	0.008
κ_h	15.22	-	16.32	12.96	ϵ_e	0.114	0.016	0.105	0.027
κ_v	2.292	1.530	2.199	2.519	ϵ_h	0.210	0.014	0.197	0.026
K^e/Y	10.78	10.89	10.77	10.79	ϵ_{ν_h}	0.021	0.021	0.021	0.021
					ϵ_{ν_e}	0.029	0.013	0.027	0.019
					ϵ_ψ	0.005	0.004	0.005	0.005
					ϵ_p	0.001	0.001	0.001	0.001
					ϵ_t	0.012	0.009	-	0.015

Note: We exclude parameter descriptions, prior means and standard deviations (see Tables 2 and 3), and statistic confidence intervals in the table due to the limited space.

credit spreads are closely linked to U.S. recessions over the Great Moderation and Great Recession periods and, hence, seen as an indicator of financial market stress. Overall, we observe supply-side factors as the primary source of credit spread variability, which is along the lines of Gilchrist and Zakrajšek (2012). That is, retail loan markup shocks account for more than half of the variability of retail credit spreads. Moreover, sticky rate adjustments significantly alter the path of retail loan rates relative to the policy rate. Monetary policy has a strong influence on the short-term interbank rate, whereas the effectiveness of interest-rate policy on long-term nonfinancial loan rates is much weaker. Imperfect bank competition attenuates the effect of monetary policy through both sticky rate adjustments and a counter-cyclical bank capital-asset ratio. Equity prices exacerbate movements in credit spreads through the financial accelerator channel, but cannot be regarded as a main driving force of credit spread variability. Both financial accelerator and bank capital channels play a significant role in propagating the movements of credit spreads.

Ireland (2011) finds that all three recessions were caused by a similar combination of exogenous demand and supply shocks, where the notable difference for the Great Recession is that these adverse shocks were deeper, and lasted longer. In contrast, we observe a remarkable decline in the influence of technology and monetary policy shocks over three recession periods. From the demand-side of the credit market, the influence of LTV shocks has declined since the 1990−91 recession, while the bank capital requirement shock exacerbates and prolongs credit spread variability over the 2007−09 recession period. Moreover, across the three recession periods, there is an increasing trend in the contribution of loan markup shocks to the variability of both retail credit spreads.

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APPENDIX

A: Data and sources

Data source from the Federal Reserve Bank of St. Louis (FRED):

1. RGDP: Real Gross Domestic Product, 1 Decimal (GDPC1), Billions of Chained 2005 Dollars, Quarterly, Seasonally Adjusted Annual Rate
2. Inflation: GDP Implicit Price Deflator (GDPDEF), Index 2005=100, Quarterly, Seasonally Adjusted
3. Nominal short-term interest rates: 3-Month Treasury Bill: Secondary Market Rate (TB3MS); 3-month average of the daily Effective Federal Funds Rate (FEDFUNDS); 3-Month AA Financial Commercial Paper Rate (CPF3M) (Percent, Quarterly, Not Seasonally Adjusted.)
4. Treasury rate: 10-Year Treasury Constant Maturity Rate (GS10), Percent, Quarterly, Not Seasonally Adjusted
5. Loan rate to entrepreneurs: Moody's Seasoned Baa Corporate Bond Yield (BAA), Percent, Quarterly, Not Seasonally Adjusted
6. Loan rate to households: 30-Year Conventional Mortgage Rate (MORTG), Percent, Quarterly, Not Seasonally Adjusted
7. Loans to households: Total Liabilities - Balance Sheet of Households and Nonprofit Organizations (TLBSHNO), Billions of Dollars, Quarterly, Not Seasonally Adjusted - includes mortgage sector and consumer credit sector (equivalent to CMDEBT)
8. Loans to entrepreneurs: Total Liabilities - Balance Sheet of Non-farm Nonfinancial Corporate Business (TLBSNNCB), Billions of Dollars, Quarterly, Not Seasonally Adjusted
9. Deposits: Deposits - Assets - Balance Sheet of Households and Nonprofit Organizations (DABSHNO), Billions of Dollars, Quarterly, Not Seasonally Adjusted
10. Monetary authority funds: Total Credit Market Assets Held by Domestic Financial Sectors - Monetary Authority (MATCMAHDFS), Billions of Dollars, Quarterly, Not Seasonally Adjusted
11. Equity: Standard and Poor 500 Index (SP500), Index, Quarterly, Not Seasonally Adjusted
12. US population: Civilian Noninstitutional Population (CNP16OV), Thousands of Persons, Quarterly, Not Seasonally Adjusted