Do Financial Shocks Drive Real Business Cycle Fluctuations in China?

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Abstract

Over the past several decades, China has enjoyed one of the world's fastest-growing economies and succeeded in rebounding quickly from historical recessions, especially the global financial crisis of 2008-2010. This paper studies the extent to which financial shocks, shocks that are originated from the financial market, can shape business cycle fluctuations in China. First, I document the business cycle properties of China's economy from 1994 to 2017 and show the procyclicality of dividend payout and the countercyclicality of debt repurchases with real GDP, respectively. To account for these features, I develop a real business cycle model that allows firms to raise funds via debt and equities to understand the role of financial shocks in generating macroeconomic dynamics. This paper finds that financial shocks contribute significantly to the growth of output, investment, hours worked, and debt repurchases, and thus are the main driving force of macroeconomic fluctuations in China.

JEL classification: E23, E32, E44, G01, G32, O53
Keywords: financial frictions, financial shocks, business cycle, real business cycle model, China

1 Introduction

The financial crisis of 2008-2010 and the European debt crisis afterward have led world economists to re-evaluate the role of financial sectors in promoting economic growth and maintaining social stability. While China's success in rebounding quickly from historical recessions has been remarkable, its financial system still faces a few major challenges. For example, China's public bond market and stock market are relatively rudimentary, and many large listed firms are state-owned. Due to the government's socio-economic objectives, those firms do not necessarily pursue profit (Ding et al. (2007)), which might obstruct China's fast growth in the long run. Besides, according to Zhang et al. (2016), China's banking sector has been relatively immune from financial crises due to the government's strict regulation. However, it also isolates domestic financial institutions from competing in the global financial market. Moreover, the nature of state ownership and associated soft budget constraints of state-owned banks has triggered the high-portion non-performing loan problem, which is partially due to the dominance of lending to state-owned enterprises and strong government influence.

With such an institutional and economic environment, this paper tests the extent to which financial shocks can shape business cycle fluctuations in China. I study this question in the following three steps. First, I document some salient features of China's economy spanning the 1994-2017 period, in particular, fixed assets investment and debt and equity flows. I find that self-financing, such as through internally generated cash flow and equity issuance, has been the dominant source of funds for fixed assets investment in China over time. Also, from measured business cycle properties, I discover the procyclicality of cash dividend payments and the countercyclicality of newly increased debt with real GDP, respectively. Second, I follow Jermann and Quadrini (2012) and build a real business cycle (RBC) model that allows firms to finance via equity and debt to highlight such features. The model contains two types of shocks, one is total factor productivity (TFP) shocks, and one is financial shocks, referring to innovations in firms' borrowing constraints. An adverse financial shock tightens firms' borrowing constraints as the value of assets used as collateral falls. Thus if firms cannot raise enough funds externally or internally through issuing equities within a short period for required payments, they have to cut employment to avoid default, which will affect the real economy. To the author's best knowledge, this paper is the first to document financial flows from a macro perspective and model China's economy using an RBC framework with financial shocks in the manner applied to this paper. Last, I construct realized time series of TFP and financial shocks from the data, feed them into the calibrated model and simulate business cycle properties of China's economy. When including both shocks, the model-implied standard deviation of macroeconomic and financial variables are able to replicate the empirical counterpart decently. However, variables' correlation with real GDP is stronger in the simulated economy than in the data. Moreover, the variance decomposition results suggest that financial shocks contribute significantly to the growth rate of output, investment, hours worked, and firms' newly raised debt.

The first step of our analysis is to present some salient features of China's financial market cycle from a macro perspective over the 1994-2017 period. I collect data mainly from the National Bureau of Statistics of China (NBS) and the China Stock Market & Accounting Research (CSMAR). The data indicate that self-financing, funds collected from retained earning, principal owners, and bond or equity issuance, is the dominant source of funds for fixed assets investment in China, accounting for about 58% of total funds. The flow of self-financing and domestic loan financing in fixed assets investment also reveals some degrees of substitutability. In China, state-owned enterprises are founded to implement the government's socio-economic objectives. Since China's government has a substantial influence on domestic financial institutions, banks strongly prefer lending to state-owned enterprises. Therefore, private firms, especially those with small and medium sizes, rely heavily on self-financing for both start-up and expansion (Ge and Qiu (2007)).

To further characterize China's financial market, I select two financial variables, cash dividend payments (dividend payout) and net increases in domestic loan financing and new bond issuance (debt repurchases) of the non-financial businesses. Their correlations with real GDP confirm the procyclicality of cash dividend payments and the countercyclicality of newly raised debt, respectively.

In the second step of the analysis, I follow Jermann and Quadrini (2012) and build a real business cycle model that allows firms to finance by taking loans and issuing equities to understand the extent to which financial shocks can contribute business cycle fluctuations in China. The model consists of a continuum of firms and households. Households supply labor and receive labor income. They also trade firms' equities, hold non-contingent corporate bonds and thus earn interests and dividend payments. Moreover, households need to pay a lump-sum tax to finance firms' tax benefits. In each period, firms choose labor, make new investments and decide how much to finance with equity and debt for production. Because I assume that payments to workers, investors, shareholders, and bondholders must be made before the realization of revenues, firms might require an intra-period loan to fill the liquidity gap. However, when adverse financial shocks hit the market, firms' borrowing constraints become tighter, as the value of capital used as collateral declines. Again, innovations in firms' borrowing constraints are referred to as financial shocks. If firms cannot raise enough funds externally or internally through issuing equities within a short time horizon, they have to cut employment to avoid default, which will affect the real economy.

The final step of our analysis is to use this model to understand the role of financial shocks in explaining macroeconomic properties in China spanning from 1994 to 2017. First, I measure the time series of TFP shocks in the data using the Solow residual approach. Similarly, I construct financial shocks as the residuals of the linearized firms' borrowing constraints. I find that the constructed TFP shocks are more persistent than financial shocks, which I interpret as the government's strict control over the capital market. Next, I feed the realized time series of two shocks into the calibrated model and simulate business cycle moments from the model.

This paper finds that when including both shocks or only financial shocks, the model-implied standard deviation of macroeconomic and financial variables are able to replicate the empirical patterns decently. However, variables' correlation with real GDP is stronger in the simulated economy than in the data, which might be due to the flexibility of labor and wage of the RBC model. Moreover, the variance decomposition results suggest that financial shocks contribute significantly to the growth rate of output, investment, hours worked, and firms' new debt, while productivity shocks capture major volatilities in consumption and dividend payments. Therefore, this paper concludes that financial shocks significantly account for business cycle movements in China.

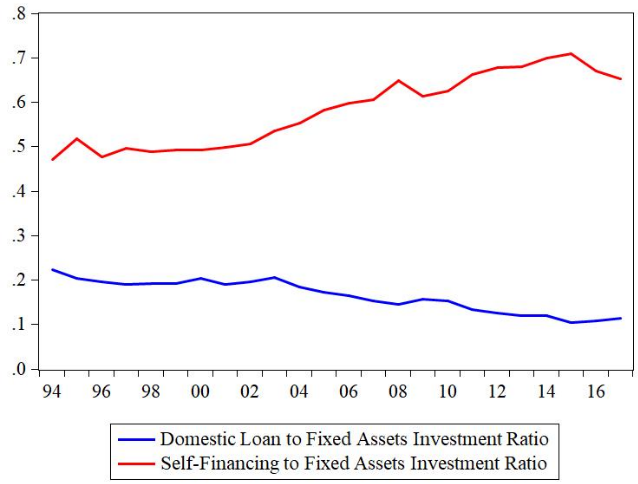
The rest of the paper is organized as follows: In section 2, I introduce the data sources of selected macroeconomic and financial variables and document some salient features of China's financial market from 1994 to 2017. In section 3, I review two strands of literature and highlight the contributions of this paper. In section 4 and 5, I build an RBC model allowing debt and equity financing to highlight the observed empirical features, calibrate the model and construct the time series of TFP and financial shocks. Section 6 presents the main findings of this paper. I also discuss the validity of applying a dynamic stochastic general equilibrium (DSGE) model to China's economy and some missing China-specific characteristics from my model in section 7. Section 8 concludes.

2 Descriptive Evidence on China's Financial Market

2.1 Data Sources

This paper combines several sources of data for empirical work. First, all national-level macroeconomic data comes from the NBS and the Qianzhan database (d.qianzhan.com). The data is measured annually over the 1994−2017 period. Specifically, I deflate gross fixed assets investment using the investment price index to obtain real investment, while other

Figure 1: Domestic Loan and Self-Financing to Fixed Assets Investment Ratio, 1994-2017



macroeconomic variables are deflated by the consumer price index, both with the base year of 2015.

Second, this paper selects two financial variables to capture China's financial cycle: debt repurchases and dividend payout, which will be defined later. Two databases used are the CSMAR and the RESSET database (`www.resset.com`). Two variables are compiled monthly, and I aggregate them to an annual frequency.

Moreover, I choose 1994 as the initial year for my sample for two different reasons. On the one hand, the Chinese stock market was established at the beginning of the 1990s, and in 1993 China started to adopt a new accounting system closer to international accounting standards and provided better information disclosure (Zou and Xiao (2006)). On the other hand, until 1994, China started to officially collect data on the source of funds of fixed assets investment that come from bond and equity issuance. As a result, data prior to 1994 will be too limited for analysis. Furthermore, my sample period ends in 2017, the last year for which the fixed assets investment data is available.

Last, in the Appendix A, I compare variables used in this paper (in the context of China's economy) and variables used in Jermann and Quadrini (2012).

2.2 Empirical Evidence on Fixed Assets Investment

There are five primary sources of funds to invest for Chinese enterprises, domestic loans (16%), state budget (5%), foreign-related investment (4%), self-financing (58%), and others

(17%).[1] In this paper, I focus on domestic loan financing and self-financing to understand the relationship between financial market fluctuations and the real economy in China.

Figure 1 plots China's domestic loan financing (blue line) and self-financing (red line) to gross fixed assets investment ratios from 1994 to 2017, respectively. *Domestic loan financing* refers to enterprises (state-owned or private) and public institutions borrowing funds from banks or other non-bank financial institutions for fixed assets investments. *Self-financing* denotes the funds that firms collect from internal sources, such as retained earnings, principal owners, and equity or bond issuance used for fixed assets investment, excluded from government funds, funds borrowed from financial institutions, and capital from overseas.[2]

The sample mean of domestic loan to investment ratio (blue line) is computed as 0.16, indicating only about 16% of total investment could be financed through taking domestic loans. Also seen in the figure, the blue line shows a declining trend since 1994, implying that the proportion of domestic loans used for funding investment has decreased over time. Besides numerous restrictions on the capital market, there is only one rudimentary public bond market in China, and so most corporate debt is provided by banks and other financial institutions, all of which are state-controlled (Firth et al. (2012)). Therefore, this declining ratio might result from commercial banks having tightened up credit policies over time so that it became harder for firms to obtain loans. However, if enterprises cannot obtain enough loans from domestic financial institutions, they must fund themselves elsewhere. Internally generated cash flows are therefore important in funding fixed asset expansion (Guariglia et al. (2011)). The time series of self-financing to investment ratio (red line) exhibits an upward-sloping trend, meaning self-financing tends to rise over the past two decades. Moreover, it suggests that in China, self-financing is considered a primary source of funds for firms as, on average, it accounts for 58% of the funds for gross investment. For example, Gregory and Tenev (2001) and Ge and Qiu (2007) argue that private firms in China, especially those with small and medium sizes, tend to face more stringent regulations in obtaining bank loans compared to state-owned enterprises. Therefore, they rely heavily on self-financing for both start-up and expansion.

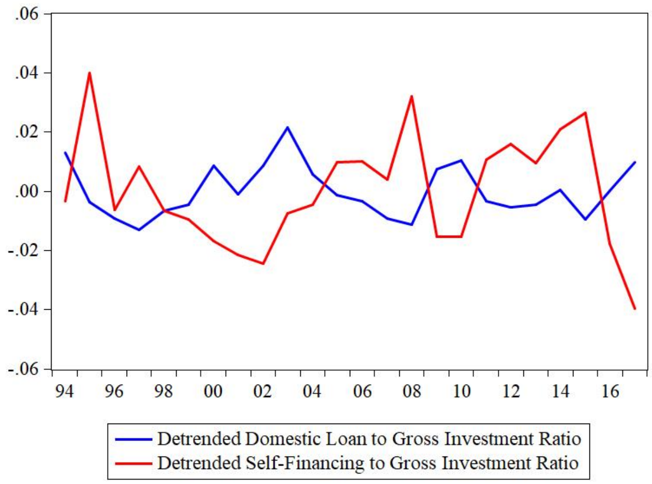
In Figure 2, I present two aforementioned flows of funds[3] to reveal an underlying substitutable relationship between debt-financing (domestic loans) and self-financing. Two patterns are clearly visible in the figure. First, domestic loan financing (blue line) is strongly and negatively correlated with self-financing (red line), implying some substitutability be-

[1] The numbers in the parentheses are the mean ratios of a particular source of funding over gross fixed assets investment from 1994 to 2017.

[2] More detailed data, for example, the portion of equity and bond issuance out of self-financing, is not available on official sources.

[3] Two variables are Hodrick–Prescott (HP) filter detrended with a smoothing parameter of 100.

Figure 2: Detrended Domestic loan and Self-Financing Ratios, 1994-2017



tween these two financing methods. I then compute the correlation between two variables, which is equal to -0.56. Second, significant increases in the volume of domestic loans tend to follow important events in China's economy. For example, there are four relatively large peaks in the domestic loan financing to investment ratio around 1994, 2000, 2003, and 2010. The coincident events are the implementation of the Reform and Opening policies since mid-1992 proposed by former President Deng Xiaoping, the catastrophic floods as well as the Asian financial crisis in 1998, China's accession to the World Trade Organization (WTO) in 2001, the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003, and two severe earthquakes combined with the global financial crisis of 2008-2010. When prominent events occur, especially disaster events, the Chinese government give out more loans to help businesses survive and stimulate the real economy. Alternatively, in normal times, as other financing methods are more accessible in the capital market, commercial banks tend to have tighter regulatory control on credit supply.

2.3 Empirical Evidence on Financial Cycle

In this subsection, I present business cycle properties of selected macroeconomic and financial variables in table 1, which are the standard deviation of each variable and their correlation with real GDP over the sample period.

I choose two financial variables, debt repurchases and dividend payout, to characterize the financial cycle in China's economy. *Debt repurchases* is defined as net increases (or decreases) in domestic loans and bonds issuance in the non-financial business sector. *Dividend payout* refers to net cash dividend paid to non-financial business shareholders. Both variables are

Table 1: Business Cycle Properties of Macroeconomic and Financial Variables, 1994-2017.

	Standard Deviation(Variable)	Corr(Variable, real GDP)
Panel A: Real Macroeconomic Variables		
GDP	0.035	1
Consumption	0.019	0.51
Investment	0.065	0.60
Hours worked	0.009	0.32
Panel B: Financial Variables		
Debt repurchases	0.037	-0.38
Dividend payout	0.020	0.30

[1] All real macroeconomic variables are in logarithms and detrended using the HP filter approach with a smoothing parameter of 100.
[2] Two financial variables are normalized by business GDP.

expressed as a fraction of nonfinancial business GDP. In Panel B, the correlation of two financial variables with real GDP confirms the procyclicality of dividend payout (0.30) and the countercyclicality of domestic loan financing (-0.38), respectively.

In contrast, in Panel A, all macroeconomic variables are positively correlated with GDP. Also, whereas consumption are less volatile than GDP, investment is much more volatile than output.

3 Literature Review

This paper relates to two extensive pieces of literature studying: (1) the relationship between financial flows and real economic activities in developed economies, and (2) the role of financial sectors in shaping macroeconomic fluctuations in China.

According to Quadrini (2011), there are two possible channels that link financial flows to the real economy: amplification through financial market frictions and financial shocks. The amplification hypothesis states that financial frictions can propagate and amplify (but not cause) the shocks that originate in nonfinancial sectors. In the canonical work of Bernanke and Gertler (1986), the authors develop a costly state verification model with information asymmetry to explore the extent to which firms balance sheet can affect business fluctuations. They conclude that reductions in collateral increase agency costs of borrowing, which then depress the demand for investment and enhance the propagation of productivity shocks to the real economy. In another classical work of Bernanke et al. (1999), they revisit the same question using a New Keynesian model with endogenously fluctuating price of capital and find that agency frictions could generate sizeable amplification of monetary policy shocks to the macroeconomy. This amplification mechanism is later referred to as the financial accelerator theory. Other papers that study the role of financial frictions in propagating and amplifying exogenous disturbances in the costly state verification framework include Carlstrom and Fuerst (1997), Gertler et al. (2007), Christiano et al. (2014), and Carlstrom et al. (2016), to name a few. An alternative way of modeling financial frictions is to incorporate limited enforceability, as in the seminal work of Kiyotaki and Moore (1997). Because debt contracts are not perfectly enforceable if borrowers default, lenders will restrict the amount of credit a borrower can access. For example, shocks that decrease asset prices used as collateral tighten credit constraints, resulting in a reduction in investment and output, and further deteriorate firms' ability to borrow (firms' credit limits). Therefore, small, temporary shocks to technology or income can generate large, persistent fluctuations in output and asset prices. Following that, Cooley et al. (2004) study a general equilibrium model subject to enforceability and show that economies in which contracts are less enforceable display greater volatility of output than economies with stronger enforceability of contracts. Iacoviello (2005) incorporates costly enforcement constraints into a monetary DSGE model to study the interplay of monetary policy and the housing market on firms' borrowing constraints and then aggregate economy.

In contrast, the branch of literature that studies financial shocks as the origin of business cycle dynamics is relatively undeveloped. The recent work of Jermann and Quadrini (2012) documents business cycle properties of U.S. firms' financial flows and shows that two funding strategies are substitutable to some extent. Then the authors develop a model with enforcement constraints and find out that financial shocks, which will limit a firm's ability to borrow, are essential for capturing the dynamics in the financial market and the real economy. Mendoza and Quadrini (2010), Christiano et al. (2010), Gertler and Karadi (2011), Gilchrist and Zakrajšek (2011), and Kiyotaki and Moore (2012) also confirm that shocks to the financial market, i.e., credit supply shocks, can play a prominent role in shaping business cycle fluctuations. Perri and Quadrini (2018) go beyond "exogenous" credit shocks and investigate the reasons for large and synchronized international economic contractions during the 2008 crisis. They find out that first, the model with endogenous credit shocks can generate cross-country comovement in both real and financial variables. Second, crises are less frequent with more international financial integration but, when they hit, they are larger and more synchronized across countries.

My paper also fits the literature that investigates the role of financial sectors in shaping macroeconomic fluctuations in China. Most existing Chinese literature has focused on analyzing the implication of the financial accelerator or amplification mechanism to China's economy. For example, with the threshold autoregression model, Zhao et al. (2007) verify a nonlinear correlation between the Chinese credit market and macroeconomic fluctuations and confirm the remarkable financial accelerator impact on China's economy during the 1990 to 2006 period. Also, Yuan et al. (2011) establish a small open economy model to analyze the financial accelerator effect under different exchange rate regimes. They conclude that the financial market frictions mainly amplify the impact of domestic investment efficiency and monetary policy shocks, as well as the currency demand shocks from overseas. However, until recently, some Chinese scholars have shifted their attention to assessing financial market shocks as the origin of business cycle fluctuations in China. Wang and Yan (2012) use a DSGE model including three kinds of financial sector shocks to study their roles in determining economic fluctuations, respectively. The Bayesian estimation results show that financial market shocks can explain 25% of output volatility in China. Moreover, the authors argue that the elasticity of substitution of direct and indirect financing in China is low. Luo and Gong (2013) extend a standard RBC model with two production sectors, state-owned and private enterprises, and dual interest rate regimes, and point out that financial repression and financial frictions are crucial to replicating the procyclicality in debt of state-owned firms and the countercyclicality of the debt in private firms. Wang and Tian (2014) use a Bayesian DSGE model to illustrate that financial shocks are the main driving force (relative to other shocks) of business cycle fluctuations in China.

Compared to the papers mentioned above, this paper contributes mainly to Chinese literature from the following aspects. From an empirical standpoint, I develop two variables, debt repurchases and dividend payout, to document the financial flows in China's nonfinancial business sector. Unlike most existing literature, I measure financial flows from a macro perspective. The empirical evidence confirms their significant relationships with real GDP, respectively. Theoretically, in order to capture these features, I embed debt and equity-financing into an RBC model to study the impact of financial shocks on the financial market and the real economy. While a number of studies of China's economy exist using the DSGE framework, there has been no effort to model China's business cycle properties in the manner applied in this paper.

4 Model

This section introduces a real business cycle model that allows financial asset trading between firms and households. I also incorporate firms' credit constraints and financial shocks into the model to characterize China's economy.

4.1 Firms

The economy consists of a continuum of firms in the [0, 1] interval. Firms produce final goods, y_t, according to a Cobb-Douglas production function by combining labor, n_t^f, capital input, k_t, which is pre-determined at time $t-1$, and an identical total factor productivity (TFP), z_t,:

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

where $\theta \in (0,1)$ is the proportion of capital income in GDP. Capital evolves according to

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

where i_t is the new investment in period t and $\delta \in (0,1)$ is the capital depreciation rate.

In every period, firms pay labor with a real wage w_t, make new investments, i_t, and decide how much to finance with equity, denoted by d_t, and debt, denoted by b_t^f, respectively. As Huang and Song (2006) provide clear evidence that Chinese companies consider tax effects in their financing decisions, I assume that interest payments are tax-deductible. Therefore, debt is preferred to equity for Chinese firms.[4,5] 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. Firms are subject to the following budget constraints:

$$y_t + \frac{b_{t+1}^f}{R_t} - b_t^f = w_t n_t^f + k_{t+1} - (1-\delta)k_t + d_t. \tag{3}$$

Besides an intertemporal debt, b_t^f, firms might still need to raise funds with an intra-period loan,[6] l_t, within the period t to fill the liquidity gap between payments made at the beginning of the period and the realization of revenues. Following Jermann and Quadrini (2012), I assume that payments to workers, investors, shareholders, and bondholders must be made before the realization of revenues. Thus, the intra-period loan is given as

[4] There are other potential reasons for such a preference. On the one hand, Firth et al. (2012) argue that despite more stringent entry to the Chinese equity market, some profitable firms are unable to make initial public offers (IPOs) or seasoned equity offers (SEOs) because they cannot get permission from China Securities Regulatory Commission. Moreover, in some years, the state has set numerical quotas for IPOs far below the number of eligible applicants. On the other hand, a large number of large listed firms are state-owned enterprises and are subject to a soft credit constraint, which makes debt financing more favorable (Chen et al. (2014)).

[5] However, the pecking order hypothesis, which states that firms prefer debt financing to equity financing because of its tax advantage, might not hold for Chinese firms as commercial banks in China have tightened up credit policies and enhanced debt monitoring since the 1990s. See Tong and Green (2005), Huang and Song (2006), Zou and Xiao (2006) and Ni and Yu (2008).

[6] The intra-period loans are repaid by the end of each period; thus there is no interest.

$$l_t = w_t n_t^f + i_t + d_t + b_t^f - \frac{b_{t+1}^f}{R_t},$$

where the size of the intra-period loan and firms' revenues are equalized.

However, firms might default on their obligations. As a result, a firm's ability to borrow will be limited by its expected liquidation values when it defaults. As argued by Jermann and Quadrini (2012), liquid assets like firms' cash flows can be diverted easily. Therefore, the assets left to lenders for liquidation will only be defaulting firms' physical capital in the current period, k_{t+1}. In addition, since default decisions are made after the realization of revenues but before repaying the intra-period loan, defaulting firms' total liabilities at the moment will be $l_t + \frac{b_{t+1}^f}{1+r_t}$. Therefore, firms' borrowing constraints are bounded as:

$$\xi_t \left(k_{t+1} - \frac{b_{t+1}^f}{1+r_t} \right) \geq l_t, \tag{4}$$

where variable $\xi_t \in (0, 1)$ is stochastic and identical to all firms. Specifically, with a probability ξ_t, lenders can recover the total value of defaulting firms' physical capital, while with a probability $1 - \xi_t$, the recovery value is zero. In other words, the value of ξ_t depends on economic conditions.[7] For example, with a depressed economic condition or a smaller ξ_t, lenders need to be compensated with more collateral to agree to lend. Alternatively, a higher level of capital stock relaxes firms' enforcement constraints. Since variable ξ_t captures the degree of financial market tightness, therefore, firms' capability to borrow, it is referred to as "financial shocks."

Next, I will illustrate how financial shocks might affect firms' financial and production decisions with the following timeline. Firms start each period with pre-determined capital stock, k_t, and an intertemporal debt, b_t^f, inherited from the last period. Then firms choose labor, n_t, and new investment, i_t, to produce. They also choose dividend payments,[8] d_t, and new funds for the next period, b_{t+1}^f, to finance. As mentioned earlier, firms might consider taking an intra-period loan to fill the liquidity gap between revenues and payments that must be made. However, firms can only fully decide how many workers to hire and how much dividend to pay shareholders, not how much to finance externally, because firms' capability to borrow is conditional on the value of physical capital assets and market conditions. When suffering negative financial shocks, i.e., with a low value of ξ_t, firms' borrowing constraints become tighter. Therefore, if firms still cannot relax their credit constraints within a short

[7] The reason to put the two variables in the parenthesis is that firms' ability to either convert physical into liquid assets or to borrow externally relies heavily on current economic situations, while loan payments do not.

[8] d_t can be negative if firms issue more shares in the market.

time horizon, such as reducing dividend payments or even issuing more shares in the market, they have to lay off workers instead.

Moreover, I assume that firms face a quadratic cost on dividend payments, $\varphi(d)$, as in Jermann and Quadrini (2012). The costs include both actual dividend payments (or new equity issuance if negative) and other related transaction costs, and it is defined as

$$\varphi(d_t) = d_t + \kappa \cdot (d_t - \bar{d})^2, \tag{5}$$

where parameter $\kappa \geq 0$, describing how easily firms can switch from debt to equity financing in the short-run, and $\bar{d}$ represents the long-run steady-state equity payout. If $\kappa = 0$, it means no additional costs on new equity issuance (if d_t is negative). Consequently, debt financing induced by financial shocks would be flexibly substituted by issuing new equity. However, if $\kappa > 0$, dividend payments display increasing marginal cost in the size of the offering, making it more difficult to make such an adjustment.

Finally, I specify firms' optimization problem. In particular, firms maximize their overall market values, $V(\omega_t; k_t, b_t^f)$, by optimizing the following recursive formulation:

$$V(\omega_t; k_t, b_t^f) = \max_{d_t, n_t^f, k_{t+1}, b_{t+1}^f} \{d_t + E m_{t+1} V(\omega_{t+1}; k_{t+1}, b_{t+1}^f)\}, \tag{6}$$

subject a budget constraint and a borrowing constraint:

$$y_t + \frac{b_{t+1}^f}{R_t} - b_t^f = w_t n_t^f + k_{t+1} - (1-\delta) k_t + \varphi(d_t), \tag{7}$$

$$\xi_t \Big(k_{t+1} - \frac{b_{t+1}^f}{1 + r_t} \Big) \geq y_t, \tag{8}$$

where ω_t denotes a firm's aggregate states and m is a stochastic discount factor.

4.2 Households

There is a continuum of identical households who maximize expected lifetime utilities over labor, $n_t^h \in (0, 1)$, and final consumption, c_t. The utility function is given as:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, n_t^h) = E_0 \sum_{t=0}^{\infty} \beta^t [ln(c_t) + \alpha ln(1 - n_t^h)], \tag{9}$$

where β is the discount factor, and $\alpha > 0$ measures the household's disutility of working.

Households also own firms' equity, d_t^h, hold non-contingent corporate bonds, b_t^h, pay a lump-sum tax, T_t, and are subject to the following budget constraint:

$$w_t n_t^h + b_t^h + s_t(d_t + p_t) = \frac{b_{t+1}^h}{1 + r_t} + s_{t+1} p_t + c_t + T_t, \tag{10}$$

where in period t, households receive labor income, w_t, interests on bonds, r_t, and per-unit dividend payment, p_t, with a share of s_t.

4.3 Competitive Equilibrium

A recursive competitive equilibrium of the economy contains a set of aggregate prices, $\{w_t, r_t, p_t\}$, an allocation of $\{c_t, n_t^h, b_t^h\}$ for households, and an allocation of $\{d_t, n_t^f, i_t, b_t^f\}$ for firms given a productivity level, z_t, and financial shocks, ξ_t, such that

- Firms optimize cumulative market values, $V(\omega_t; k_t, b_t^f)$, subject to the budget constraint (7) and the borrowing constraint (8), respectively.
- Households maximize expected lifetime utilities, subject to the budget constraint (10).
- Goods market clears
$$y_t = c_t + i_t.$$
- Labor market clears
$$n_t^h = n_t^f.$$
- Corporate bonds market clears
$$b_t^h + b_t^f = 0.$$
- Equity market clears
$$s_t = 1.$$

5 Calibration and Estimation

To quantitatively analyze the model, I calibrate the model using China's data from 1994 to 2017. The parameters are grouped into two sets. The first set consists of the parameters that can be calibrated using steady state targets, while the second set cannot. Therefore, I use numerical methods by solving a log-linear approximation of the dynamic system. Table 2 summarizes the parametrization of the model.

Table 2: Calibrated Parameters for China's Economy

Name	Description	Value	Sources
β	Discount factor	0.952	calibrated
τ	Tax rate	0.250	Enterprise Income Tax Law
α	Utility parameter	1.3526	calibrated
θ	Capital income share	0.500	common literature
δ	Depreciation rate	0.080	Chow and Li (2002), Chen (2014)
$\bar{\xi}$	Enforcement parameter	0.255	calibrated
κ	Payout cost parameter	0.250	std. of dividend payout ratio
σ_z	Std. of productivity shock	0.015	Solow residuals
σ_ξ	Std. of financial shock	0.0420	enforcement constraint residuals
$\mathbf{A}$	Matrix for shock processes	$\begin{bmatrix} 0.749 & -0.084 \\ -0.370 & 0.089 \end{bmatrix}$	calibrated

5.1 Set One

To calibrate the discount factor β, I solve $\beta = \frac{1}{1+r}$ at the steady state. From 1994 to 2017, the average annual nominal interest rate is 5.09%, where β is calculated to be equal to 0.952. The production parameter θ represents the share of capital income in GDP. I follow most Chinese literature and set it to be 0.5 (see Wang and Tian (2014) and He et al. (2007)). The utility parameter is calibrated to match real consumption to GDP ratio equal to be 0.406 and the steady-state fraction of working time to be 1/3. I set the tax advantage parameter to be 0.25 according to the Enterprise Income Tax Law implemented in January 2008. Also, I follow Chow and Li (2002) and Chen (2014) and set the annual depreciation rate at $\delta = 0.08$. Last, I calibrate the enforcement parameter $\bar{\xi}$ based on firms' enforcement constraints (equation (8)). I compute the steady state debt over GDP equal to be 1.52, which equals the mean ratio from 1994 to 2017. For the capital stock to GDP ratio, I follow the estimation of Piketty et al. (2019) and set the mean ratio at 5.97. Therefore, the value of $\bar{\xi}$ is 0.255.

5.2 Set Two

The parameters that cannot be determined by steady state targets are the cost of dividend payout factor κ and two stochastic shock processes, productivity shocks and financial shocks. First, I choose $\kappa = 0.25$ to match the model's standard deviation of dividend payout-to-GDP ratio with the empirical counterpart.

Next, I construct the TFP series z_t according to the standard Solow residuals approach, using the log-linearized production function

$$\hat{z}_t = \hat{y}_t - \theta \hat{k}_t - (1-\theta)\hat{n}_t, \tag{11}$$

where $\hat{z}_t$, $\hat{y}_t$, $\hat{k}_t$, and $\hat{n}_t$ are log-deviations from the deterministic trend. Given capital income shares θ and the HP filter detrended empirical series for $\hat{y}_t$, $\hat{k}_t$ and $\hat{n}_t$, I can construct the TFP series $\hat{z}_t$.

Similarly, to construct the time series of financial variable ξ_t, I log-linearize firms' enforcement constraints and assume that it is always binding, which yields

$$\hat{\xi}_t = \hat{y}_t + \frac{-\bar{\xi}\bar{k}}{\bar{y}}\hat{k}_t + \frac{\bar{\xi}\bar{b}^e}{\bar{y}}\hat{b}^e_t, \tag{12}$$

where $b^e_t = \frac{b^f_t}{1+r_t}$, and variables with a bar sign denote their steady state values. Therefore, ξ_t is determined residually using the empirical series of $\hat{k}_t, \hat{b}^e_t$ and $\hat{y}_t$.

After obtaining two series for TFP and the financial variable over my sample period, I construct productivity and financial shocks by estimating the following autoregressive system

$$\begin{pmatrix} \hat{z}_{t+1} \\ \hat{\xi}_{t+1} \end{pmatrix} = \mathbf{A} \begin{pmatrix} \hat{z}_t \\ \hat{\xi}_t \end{pmatrix} + \begin{pmatrix} \epsilon_{z,t+1} \\ \epsilon_{\xi,t+1} \end{pmatrix}, \tag{13}$$

where innovations $\epsilon_{z,t+1}$ and $\epsilon_{\xi,t+1}$ are i.i.d. with standard deviations of σ_z and σ_ξ, respectively. The estimated matrix for shock processes $\mathbf{A}$ is shown in Table 2. The coefficient of estimated financial shocks series (0.089) is much less than TFP shocks' (0.749), indicating financial shocks in China are less likely to persist across years.

6 Findings

In this section, I present the main findings of this paper: model-simulated business cycle moments, variance decomposition results, and impulse response functions, with respect to TFP and financial shocks.

6.1 Simulated Business Cycle Properties

Table 3 compares business cycle properties between the simulated economy and the empirical counterpart. All model-implied log variables presented in the table are HP filtered with a smoothing parameter of 100.

Panel A in Table 3 lists the standard deviation of model-simulated variables (column (2)-(4)). Compared to data, the economy with both shocks (column (3)) replicates empir-

Table 3: Data and Model-Simulated Business Cycle Moments, 1994-2017.

	(1) Data	(2) Both shocks	(3) TFP shocks only	(4) Financial shocks only
Panel A: Standard Deviation				
GDP	0.035	0.035	0.008	0.033
Consumption	0.019	0.012	0.005	0.009
Investment	0.065	0.085	0.017	0.084
Hours worked	0.009	0.061	0.017	0.065
Debt repurchases	0.037	0.049	0.018	0.053
Dividend payout	0.020	0.020	0.030	0.017
Panel B: Correlation with real GDP				
Consumption	0.51	0.78	0.71	0.70
Investment	0.60	0.99	0.93	0.99
Hours worked	0.32	0.92	0.30	0.99
Debt repurchases	-0.38	-0.52	-0.27	-0.76
Dividend payout	0.30	0.19	-0.21	0.85

[1] Debt repurchases and dividend payout are normalized by business GDP.

[2] All model-simulated log variables are detrended by HP filter with a smoothing parameter of 100.

ical standard deviations reasonably well. However, the estimated hours worked are much more volatile than the data. One possible explanation is that in the model, if financially constrained firms cannot fund themselves, they must cut employment to avoid defaulting, thus generating volatility in hours worked. However, in reality, labor is hard to adjust, especially for state-owned enterprise employees in China. Also, the standard deviation of model-simulated debt repurchases is slightly higher (with financial and both shocks) than the empirical one. In China, the government imposes strict regulatory control on bank loans and thus induces frictions in the credit market, causing smaller volatility in debt-financing.. Moreover, the simulated economy with only TFP shocks (column (3)) is incapable of accounting for macroeconomic volatilities observed in the data, which alternatively emphasizes the importance of financial shocks in shaping business cycle fluctuations.

Panel B in Table 3 shows variables' correlations with real GDP. On the one hand, the calibrated model can reproduce the signs of empirical correlations (with financial and both shocks) but with a larger magnitude. Since this parsimonious RBC model abstracts from other types of frictions such as investment adjustment costs and rigid wages, it is reasonable to expect a more significant relationship among model-implied variables. On the other hand, for variables like dividend payout, the impact of TFP shocks dampens the impact of financial shocks, thus causing a smaller overall effect.

Table 4: Variance Decomposition of Productivity Shocks z_t and Financial Shocks ξ_t

	z_t	ξ_t
Output	42.36	57.64
Consumption	63.16	36.84
Investment	35.88	64.12
Hours worked	24.23	75.77
Debt repurchase	24.61	75.39
Dividend payout	54.75	45.26

[1] Numbers shown in the table are in percentages.
[2] Model-simulated log variables are HP-filter detrended using with a smoothing parameter of 100.

6.2 Variance Decomposition

Table 4 reports variance decomposition results of selected macroeconomic and financial variables in the estimation. The results suggest that financial shocks contribute significantly to the growth rate (log-deviations) of output (58%), investment (64%), hours worked (76%), and debt repurchases (75%). Although private firms that dominate GDP growth in China have very limited access to domestic loans (Ge and Qiu (2007)), financial shocks can still make a significant contribution to GDP growth, revealing the non-negligible role of financial shocks in shaping China's macroeconomy. In addition, financial shocks or changes in ξ affect firms' ability to borrow directly and employment and new investment accordingly. Therefore, the shock can explain most volatilities in those variables.

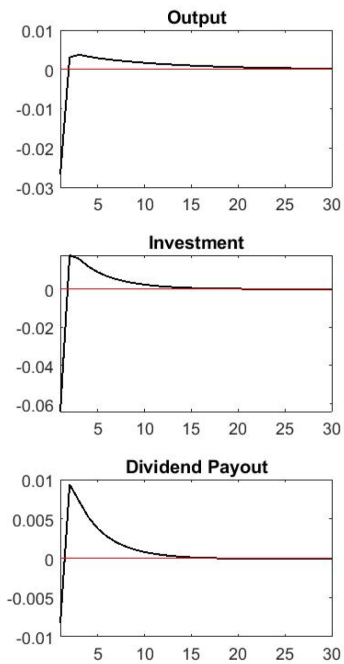
However, financial shocks have a limited contribution to explaining consumption and dividend payment growth. For consumption, it might cause by the consumption habits of Chinese households. For example, high savings and low reliance on personal loans, particularly among older generations, make Chinese households less exposed to financial market shocks and thus smooth consumption.

6.3 Impulse Response Analysis

Figure 3 reports the impulse responses of selected macroeconomic and financial variables to one-time financial shocks.

First, as observed in the figure, the impact of financial shocks on the aggregate economy tends not to persist over the years. Second, the estimated results are consistent with the discussion on how financial shocks might affect the real economy in section 4.1. For example, an adverse financial shock, such as a decrease in asset prices, leads to a decline in ξ and will, in turn, tighten firms' borrowing constraints. However, if firms want to maintain

Figure 3: Impulse Responses to Financial Shocks



their current output level, they have to either reduce dividends paid to shareholders or even cut employment, causing a fall in hours worked and dividend payments. Also, in Figure 3, negative financial shocks decrease consumption and investment. A poor financial environment makes it harder for firms to obtain enough funds for production, so they have to cut investment (5%). In addition, the decline in consumption is relatively small in magnitude, which is in accordance with variance decomposition results on consumption. Finally, with pre-determined capital stock and a lower hours worked, output decreases (2.5%).

7 Discussions

7.1 Validity of Applying a DSGE Model to China's Economy

DSGE models have become increasingly popular recently to understand the welfare implications of policies in China's economy. A concern might be raised on whether a DSGE model, designed for advanced countries, can model an economy at early development stages like China's. However, as argued by Le et al. (2014), a DSGE model does not appear to make assumptions that restrict its application to developing countries if these economies have normal market structures. Since the late 1970s,[9] China has transformed its economic structure from a planned central-control regime towards a market-oriented free economy. Therefore, a DSGE model is appropriate to study China's business cycle fluctuations in the past four decades.

Moreover, since the DSGE model of Smets and Wouters (2007) assumes a closed economy, China might not be suitable for such a framework, as it has large exports (over 20% in GDP over my sample period) and imports sectors. According to Dai et al. (2015), the rapid expansion of the two sectors was mainly driven by national demand for investing in new infrastructure in cities and transportation. Consequently, most goods were sold aggressively into the world market at prices that the market offered, suggesting a weak correlation between the prices of goods sold and the world demand for them. For a similar reason, imports are also 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.

7.2 A RBC Model of China's Economy

One of the main issues that emerged from the calibrated RBC model in this paper was its failure to capture the stylized features of the labor market observed in the data. For example, the correlation between real wages and output was found to be much too high (97%) than the empirical counterpart (37%) due to the flexibility of real wage in the RBC model. A similar feature holds for employment as well. In order to better characterize China's economy, one can set up a hybrid model by mixing both New Keynesian and New Classical features as in Dai et al. (2015). For example, allow different degrees of imperfect competition between labor and product markets, since, in China, the degree of wage rigidity turns out to be more severe than sticky prices over the past several decades.

7.3 Banks' Discrimination in China

China's economy has two salient institutional features compared to developed countries. First, although China has been in transition from a central-planned economy to a market-oriented one since 1978, the central and state government still have substantial control in the People's Bank of China (China's central bank) and four large state-owned banks. Under state control, those banks serve the socialist plan primarily of directing credits to projects dictated by political preference rather than a commercial imperative (Le et al. (2014)). Second, in China, state-owned enterprises are responsible for implementing social welfare-

[9] China began to implement the Reform and Opening policies since the end of 1978 under President Deng Xiaoping's leadership.

related projects. To achieve the goals, state-owned firms are subject to a soft credit constraint and obtain many more bank loans than private firms (Chen et al. (2014)). In addition, a large number of large listed firms are state-owned enterprises that do not necessarily pursue profits, as the original purpose of China's stock market was to help state-owned enterprises raise funds and improve their operating performance (Ding et al. (2007)).[10] However, as pointed out by some researchers, with such an institutional environment, capital sometimes cannot be allocated inefficiently. For example, state-owned enterprises, on average, are less productive and contribute much less to China's GDP growth. My findings align with the previous literature, as debt repurchases and dividend payout have a relatively weak correlation with real GDP. Like Song et al. (2011), one might develop a model that allows heterogeneous firms differing in productivity and access to credit markets to characterize two distinct types of Chinese enterprises.

8 Conclusions

Do financial shocks drive real business cycle fluctuations in China? The answer from my paper's analysis suggests that they do. To reach this conclusion, I begin by presenting some characteristics of firms' financial flows and business cycle properties of China's economy spanning the 1994-2017 period. In particular, I discover the procyclicality of dividend payout and the countercyclicality of debt repurchases with real GDP, respectively. To account for these features, I build an RBC model embedded with debt and equity financing. With this model, I show that financial shocks affect firms' ability to borrow and play an important role in generating macroeconomic fluctuations, especially for labor. Finally, I construct realized time series of TFP and financial shocks from the data, feed them into the calibrated model and simulate business cycle properties of China's economy. The estimation suggests that the model-implied standard deviation of macroeconomic and financial variables are able to replicate the empirical counterpart decently. However, variables' correlation with real GDP is stronger in the simulated economy than in the data. Moreover, the variance decomposition results suggest that financial shocks contribute significantly to the growth rate of output, investment, hours worked, and firms' newly raised debt. Therefore, this paper concludes that financial shocks play an important role in shaping macroeconomic fluctuations.

This paper studies the impact of financial shocks on the real economy, which underlines the importance of maintaining financial stability. In future work, one might include a government or banking sector into a DSGE model to work on policy implications with respect to financial shocks. On the other hand, one might consider the impact of financial shocks in an

[10] The state government maintains its controlling right even after state-owned enterprises go public.

open economy framework to fully characterize China's economy. In addition, understanding the causes of financial shocks, such as non-performing loans, is also an interesting topic. I will leave them for future work.

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A Data Comparison

In table 5, I compare variables used in this paper in the context of China and variables used in Jermann and Quadrini (2012).

Table 5: Variables used in the U.S. and China economies

	U.S. (quarterly)	**China (annually)**
GDP	Real GDP	Real GDP
Consumption	Real personal consumption expenditure	Real final consumption expenditure
Investment	Real gross private domestic investment	Real gross fixed assets investment
Employment	Total private aggregate weekly hours	Gross hours worked
Wage	Real hourly compensation in business sector	Average real wage per person in urban units
Interest Rate	Federal fund rate	One-year nominal interest rate
Debt repurchases	Negative of net increases in credit market instruments of the nonfinancial businesses	Net increase in domestic loan financing and new bond issuance of the nonfinancial businesses
Dividend payout	Net dividends minus net increase in corporate equities minus proprietor's net investment in noncorporate businesses	Net increase in cash dividend paid to shareholders in nonfinancial businesses

B Model Solution

In this section, I solve the model using a linear approximation under the assumption that firms' borrowing constrains are always binding.

B.1 Firms' First-Order Conditions

Let λ_t denote the Lagrange multiplier of firms' budget constraints and μ_t denote the Lagrange multiplier of firms' enforcement (or borrowing) constraints. Firms' first-order conditions with respect to d_t, n_t^f, k_t, b_t^f, respectively, are as follows:

$$1 - \lambda_t[1 + 2\kappa \cdot (d_t - \bar{d})] = 0 \tag{14}$$

$$w_t = (1 - \frac{\mu_t}{\lambda_t})(1-\theta)\frac{y_t}{n_t^f} \tag{15}$$

$$Em_{t+1}(\lambda_{t+1}[1 - \delta + \theta \cdot \frac{y_{t+1}}{k_{t+1}}] - \mu_{t+1} \cdot \theta \cdot \frac{y_{t+1}}{k_{t+1}}) - \lambda_t + \mu_t \xi_t = 0 \tag{16}$$

$$R_t Em_{t+1}(1 - \lambda_{t+1} - \lambda_{t+1}(1 + 2\kappa(d_{t+1} - \bar{d}))) + \lambda_t - \mu_t \xi_t \frac{R_t}{1 + r_t} = 0 \tag{17}$$

Equation (14) implies that the marginal cost of dividend payout equals the marginal utility of it. Also, a divergence of the dividend payment from the steady-state increases the marginal cost. Equation (15) shows that wages equal the marginal productivity of labor multiplies a term of $(1 - \frac{\mu_t}{\lambda_t})$. When the economy suffers downturns (with a low ξ_t), firms' enforcement constraints become 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.

B.2 Households' First-Order Conditions

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

$$\frac{\beta^t}{c_t} - \lambda_t' = 0 \tag{18}$$

$$\frac{w_t}{c_t} - \frac{\alpha}{(1 - n_t^h)} = 0 \tag{19}$$

$$\frac{1}{c_t} - \beta(1 + r_t)\frac{1}{c_{t+1}} = 0 \tag{20}$$

$$\frac{p_t}{c_t} - \beta E(d_{t+1} + p_{t+1})\frac{1}{c_{t+1}} = 0 \tag{21}$$

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

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