Does the financial shock drive real business cycle fluctuations in China?

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Abstract

The recent global financial crisis highlighted the link between financial market and the whole real economy. In this paper, I document that domestic loans are countercyclical to GDP in China. Then I use a standard real business cycle (RBC) model that includes the debt and equity financed by firms to explore how real economy variables are affected by financial shocks. My analysis shows that financial shocks explain about 66 percent of GDP fluctuations. Therefore, financial frictions are the main driving force of macroeconomic fluctuations in China through the real economic factor of labor.
Keywords: Financial frictions, Financial shocks, business cycle, RBC model

1 Introduction

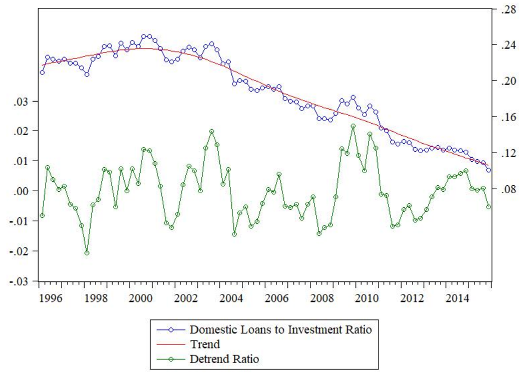
The financial crisis in 2008 has led economists to ask whether the financial sector plays a significant role in explaining macroeconomic fluctuations. After the financial crisis, much research has studied the business cycle not only through dynamic stochastic general equilibrium (DSGE) models which show that financial frictions propagate shocks that originate in other sectors, but also incorporates financial shocks to be a source of business cycle fluctuation. This paper attempts to find out the main source of China's business cycle behaviors in a DSGE model, in the model that used to applied to the U.S. economy.

In my paper, I follow Jermann and Quadrini (JQ) (2012) to build a close economy real business cycle framework. JQ (2012) argue that financial rigidity occurs when firms switch their financial structure from debt to equity financing. They also denote that financial shocks are the innovations affecting the ability of firms to borrow. When the economy is at downturns, firms have to cut their intertemporal borrowing, and turn to equity financing. A reduction in dividend payment comes with quadratic adjustment costs, which will lead to a decrease in employment. Financial shocks are transmitted to the real economy through negative effects in the labor market. In this paper, I will examine whether the Chinese economy in the past two decades could be explained by a model that has been successfully applied to the U.S. in JQ (2012). In particular, I will verify whether China's business cycle fluctuations are driven by financial shocks.

Firstly, I use fixed assets investment data to illustrate the financial cycle in the Chinese credit market. Figure 1 plots the domestic loans to total fixed assets investment ratio in the nonfinancial business sector. Domestic loans are one of five sources of funds to invest, which accounts for about 19% of total investments. The other four sources are state budget (5%), foreign-related investment (5%), self-financing (55%), and others (16%). Investment data comes from the National Bureau of Statistics of China (NBSC), starting from 1996Q1 to 2015Q4. This paper chooses data from 1996 onward due to data availability.

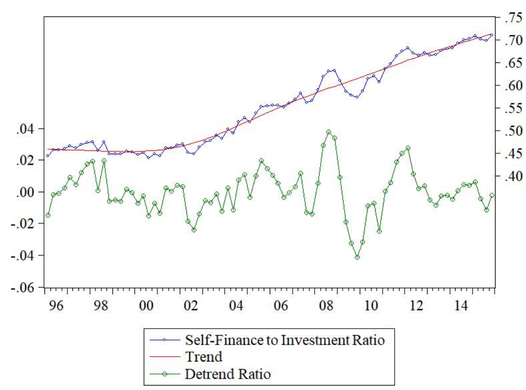
The original data (blue solid line) shows a declining trend of domestic loans to total fixed assets investment since 1996. The trend implies that the proportion of domestic loans in total investment has been decreasing in the past two decades. This might be the consequences of tighter lending standards that make investing units like firms and individuals obtain less

Figure 1: HP Filter Detrended Domestic Loans to Investment Ratio



loans from financial institutions. The mean of the domestic loans to total fixed assets investment ratio is around 0.19, showing that only about 19% of total investment could be financed through financial institutions. The variables are seasonally adjusted by Census X12 in EViews and detrended using a Hodrick-Prescott (HP) filter with a smoothing parameter of 1600.

Figure 2: HP Filter Detrended Self-Finance to Investment Ratio



If domestic firms cannot take enough loans, they turn to other sources to obtain funds. Figure 2 depicts the self-finance to investment ratio. Self-finance is the major source of funds for firms. In China, firms achieve self-financing mainly through issuing new equities to the public. Therefore, the upward-sloping trend suggests some substitutability between debt and equity financing. When financial situation in China becomes more serious, firms need to restructure their financial position by reducing domestic loans and issuing more equities.

Figure 3: Financial Flows in Chinese nonfinancial Business Sector

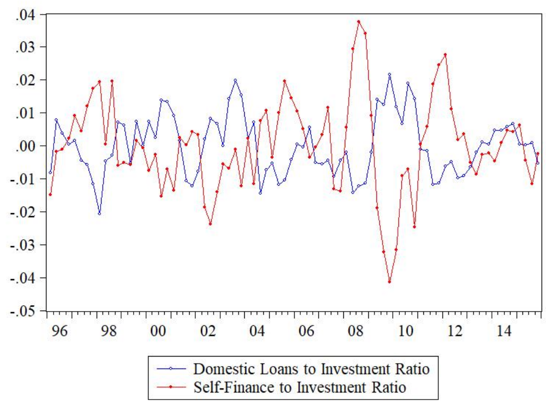


Figure 3 captures two financial flows, domestic loans financing and self-financing. In the figure, the pattern is clearly visible. Initially, the figure exhibits a strong negative correlation between domestic loans financing and self-finance, which implies a substitution to some degree between debt and equity financing. Next, the domestic loans ratio tends to increase during recessions, while the self-finance ratio rises around booms. When the economy is in expansion, firms have various sources to finance investments. In particular, as credit supply is strictly controlled by financial institutions in China, firms barely rely on bank loans. However, while the economy is at downturns, the severe situation cannot allow firms to accumulate sufficient funds through self-financing, they are forced to borrow. Moreover, in figure 3 there are four dramatic peaks in the domestic loans to investment ratio, which happened in the year 1998, 2001, 2003 and 2008. They are consistent with four important events in the Chinese economy: the catastrophic flood and Asian financial crisis around 1998, the accession to the World Trade Organization (WTO) in 2001, the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003 and the recent global financial crisis in 2008. All the significant events were followed by an increase of credit supply. When big events occur, the Chinese government implements expansionary policies to stimulate the whole economy.

Table 1: Business cycle properties of selected real macroeconomic and financial variables, 1996Q1-2015Q4.

Variables	Standard Deviation	Correlation with GDP
Real Macroeconomic Variables		
GDP	1.33	1
Consumption	1.21	0.72
Investment	4.14	0.86
Hours Worked	0.05	0.65
Financial Variables		
Equity Payout/GDP	0.18	0.68
Debt Repurchase/GDP	0.84	-0.58

Real macroeconomic variables are from the National Bureau of Statistics of China (NBSC) and financial variables come from the CSMAR database. "Equity Payout" equals gross dividend times dividend payout ratio in corporate sector. "Debt Repurchase" is defined as the net decrease in domestic loans used for fixed assets investments over the quarter. All macro variables are in logarithm forms. The statistics are computed after detrending by HP filter method with a smoothing parameter of 1600 and seasonally adjusted by Census X12 in EViews.

Table 1 records business cycle moments of some typical macro variables and two key financial variables that I will use to fit in my model. The real macro variables are GDP, consumption, investment and hours worked, while two financial variables are the equity payout to GDP ratio and the debt repurchase to GDP ratio. By examining the correlations, I find out that the equity payout ratio shows a pro-cyclical pattern since it is positively correlated with GDP, while the debt repurchase ratio is countercyclical. I also calculate the correlation between the Equity Payout/GDP ratio and the Debt Repurchase/GDP ratio, which is -0.78. These suggest a negative relationship between domestic loans acquired and equity payments. My assessment also shows that all macro variables are positively correlated with GDP. Consumption is less volatile than GDP, while investment is much more volatile than output. In addition, both financial variables are less volatile than GDP, but debt repurchase ratio shows a higher volatility than equity payout ratio.

In my paper, I firstly employ JQ (2012)'s DSGE model in the close economy real business cycle (RBC) framework. The model consists of a representative firm and a representative household. Households are firm shareholders and hold non-contingent corporate bonds. Households receive labor income, and equity payments. They also consume firm outputs, purchase new equities and pay a lump-sum tax that finances firm tax benefits. Firms take intra and intertemporal loans to pay worker wages and shareholder dividends, and to finance investments. A firm's intra-period borrowing is limited by its realized liquidation values at default, which will be defined as an enforcement constraint. Firm enforcement constraints become tighter when there is a negative financial shock hitting the economy. As the financial condition becomes more serious, firms become unable to take on enough loans from financial institutions, and have to switch financial structure from debt to equity financing. Adjusting equity payouts incurs additional costs that lead firms to change production plans.

Next, I present my construction of two quarterly time series of productivity and financial shocks for China. According to JQ (2012), the productivity shock series follows a standard Solow residual approach, while the financial shock series is computed as the residuals of enforcement constraints. Using the empirical data and constructed shocks, I calibrate all parameters in the model, present variance decomposition and conduct impulse responses.

My results show that financial shocks explain major volatilities in output, investment, labor and debt issuance, while productivity shocks capture most fluctuations in consumption and equity payout. Therefore, financial shocks dominate in explaining real business cycle movements in China.

2 Literature Review

There has been a substantial body of economic literature studying financial frictions in the U.S. and European economies. Bernanke and Gertler (1989) is one of the earliest and classic studies that introduces a costly state verification model. The financial friction comes from the asymmetric information between the borrowers (entrepreneurs) and the lenders (savers). The authors illustrate that whenever the asymmetric information occurs, optimal financial arrangements will entail agency costs. Typically, the higher the level of borrower's total net worth, the smaller expected agency costs will be. Carlstrom and Fuerst (1997) also demonstrate a traceable way to model and verify the role of agency cost in business cycle. An alternative way to model financial frictions is to endogenize collateral constraint faced by non-financial borrowers into models (Kiyotaki and Moore, 1997). Their paper shows that the size of external finance depends on the condition of borrower's balance sheets. Cooley, Marimon, and Quadrini (2004) also model collateral constraints through optimal contracts subject to enforceability constraints. They illustrate that limited enforceability increases the sensitivity of investments to the arrival of new technologies and generates greater macroeconomic volatility.

According to Quadrini (2011), there are two possible channels that link financial flows to the real economy: the financial accelerator and financial shocks. The "financial accelerator" hypothesis was introduced by Bernanke, Gertler, Gilchrist (1999), suggesting the financial frictions work to amplify and propagate shocks that originate in other sectors, such as productivity shocks or monetary policy shocks, to the macro economy. As to the previous literature, the financial accelerator theory has been paid more attention in the macro finance literature. Gertler, Gilchrist and Natalucci (2007) then extend the financial accelerator mechanism to a small open economy general equilibrium framework. The financial accelerator mechanism turns out to be significantly accounting for a large proportion of business cycle fluctuations. Gilchrist, Ortiz, and Zakrajsek (2009) also use a Bayesian DSGE model to indicate the presence of an operative financial accelerator in explaining U.S. cyclical fluctuations. In addition of propagating the effects of other shocks, the financial shocks hypothesis also treats financial frictions as the origin of business fluctuations. By simulating exogenous credit shocks on the borrowing capability of entrepreneurs, Jermann and Quadrini (2012) find out that financial shocks are important for capturing the dynamics of both financial flows and labor in the real economy. Christiano, Motto, and Rostagno (2008), Mendoza and Quadrini (2010), and Gertler and Karadi (2011) also present that the shocks derived from the financial sector can play a crucial role in illustrating business cycle fluctuations.

In recent years, Chinese scholars have conducted a lot of research on quantitatively presenting macroeconomic effects of financial frictions. Some of them use collateral constraints to model financial frictions to explain macro fluctuations in the Chinese economy. Chen and Zhang (2010) and Huang and Lv (2011) suggest that by introducing collateral constraints, previous models can better fit business cycle movements in the Chinese economy. So far most Chinese scholars have focused on analysing the financial accelerator effects. Zhao et al (2007) and Wang et al (2011) conclude that financial frictions exacerbate shocks that are derived from other shocks. There also have been studies like Tian and Wang (2014) which use the Bayesian DSGE model to illustrate that financial shocks are the main driving force (relative to other shocks) of business cycle fluctuations in China.

My paper's methodology follows Kiyotaki and Moore (1997), Bernanke, Gertler, and Gilchrist (1999), Jermann and Quadrini (2012) and Tian and Wang (2014). My paper contributes to previous literature in that in addition to exploring the financial accelerator effects of financial frictions, I also use more accurate dividend payout data to examine the significance of financial shocks to Chinese real business cycle dynamics.

The rest of the paper is organized as follows: Section 3 introduces a standard RBC dynamic stochastic general equilibrium model which follows JQ's paper. Section 4 describes data sources. Section 5 presents the constructions of technology and financial shock series and calibrations. Section 6 performs impose responses and simulations of business cycle properties. Finally, in section 7 I present my conclusions.

3 Data

All macroeconomic quarterly data used in my paper is in real terms, coming from the National Bureau of Statistics of China (NBSC). I adjust the real investment using the investment price index (base year 1990) while I use the consumer price index (base year 1990) to deflate other variables. I divide the annualized overnight lending rate by four to produce a quarterly frequency. Also, I obtain two financial variables, the equity payout and debt repurchases from the CSMAR database. "Equity Payout" equals gross dividend, multiplied by net dividend payout ratio in the corporate sector. I aggregate monthly data to calculate a quarterly dividend payment. "Debt Repurchase" is defined as net decrease in domestic loans for fixed assets over the quarter. Both financial variables are normalized by real GDP. My paper covers the time period from 1996Q1 to 2015Q4 due to the availability of some macro variables. Data is seasonally adjusted by Census 12 in EViews and detrended by a HP filter with a smoothing parameter of 1600. Table 2 in page 9 compares the data used in the U.S. and China economies:

Table 2: Data used in the U.S. and China economies

	U.S.	***China***
GDP	Real GDP	Real GDP
Consumption	Real personal consumption expenditure	Real aggregate consumption expenditure
Investment	Real gross private domestic investment	Total real investment in fixed assets
Hours Worked	Total private aggregate weekly hours	Total private aggregate quarterly hours
Wage	Real hourly compensation in business sector	Average real wage per person in urban units
Interest Rate	Federal fund rate	Shanghai Interbank offered annualized overnight rate
Debt Repurchase	Negative of net increase in credit market Instruments in real terms	Negative of real net increase in domestic loans for fixed assets investment
Equity Payout	Net dividends minus net increase in corporate equities minus proprietors net investment of nonfinancial business in real terms	Gross dividends times net dividend payout ratio in real terms

4 Model

In this section, I will introduce credit constraints and financial shocks to a standard real business cycle model to capture some primary characteristics of the Chinese economy. The economy consists of a continuum of identical, perfectly competitive firms and a continuum of identical households, in the [0, 1] interval. Households supply labor to firms and consume final goods. Firms produce final goods using labor and capital. In addition, there is an asset, equity, which can be traded between firms and households. After the introduction above, I will present the general equilibrium.

4.1 Firms sector

A representative firm produces final goods by combining labor demand n_t^f, capital k_{t-1}, and technology z_t, according to a Cobb-Douglas production function:

$$y_t = z_t k_{t-1}^{\theta} n_t^{f\,1-\theta} \tag{1}$$

where $\theta \in (0,1)$ is the share of capital in income. In every period, firms hire workers and pay each unit of labor a real wage w_t, make investments i_t, and issue equity payments d_t to shareholders. Firms also decide how much to finance investment.

Firms use equity, denoted by d_t, and debt, denoted by b_t^f, to finance investments. Following JQ (2012), I assume that interest payments are tax deductible, which makes debt, given the tax advantage, preferable to equity. Given the interest rate r_t, the effective gross interest rate for firms is $R_t = 1 + r_t(1-\tau)$, where τ represents tax benefits.

And the investment is described as the net change in firm's capital stock at a depreciation $\delta \in (0,1)$:

$$i_t = k_t - (1-\delta)k_{t-1} \tag{2}$$

The firm's budget constraint can be written as follows:

$$y_t + \frac{b_t^f}{R_t} - b_{t-1}^f = w_t n_t^f + k_t - (1-\delta)k_{t-1} + \varphi(d_t)$$

in the equation above, $\varphi(d)$ represents firm's quadratic equity payout cost, that is defined as

$$\varphi(d_t) = d_t + \kappa \cdot (d_t - \bar{d})^2$$

where $\kappa \geq 0$ is the key parameter to determine the impact of financial shocks, illustrating the rigidities of changing a firm's financial structure from debt to equity; and $\bar{d}$ denotes the long-run steady state equity payout.

Firms start each period with intertemporal liabilities b_{t-1}^f. Before production they choose labor inputs, investment, equity payments, and the new intertemporal debt b_t^f. Following JQ (2012), I assume that payments to workers, suppliers of investments, and shareholders should be made before the realization of revenues. Therefore, in addition to the intertemporal debt, b^f_{t-1}, firms need to raise funds with an intra-period loan l_t (at no interest) to finance the cash flow mismatch between the payments made at the beginning of the period and the realization of revenues. The intra-period loan l_t is defined as

$$l_t = w_t n^f_t + i_t + \varphi(d_t) + b^f_{t-1} - \frac{b^f_t}{R_t}$$

By comparing to the firm's budget constraint,

$$y_t + \frac{b^f_t}{R_t} - b^f_{t-1} = w_t n^f_t + k_t - (1-\delta)k_{t-1} + \varphi(d_t)$$

I find out that the intra-period loan should be equal to output y_t.

A firm's ability to borrow is limited by its expected liquidation values when it defaults. According to JQ (2012), the default decisions are made after the realization of revenues but before repaying the intra-period loan. Because a firm's revenues cannot be diverted easily, the assets left to lenders for liquidation would be the capital stock k_t. Therefore, the firm borrowing (enforcement) constraints yield:

$$\xi_t\Big(k_t - \frac{b^f_t}{1+r_t}\Big) \geq l_t$$

where $\xi_t \in (0,1)$ follows a stochastic process that captures the degree of financial frictions, and is identical to all firms. With a probability ξ_t, lenders can recover the full value k_t of firms, but with the probability $1-\xi_t$, the recovery value is zero. A smaller ξ_t needs to be compensated with a lager collateral value to sign contracts. On the other hand, a higher stock of capital relaxes firm enforcement constraints.

To consider a firm's maximization problem, I use JQ's (2012) recursive formulation as follows. An individual state consists of a capital stock k_t and debt level b^f_t. The aggregate states are denoted by ω_t. According to JQ (2012), $\omega_t = (z_t, \xi_t, K_t, B_t)$. The parameter ω_t depends on the technology z_t, the financial condition parameter ξ_t, aggregate capital stocks K_t and aggregate bonds B_t. Firms maximize shareholder market values that subject to the budget constraint in equation (3) and the enforcement constraint in equation (4):

$$V(\omega_t; k_{t-1}, b^f_{t-1}) = \max_{d_t, n^f_t, k_t, b^f_t} \{d_t + Em_{t+1}V(\omega_{t+1}; k_t, b^f_t)\} \tag{3}$$

subject to:

$$y_t + \frac{b^f_t}{R_t} - b^f_{t-1} = w_t n^f_t + k_t - (1-\delta)k_{t-1} + \varphi(d_t) \tag{4}$$

$$\xi_t\Big(k_t - \frac{b^f_t}{1+r_t}\Big) \geq y_t \tag{5}$$

where n_{t-1} is the stochastic discount factor.

Suppose λ_t is the Lagrange multiplier of budget constraints and μ_t is the Lagrange multiplier of enforcement constraints. Firms' first-order conditions with respect to d_t, n^f_t, k_t, b^f_t, respectively, are

$$1 - \lambda_t[1 + 2\kappa \cdot (d_t - \bar{d})] = 0 \tag{6}$$

$$w_t = (1 - \frac{\mu_t}{\lambda_t})(1-\theta)\frac{y_t}{n^f_t} \tag{7}$$

$$Em_{t+1}\lambda_{t+1}[1 - \delta + \theta \cdot \frac{y_{t+1}}{k_t}] - \mu_{t+1} \cdot \theta \cdot \frac{y_{t+1}}{k_t} - \lambda_t + \mu_t \xi_t = 0 \tag{8}$$

$$R_t Em_{t+1}\lambda_{t+1} - \lambda_t + \mu_t \xi_t \frac{R_t}{1+r_t} = 0 \tag{9}$$

Equation (6) implies that the marginal cost of dividend payout equals the marginal utility of dividend. A divergence of dividend payment from the steady state increases the marginal cost of equity payout. Equation (7) shows that wages equal the marginal productivity of labor, but multiplied by a term $(1 - \frac{\mu_t}{\lambda_t})$. When the economy is suffering (at a low ξ_t), the enforcement constraint becomes tighter. This can lead to a positive μ_t and create a labor wedge. Given higher wages, firms will eventually cut employments. Equation (9) reveals a negative relationship between the Lagrange multiplier μ_t and the financial condition parameter ξ_t. When ξ_t becomes lower, μ_t will get larger ($\mu_t \geq 0$) which implies a tighter borrowing constraint.

4.2 Households sector

A representative household supplies labor, $n_t^h \in (0,1)$, to firms and consumes firm final goods, c_t. Households are also firm shareholders and hold non-contingent corporate bonds, b_t^h. Households maximize expected lifetime utilities:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, n_t^h) = E_0 \sum_{t=0}^{\infty} \beta^t [ln(c_t) + \alpha ln(1 - n_t^h)] \tag{10}$$

subject to the budget constraint

$$w_t n_t^h + b_{t-1}^h + s_t(d_t + p_t) = \frac{b_t^h}{1 + r_t} + s_{t+1} p_t + c_t + T_t \tag{11}$$

where β^t is household's discount factor and $\alpha > 0$ represents household's disutility of working. Households receive labor income $w_t\ n_t^h$, and per-unit dividend payment d_t with shares of s_t. They also consume firms' outputs c_t, purchase new equity at a price p_t, hold corporate bonds b_t^h and pay a lump-sum tax T_t.

I define λ_t' as the Lagrange multiplier of household budget constraints. Then first order conditions with respect to c_t, n_t^h, b_t^h and s_{t+1} are derived as

$$\frac{\beta^t}{c_t} - \lambda_t' = 0 \tag{12}$$

$$\frac{w_t}{c_t} + \frac{\alpha}{(1 - n_t^h)} = 0 \tag{13}$$

$$\frac{1}{c_t} - \beta^t (1 + r_t) \frac{1}{c_{t+1}} = 0 \tag{14}$$

$$\frac{p_t}{c_t} - \beta^t E(d_{t+1} + p_{t+1}) \frac{1}{c_{t+1}} = 0 \tag{15}$$

Equation (13) determines labor supply. Equation (14) is the Euler equation that implies the risk-free interest rate. By re-arranging and using forward substitution on equation (15), I calculate that the equity price is

$$p_t = E_t \sum_{j=1}^{\infty} \Big(\frac{\beta^j \cdot U_c(c_{t+j}, n_{t+j})}{U_c(c_t, n_t)} \Big) d_{t+1}$$

4.3 Competitive equilibrium

A competitive equilibrium is defined as a set of functions for

(i) Households' policies c_t, n_t^h, b_t^h;

(ii) Firms' policies d_t, n_t^f, i_t, b_t^f;

(iii) Aggregate prices w_t, r_t, p_t.

such that

(i) Households' policies satisfy conditions (12)-(15) given aggregate prices;

(ii) Firms' policies are optimal and $V(\omega_t; k_{t-1}, b_{t-1}^f)$ satisfies the Bellman equation (3);

(iii) Goods market-clearing condition is

$$y_t = c_t + i_t + \kappa \cdot (d_t - \bar{d})^2$$

(iv) Labor market-clearing condition is

$$n_t^h = n_t^f$$

(v) Corporate bonds market-clearing condition is

$$b_t^h + b_t^f = 0$$

(vi) Equity market-clearing condition is

$$s_t = 1$$

5 Calibration and Estimation

To quantitatively analyze the model, I calibrate the model using Chinese data from 1996Q1 to 2015Q4. The parameters can be grouped into two sets. The first set consists of the parameters that can be calibrated using steady state targets. The second set includes parameters that cannot be calibrated using steady state targets, therefore I use numerical methods by solving a log-linear approximation of the dynamic system. Table 3 in page 15 summarizes the model calibrations.

Table 3: Calibrated Parameters in China's Economy

Description	***Value***
Discount factor β	0.9840
Tax advantage τ	0.2500
Utility parameter α	2.1800
Production technology θ	0.5000
Depreciation rate δ	0.0250
Enforcement parameter $\bar{\xi}$	0.3575
Payout cost parameter κ	1.4500
Std. of productivity shock σ_z	0.0055
Std. of financial shock σ_ξ	0.0087
Matrix for shocks process $\boldsymbol{A}$	$\begin{bmatrix} 0.928 & -0.175 \\ 0.013 & 0.741 \end{bmatrix}$

5.1 Set One

To calibrate the discount factor β, I solve $\beta = \frac{1}{1+r}$ in the steady state. From 1996Q1 to 2015Q4, the average annual lending rate is about 6.44%, where β is calculated to be equal to 0.984. The utility parameter $\alpha = 2.49$ is calibrated to match the household's consumption to GDP ratio which equals 0.534 and to make the steady state fraction of working time be 1/3.

Then I calibrate parameters for firms. The new Enterprise Income Tax Law implemented in January 2008 has proclaimed that the tax wedge is set to be 25%, so I choose 0.25 as the tax advantage parameter. The production parameter represents the share of capital in income. There has been much Chinese literature that studies capital shares. He et al (2007) estimate the capital share to be 0.6, Zhang (2009) chooses that $\alpha = 0.45$, also Tian and Wang (2014) use 0.5 as the capital share value. In this paper, I set the technology parameter to be 0.5. Also I follow Chen and Gong (2006) and Wang (2010)'s calibration by setting the annual depreciation rate at 0.1, which yields a quarterly depreciation rate $\delta = 0.025$.

Recall $\bar{\xi}$ is the financial friction coefficient in the steady state. $\bar{\xi}$ needs to be chosen to make the ratio of steady state debt over quarterly GDP equal to 1.25 from 1996Q1 to 2015Q4. Equation (5), therefore, implies $\bar{\xi}$ is required to be 0.3575.

5.2 Set Two

The parameters that cannot be determined by steady state targets are the cost of equity payout factor κ and the stochastic properties of two shocks. Firstly, I choose $\kappa = 1.45$ which matches the model's standard deviation of equity payout-to-GDP ratio with the empirical standard deviation.

Secondly, there are two shock series that need to be constructed, the productivity shock and the financial shock. The productivity innovation z_t follows the standard Solow residuals approach. Using log-linearized production function I derive

$$\hat{z}_t = \hat{y}_t - \theta \hat{k}_{t-1} - (1-\theta)\hat{n}_t \tag{16}$$

where $\hat{z}_t$, $\hat{y}_t$, $\hat{k}_{t-1}$ and $\hat{n}_t$ are the log-deviations from the deterministic trend. Given the value of production parameter θ and the empirical series for $\hat{y}_t$, $\hat{k}_{t-1}$ and $\hat{n}_t$, I can construct shock series $\hat{z}_t$.

To construct the series for financial shock ξ_t, I follow a similar approach but use firms' enforcement constraint under the assumption that it is always binding, which is

$$\xi_t \Big(k_t - \frac{b_t^f}{1+r_t} \Big) = y_t$$

After log-linearization, the enforcement constraint yields

$$\hat{\xi}_t = \hat{y}_t + \frac{-\bar{\xi}\bar{k}}{\bar{y}} \hat{k}_t + \frac{\bar{\xi}\bar{b}^e}{\bar{y}} \hat{b}_t^e \tag{17}$$

where $b_t^e = \frac{b_t^f}{1+r_t}$. The bar sign denotes steady state values. The variable ξ_t is determined residually using the empirical data series for k_t, $\frac{b_t^f}{1+r_t}$ and y_t.

After constructing two series for productivity and financial variables over the period 1996Q1 to 2015Q4, I estimate the autoregressive system

$$\begin{pmatrix} \hat{z}_{t+1} \\ \hat{\xi}_{t+1} \end{pmatrix} = \mathbf{A} \begin{pmatrix} \hat{z}_t \\ \hat{\xi}_t \end{pmatrix} + \begin{pmatrix} \epsilon_{z,t+1} \\ \epsilon_{\xi,t+1} \end{pmatrix} \tag{18}$$

where $\epsilon_{z,t+1}$ and $\epsilon_{\xi,t+1}$ are *iid* with standard deviations σ_z and σ_ξ respectively. Note all parameters are shown in table 3 above.

6 Findings

In this section, I examine the calibrated model by comparing business cycle moments in the simulated and empirical data. Then I will report the variance decomposition and impulse response functions.

6.1 Second moments

Table 4: Business cycle moments of real macroeconomic and financial variables, 1996Q1-2015Q4.

	Data	Both Shocks	Productivity Shock Only	Financial Shock Only
Standard Deviations (*100)				
GDP	1.33	0.86	0.46	0.71
Consumption	1.21	0.26	0.15	0.18
Investment	4.14	2.82	1.25	2.45
Hours Worked	0.05	1.61	0.91	1.19
Equity Payout/GDP	0.18	0.18	0.12	0.12
Debt Repurchase/GDP	0.84	1.35	0.73	1.02
Correlation with GDP				
GDP	1	1	1	1
Consumption	0.72	-0.36	0.51	-0.81
Investment	0.86	0.99	0.98	0.99
Hours Worked	0.65	0.52	-0.13	0.84
Equity Payout/GDP	0.68	0.73	0.33	0.94
Debt Repurchase/GDP	-0.58	-0.63	-0.04	-0.90

All empirical variables are seasonally adjusted by Census X12 in EViews and detrended by HP filter with a smoothing parameter of 1600.

Table 4 compares the business cycle properties of the simulated model to the empirical data. All simulated variables are HP filtered with a smoothing parameter of 1600. Overall, the model with both shocks matches the empirical data well. Model generated correlations fit the empirical data better than the volatilities. However, there are still some results that deserve to be mentioned, such as hours worked and consumption. The standard deviation of hours worked in the data is 0.05, which is substantially lower than the simulated one 1.61. One possible explanation for this huge gap is that I calculate the working hour variable by setting a consistent fixed daily working hour at eight hours. My calculation reduces some fluctuations from the empirical variable. On the other hand, the labor market frictions in China, like wage rigidity, affect labor demand and generate fluctuations in employment. Both explanations imply that the data volatility is underestimated. Simulation moments of consumption (0.26) fit empirical data (1.21) poorly as well. This might suggest that in the model two shocks affect consumers indirectly. According to JQ (2012), this problem could probably be fixed by linking financial frictions and financial shocks to the consumption side.

Columns four and five in table 4 present business cycle moments when only one shock occurs. The standard deviations calculated from the model with only the productivity shock are significantly smaller than the data. The comparison between the two cases indicates that financial shocks provide stronger explanations of most real variables compared to productivity shocks. Moreover, the simulation's performance improves even further when we consider both shocks simultaneously.

6.2 Variance Decomposition

Table 5: Variance decomposition of productivity shock z_t and financial shock ξ_t

	z_t	ξ_t
Output	33.53	66.47
Consumption	50.46	49.54
Investment	26.33	73.67
Labor	47.54	52.55
EquityPayout/GDP	59.08	40.92
DebtRepurchase/GDP	44.37	55.63

Note: The numbers shown in the table above are in percentages.

Table 5 reports variance decomposition results of some key macroeconomic variables in China. The financial shock accounts for about 66% of output fluctuations. The result indicates that the financial shock dominates the real business cycles. Financial shocks are the main driving forces of investment, labor, and debt issuing, whereas they have a relative limited contribution to consumption and equity payment. This may be caused by the special consumption habits of Chinese households, say, relatively low consumption levels in the rural area, high saving rates, and the hesitation about taking personal loans among older generations. In JQ (2012), they concluded that the financial shocks explain about 46% of output variance in the U.S. The different results in variance decomposition, on the other hand, reveal that the Chinese financial market is more severe in terms of transmitting negative shocks to the real economy.

6.3 Impulse response functions

Figures 4 and 5 plot the impulse response of the main macroeconomic variables to each shock. Initially, I examine how the economy reacts to a one-standard-deviation positive productivity shock. Figure 4 shows a rise in output, consumption, investment and debt repurchase, which is consistent with macro theories. When technology improves, consumption, investment and output will increase. Households also adjust their behaviors by obtaining more corporate bonds and private loans, which corresponds with the jump in debt issuing. Intuitively, in the labor market, the positive shock might induce firms to post additional vacancies. Higher labor costs would reduce firm collaterals, therefore, cutting down dividend payments.

Figure 4: Impulse Response to a one-time Productivity Shock

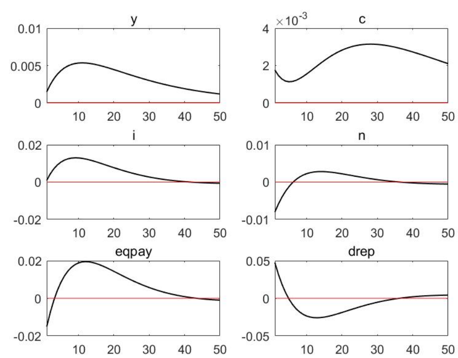
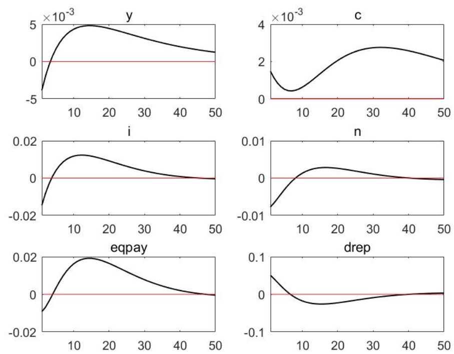


Figure 5 illustrates the result of a one-standard-deviation negative financial shock on selected variables. The effects of financial shocks are persistent,

Figure 5: Impulse Response to a one-time Financial Shock



and usually last for more than thirty quarters. The performance of the model in response to the impacts that financial shocks have is through the labor market. When a negative financial shock occurs, the enforcement constraint becomes tighter. If firms want to maintain the current output level, they have to choose to reduce in part the equity payout and in part the labor input. A negative shock makes investment and output fall as well. As firms' working capital drops, debt repurchase jumps dramatically. It is interesting to show an unconventional response that consumption rises when the financial situation becomes more serious. One reason could be the way which I define utility function cannot capture the actual linkage between consumer and the financial market. I will leave this to future work.

7 Discussions

One might argue how a DSGE model employed by my paper, that is designed for advanced countries, could capture the features of China's economy. As mentioned by Scheibe and Vines (2005), since the 1970s, China has transformed its economic system from a planned central-control regime to a more market-oriented free economy. As such market structure evolved rapidly, it does not seem to be inappropriate to explain Chinese business cycle behavior in a framework of advanced economies, especially for the past two decades. Chow (2010) also argued that "good quantitative relations are valid for different periods in China, including both the periods of planning and after market reform." In addition, China's Central Economic Working Commission has set long-run targets for particular economic indicators since 1990, such as the GDP growth target, ranging between 7 and 9 percent, which could be regarded as an implicit assumption of steady-state paths.

Another concern might be that as China has a large exports and imports proportion, it cannot be modelled as a closed economy. However, according to Le et al (2014), China's export and import sector has developed rapidly as a result of decisions to invest in new infrastructure in cities and transportation; as a consequence, the resulting outputs were sold aggressively into the world market at prices that the market required. Because the industrial structure is largely dominated by multi-national companies, imports too are closely related to export volumes. Therefore, it is reasonable to model net imports as exogenous processes, with little connection to China's business cycle fluctuations.

A survey conducted by the World Bank on investment climate in 2000 highlights that 80% of private firms in China cite financing constraints as major obstacles. It also suggests that most small firms in China fail to grow to medium and large scale mainly due to the lack of formal credit for expansion. This is consistent with my finding that in China only about 19% of investment could be financed by domestic loans through financial institutions from 1996Q1 to 2015Q4. The access to external finance is crucial to firms because efficient investments do not only determine business expansion, but also promote economic growth. The model in my paper captures this financial incompleteness by imposing credit constraints on firms. An enterprise's borrowing capability is restricted by its realized liquidation values when the firm defaults. The negative financial shock affects firms' ability to borrow and in turn influences the real economic activities.

I estimate parameters to make the selected theoretical moments match realistic data as closely as possible. In my paper, the key financial parameter κ, which illustrates the rigidities of changing firms' financial structure from debt to equity, is chosen to match the simulated standard deviation of equity payout to GDP ratio exactly to the empirical standard deviation. Moreover, to construct productivity and financial shock series, I calculated Solow and enforcement residuals using empirical data, respectively. Even though the RBC model in my paper does not seem to provide a full characterization of the Chinese economy, using these estimation methods, I would like to make the model more relevant to reality.

There are also some drawbacks in my model that deserve to be mentioned. I summarize them as follows. The main concern is the feasibility to model

China's business cycle fluctuations using a standard RBC framework. The parsimony model in my thesis assumes that prices and wages are flexible, however, these assumptions seem unconvincing when facing observed data. To improve the model's applicability, I might need to construct and estimate a New Keynesian (NK) DSGE model with labor market segmentation and good market frictions in terms of price and wage rigidities. In China, the degree of wage rigidity turns out to be more severe than sticky prices in the past several decades. Dai (2012) sets up a hybrid model to mimic China's economy by mixing both New Keynesian and New Classical features. The economy consists of product sectors where rigidity prevails, while others have flexible prices. The hybrid model allows the degree of imperfect competition to differ between labor and product markets. His results show that this combined model got much closer to the observed data in China. In my findings, the model simulated "working hours" variable failed to capture the volatilities of the Chinese labor market observed in actual data. Thus, to modify the labor market in my model should be my first aim to achieve.

Another concern might be raised by some distinct characteristics in China's economy. On one hand, People's Bank of China ,the central bank in China, along with other state-owned banks, have monopoly powers in controlling credit supply. To achieve social welfare, the government sometimes allocates capitals inefficiently. On the other hand, the Chinese corporate sector is categorized into two groups by firms' political properties, which are state-owned enterprises (SOE) and private enterprises. SOE firms usually have low productivity but better access to the credit market, while private firms are more efficient but limited by less financial resources. This problem could be addressed by assuming two production sectors in the model like Smets and Wouters (2007), the final firm in a perfect competition market and the intermediate firm in a monopolistic market. SOE companies have monopolistic positions by controlling the raw materials and energy sectors as intermediate firms. The private companies produce final consumption goods in competitive market.

8 Conclusion

Does the financial shock drive the real business cycle movements in China as well? The answer from my analysis is yes. In this paper, first I present the data of funds for fixed assets investment to illustrate the financial cycle in the Chinese economy. I conclude that debt financing (domestic loans) is countercyclical, while the equity financing (self-finances) reveals a procyclical pattern. Based on my findings, I then use JQ's (2012) real business cycle DSGE framework to model China's financial flows. Within the model, I explain that the financial shocks to firms' ability to borrow play a crucial role in generating business cycle fluctuations. The key is the interaction between credit conditions and labor demand. In addition, I use observed data and model restrictions to construct productivity and financial shock series. Finally, the results of variance decomposition and impulse responses combined with simulation performance suggest that financial shocks are the main driving force of macroeconomic fluctuations.

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