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State-owned enterprises and entrusted lending: A DSGE analysis for growth and business cycles in China

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Abstract

In this paper, we build and estimate a DSGE model to study how state-owned enterprises (SOEs) and entrusted lending affect growth and business cycles in China. Our model is featured SOEs being bank-favoured firms as well as policy tools, and more productive private firms (POEs) who can borrow from SOEs through entrusted lending. Our findings suggest SOEs dampen output volatility at the cost of TFP volatility. As policy tools, SOEs cause the expense larger than the dampening effect while a reverse case is found for SOEs being bank-favoured firms. In contrast, entrusted lending could dampen variations of both output and TFP by reallocating credits between SOEs and POEs, hence mitigating the cost of SOEs. Focusing on the recent growth slowdown in China, we further show that entrusted lending was conducive to both economic growth and TFP growth by mitigating capital misallocation.

JEL classification: C32, E32, E44

Keywords: State-owned Enterprises, Shadow Lending, Resource Allocation, Financial Friction, Business Cycles

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1 Introduction

A pronounced economic phenomenon in the last decade is a sharp rising of a shadow banking system in China which accounts for 80% of its GDP in 2016 (Moody's 2017). Unlike market-based shadow banking in the US, the Chinese counterpart is characterised as bank-like credit intermediation (Ehlers et al. 2018). Particularly, a major and long-lasting form of Chinese shadow banking activity is inter-firm loans or officially entrusted lending (Chen et al. 2018), with state-owned enterprises (SOEs) and private owned enterprises (POEs) being major lenders and borrowers respectively (Allen et al. 2019, Bleck & Liu 2018, Ehlers et al. 2018). We argue that accounting for entrusted lending has important implications for growth and business cycles, and provides new insights into roles of SOEs played in the Chinese economy.

In this study, we quantitatively investigate effects of SOEs and entrusted lending on growth and macroeconomic fluctuation using a Dynamic Stochastic General Equilibrium (DSGE) model. We incorporate two different entrepreneurs (SOEs and POEs) with two sources of finance (official credits and entrusted loans). In line with existing literature (Chang et al. 2019, Song et al. 2011), we assume that SOEs receive preferential financial arrangements whereas POEs are subject to a borrowing constraint.

Our model provides two essential departures compared with existing literature. First, we incorporate entrusted lending as inter-firm borrowing rather than bank off-balance-sheet loans. This is motivated by empirical evidence (Allen et al. 2019, Chen et al. 2018) that entrusted loan contracts are directly determined by lenders and borrowers while banks only act as passive facilitators.[1] Moreover, our model captures a key fact that entrusted loans are channelled from SOEs to POEs whose business is riskier but more productive. In equilibrium, the entrusted loan is determined by funding demand of POEs and required compensation charged by SOEs. The presence of entrusted loans provides a credit reallocation channel between the two types of firms, and hence important for variation of total factor productivity (TFP).

Second, we distinguish two forms of SOE preferential arrangements–investment subsidies and privileged access to credits. The investment subsidy is an exogenous government policy imposed on SOEs who internalize its effects on business decisions; heavy use of investment subsidies is able to reverse movement of SOE investment, creating a state-dependent cyclical pattern which is consistent with data. In contrast, the privileged access to credits is a business advantage which is unnecessary to reflect government intervention. Accounting for this differentiation helps us understand different roles played by SOEs, as policy vehicles or bank-favoured firms.

To quantitatively evaluate implications of our model, we conduct structural estimation using Bayesian techniques over 1997Q1 to 2017Q4. Following impulse response analysis, we find a business cycle trade-off between output and TFP due to the presence of SOEs. With the preferential arrangements and low productivity, SOEs are muted from a financial acceleration mechanism but trigger a capital reallocation

[1] Chen et al. (2018) shows that banks actively bring shadow banking products onto the balance sheet and hence bear the risks.

effect. Consequently, SOEs dampen output variation but amplify that of TFP. Comparing the two roles, SOEs as policy tools significantly distort capital allocation, leading to the amplification effect exceeding the dampening effect; while an opposite case is found for privileged access to credits, implying a milder trade-off due to this priority.

In contrast, entrusted lending can weaken both the financial acceleration and the capital reallocation effects. The presence of entrusted loans provides a channel to shift credits from SOEs to POEs when the latter has tighter borrowing constraints. Such a credit reallocation activity counteracts with some key driven forces of the Chinese business cycles, particularly including investment and financial shocks. As a result, variations of output and TFP are dampened simultaneously. This finding further implies an essential role of entrusted loans in breaking the trade-off results from SOEs.

In light of model mechanisms, we proceed to access consequences of SOEs or entrusted lending on recovery and growth slowdown in China respectively. Focusing on two recent recessions in 1998-1999 and 2008-2009, we find that SOEs impaired TFP growth as side effects of rescuing the economy. The cost was mainly due to privileged access to credits in the former period while investment intervention was the major cause in the latter period. Not surprisingly, loss on TFP growth is larger in the 2008 recession. Furthermore, by focusing on entrusted lending, we also study its implication for the recent economic slowdown in China. In the post-crisis period, China entered a new era with relatively low economic and TFP growth. At the same time, tightened monetary policies were implemented to curb credit growth but shadow banking sectors expanded rapidly. However, regulations about shadow banking activities were gradually strengthened and POEs found it harder to obtain external finance. We show that entrusted lending mitigated capital misallocation induced by the tightened financial situation, and hence contributed to both economic growth and TFP growth in the 2010s.

This study provides a crossroad to two strands of literature, namely macroeconomic implications of SOEs and shadow banking in China. Within the area of SOEs, its growth effects (Anzoategui et al. 2015, Brandt et al. 2008, Song et al. 2011) are extensively studied but business cycle effects have been paid insufficient attention.[2] In terms of shadow banking, its development, risks, and benefits are drawing discussions (Allen et al. 2019, Lu et al. 2015) yet there is no consensus. We extend the two strands of literature by showing how and to what extent SOEs lead to a business cycle trade-off between output and TFP, how entrusted lending interacts with this trade-off, and empirical applications of these mechanisms on recovery and growth slowdown. Our study is related to Chen et al. (2018) and Chang et al. (2019)[3], both of which analyse implications of shadow banking for the effectiveness of monetary policies using calibrated models. Departing from the policy evaluation, we study the effects of entrusted lending on the propagation of major driven

[2]Specifically, business cycle studies about SOEs mainly focus their links with the Chinese economic stimulus plan during the Financial Crisis period. Cong et al. (2019) show that the stimulus plan reversed the process of capital allocation toward POEs before 2008 based on loan-level data. Wen & Wu (2019) shows a stabilisation effect on employment through SOEs.

[3]Chang et al. (2019) also draw attentions on resource allocation between SOEs and POEs due to adjustment of required reserve rate.

forces of the Chinese business cycles. By doing so, we also stress the importance of entrusted lending for maintaining productivity-based economic growth in recent China. Moreover, our analysis is based on a Bayesian DSGE model which allows data to help us identify some China-specific features in addition to our theoretical model.[4]

Broadly, our study is also related to several strands of literature, including macroeconomic consequences of the Chinese stimulus policies in 2008-2010 (Cong et al. 2019, Wen & Wu 2019), recent growth slowdown in China (Zilibotti 2017) and role of financial frictions in resource allocation (Bleck & Liu 2018, Chen & Song 2013, Zetlin-Jones & Shourideh 2017). We complement them by distinguishing two types of preferential financial arrangement of SOEs, showing how and to what extent a financial shock affects the growth slowdown in China, and developing a model with inter-firm loans. This model can be applied to other emerging economies where inter-firm lending is a typical structure (Avdjiev et al. 2014).

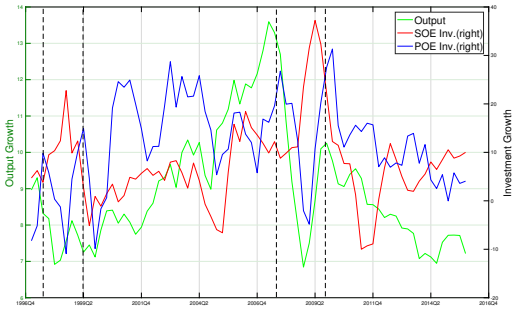
The rest of the paper is organized as follows. Section 2 presents some empirical facts about SOE investment, POE investment and entrusted lending. Section 3 presents the DSGE model with SOEs and entrusted lending. Section 4 presents our estimation results. In section 5, we make use of the estimated model parameters for impulse response analyses. Section 6 studies growth in 1998-1999, 2008-2009 and recent slowdown in light of our model. Section 7 check robustness before Section 8 concludes with comments.

2 State-owned Enterprises and Shadow Banking

This section provides empirical facts and a descriptive analysis of some Chinese macroeconomic variables over the last few decades. We focus on two aspects–SOE investment and entrusted credits.

Figure 1: SOE investment growth

(a) Output growth and investment growth



(b) Cyclical feature of SOE investment growth

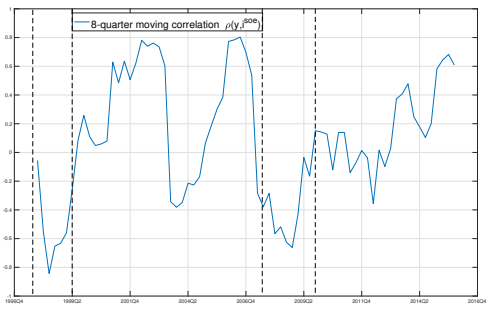
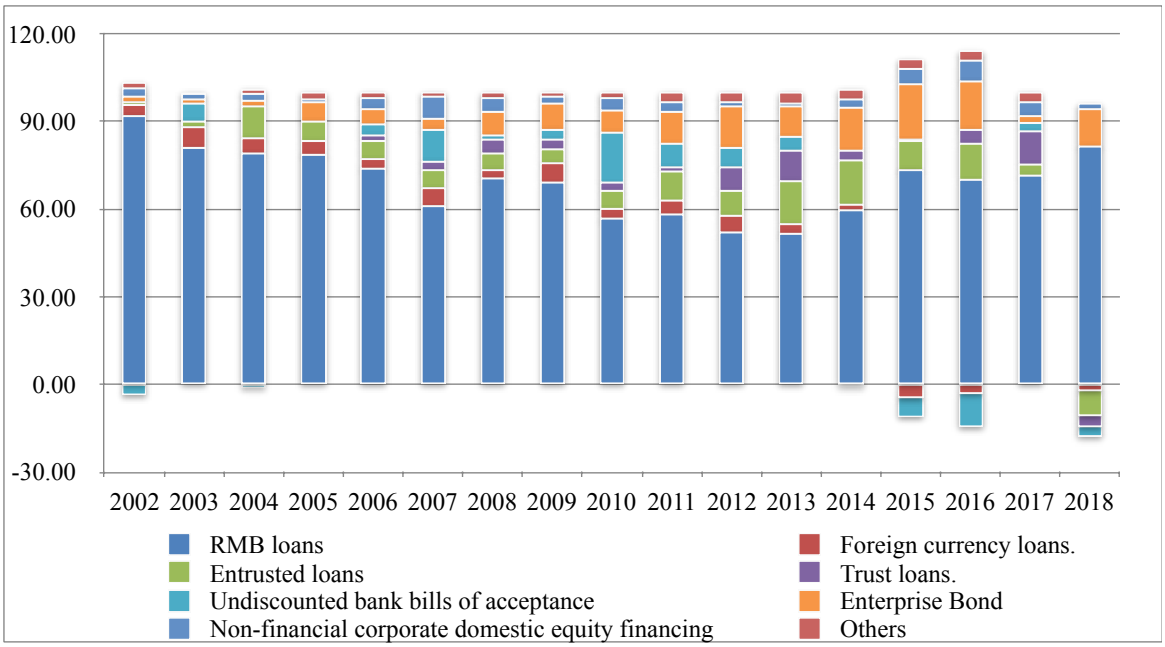


Figure 1(a) shows different properties between SOEs and POEs in terms of investment growth. A pronounced difference is that SOE investment growth has weak correlation (0.112) with output growth compared

[4]Unlike Chang et al. (2019) who adopt a BGG framework and assume shadow borrowing as the only source of external finance for POEs, our model is based on a borrowing constraint (for official credits) and allow POEs to have limited access to official credits.

with POE investment growth (0.457). The weak correlation seems to suggest that SOE investment is acyclical. However, by visually checking the movement of output and SOE investment growth, we instead find a state-dependent relationship between the two variables; during recession periods such as the Asian Financial Crisis and the Global Financial Crisis, output growth and SOE investment growth are shown negative relationships while in normal time they are more likely to co-move. In order to further investigate this issue, we calculate moving correlations between output growth and investment growth over 8-quarter windows. Figure 1(b) indeed shows that the moving correlation is almost positive in normal time but turns to be significantly negative in recessions. Considering that SOEs were heavily intervened mainly in recessions, the state-dependent cyclical pattern of SOE investment could be due to government policies such as SOE investment subsidies. This further implies double roles of SOEs as both business enterprises and intervention vehicles.

Figure 2: Share of major components of social financing



Since the beginning of the 2000s, entrusted loans emerged in China due to financial distortion. By definition, entrusted lending is a borrowing activity between two non-financial firms and commercial banks only play as trustees (Chen et al. 2018). Ehlers et al. (2018) suggest that entrusted loans are mainly channelled from SOEs to POEs. This is further confirmed by empirical evidence, e.g., Allen et al. (2019). Considering that POEs are financially constrained but more productive, an entrusted lending market may provide a credit reallocation channel and hence potentially correct financial distortion.

Figure 2 and Table 1 show that entrusted loans are an important component in Chinese financial system, accounting for the third largest share (7.77%) of total social financing following bank RMB loans (68.54%)

Table 1: Averaged share of major components of social financing

Period	RMB loans	Foreign currency loans	Entrusted loans	Trust loans	Undiscounted bank bills of acceptance	Enterprise bond	Non-financial corporate domestic equity financing	Others
2002-2018	68.54	3.22	7.77	4.62	2.60	8.37	3.48	2.56

and enterprise bonds (8.37%). Given that POEs are unfavourable lenders for bank loans and enterprise bonds, entrusted loans are a critical source of finance for POEs. Indeed, entrusted loans may account for 30% of total finance for POEs considering that POEs' loans only constitute 25% of total bank loans[5]. Furthermore, entrusted lending is the major form of shadow banking in China, accounting for almost half of shadow loans between 2009 and 2015 (Chen et al. 2018). Therefore, given the importance of entrusted lending, it is essential to understand macroeconomic implications of a shadow banking activity like entrusted lending.

3 The Model

We expand the Smets & Wouters (2007)'s model, incorporating state-owned enterprises (SOEs), quantity-based financial friction (borrowing constraint) similar to Jermann & Quadrini (2012), Chen & Song (2013) and Wang et al. (2018), and a shadow lending activity in the form of entrusted loans. We model official borrowing based on a quantity-based rather than price-based financial friction such as Bernanke et al. (1999) due to two reasons. Owing to ceilings, the official lending rate in China is only allowed to fluctuate within a restricted interval and hence may not be determined by firms' financial conditions. On the other hand, there is firm-level evidence that POEs are subject to borrowing constraint (Ayyagari et al. 2010). Accordingly, we adopt a quantity-based financial friction. Furthermore, motivated by the role of banks as passive facilitators in channelling entrusted loans (Chen et al. 2018), we focus on production sectors to model entrusted lending.[6]

3.1 Final Goods Producer

There are a continuum of monopolistic competitive final goods producers, measuring unity, each of which is like a retailer, who buys intermediate goods and transfers them into differentiated final goods Y_t. Then they are sold in a monopolistically competitive market.

The final goods sector is used to introduce nominal rigidity into this economy. Following Calvo (1983) and Anzoategui et al. (2019), we assume each final goods producer sets price on a staggered basis. In each period there is a probability $1-\epsilon_p$ that a final goods firm can reset its optimal price P_{it}^* otherwise firms set prices according to the following index rule $P_{it} = P_{i,t-1}\pi^{1-\iota_p}\pi_{t-1}^{\iota_p}$ where π is steady state inflation and ι_p is

[5]The Chairman of China Banking and Insurance Regulatory Commission, Guo Shuqing, said that "POEs' loan account for 25% of current bank loan balance." in an interview by Financial Times in 7/11/2018.

[6]Although banks bring shadow banking products onto their balance sheets, the making of entrusted loans is still determined by non-financial firms (Chen et al. 2018).

the degree of indexation.

The final goods producer maximizes expected profit from which we obtain the optimally chosen reset price:

$$\sum_{l=0}^{\infty} \epsilon_p^l \Lambda_{t,t+l} [\frac{P_t^*(\pi_{t-1}^{t+l-1})^{\iota_p} \pi^{1-\iota_p}}{P_{t+l}} - \varepsilon_t^s MC_{t+l}^f] Y_{i,t+l} = 0 \tag{1}$$

where $\Lambda_{t,t+l}$ is the stochastic discount factor decided by the household and MC_t^f is the marginal cost of the final goods producer.

3.2 Entrepreneur

Monopolistic intermediate goods producers use labour hour H_t and capital K_t to produce intermediate goods.

$$Y_{jt}^o = A_t^o (K_{jt}^o)^\alpha (H_{jt}^o)^{1-\alpha}, \quad o = SOE, POE \tag{2}$$

where productivity A_t^o has three components

$$A_t^o = A^o (1+g^y)^t \varepsilon_t^a, \quad o = SOE, POE \tag{3}$$

The first component A^o captures productivity associated with each type of intermediate goods producers. The second component $(1+g^y)^t$ is the trend growth. The third component ε_t^a is an aggregate productivity shock following an AR(1) process as follows: $ln\varepsilon_t^a = \rho_a ln\varepsilon_{t-1}^a + \eta_t^a$. η_t^a follows i.i.d $N(0, \sigma_A^2)$.

The following CES technology is used to aggregate differentiated intermediate goods into an intermediate goods composite:

$$Y_t^m = \left\{ \int_0^\omega [Y_{jt}^{SOE}]^{1/\lambda^m} dj + \int_\omega^1 [Y_{jt}^{POE}]^{1/\lambda^m} dj \right\}^{\lambda^m} \tag{4}$$

where $\omega \in [0,1]$ is the steady-state share of SOEs' production in aggregate intermediate goods. In the following subsections, we describe problems for SOEs and POEs when there is no entrusted lending channel. Then we describe the case when entrusted lending channel is switched on.

3.2.1 State-owned Entrepreneur

The SOE j maximizes expected utility V_{jt}^{SOE}

$$V_{jt}^{SOE} = \max_{P_{jt}^{m,SOE}, D_{jt}^{SOE}, H_{jt}^{SOE}, I_{jt}^{SOE}, K_{jt}^{SOE}, B_{jt}^{SOE}} \{log(D_{jt}^{SOE}) + \beta E_t(V_{jt+1}^{SOE})\} \tag{5}$$

subject to budget constraint, law of motion of capital and demand of SOE intermediate goods

$$P_t D_{jt}^{SOE} + W_t H_{jt}^{SOE} + \frac{P_t}{\varepsilon_t^{soe}} I_{jt}^{SOE} + R_{t-1}^b B_{jt-1}^{SOE} = B_{jt}^{SOE} + P_{jt}^{SOE} Y_{jt}^{SOE} \tag{6}$$

$$K_{jt+1}^{SOE} = (1-\delta)K_{jt}^{SOE} + \varepsilon_t^i[1 - S(\frac{I_{jt}^{SOE}}{(1+g^y)I_{jt-1}^{SOE}})]I_{jt}^{SOE} \tag{7}$$

$$Y_{jt}^{SOE} = Y_t(\frac{P_{jt}^{SOE}}{P_t^m})^{\lambda^m/(1-\lambda^m)} \tag{8}$$

where β is the subjective discounting factor for the SOE, D_{jt}^{SOE} the SOE dividend, W_t nominal wage, H_{jt}^{SOE} is the SOE labour hour, I_{jt}^{SOE} the SOE investment, P_{jt}^{SOE} price of the SOE intermediate goods, R_t^b borrowing rate, B_{jt}^{SOE} SOE borrowing, K_{jt}^{SOE} is the SOE capital, δ depreciation rate and $S()$ is the adjustment cost function with $S(1) = 0$, $S'(1) = 0$ and $S''() > 0$. ε_t^i is an investment efficiency shock common to both types of entrepreneur. ε_t^i follows an AR(1) process: $ln\varepsilon_t^i = \rho_b ln\varepsilon_{t-1}^i + \eta_t^i$ and η_t^i follows an i.i.d $N(0, \sigma_I^2)$.

We model subsidy to SOE, ε_t^{soe}, as an AR(1) shock process as follows: $ln\varepsilon_t^{soe} = (1-\rho_{soe})ln\varepsilon^{soe} + \rho_{soe}ln\varepsilon_{t-1}^{soe} + \eta_t^{soe}$. Alternatively, ε_t^{soe} can be treated as a SOE specific investment shock which is useful to fit SOE investment data. Note that an increase in ε_t^{soe} will stimulate investment, increase adjustment cost and hence investment efficiency will decrease. This effect is consistent with empirical finding that government intervention inversely affect investment efficiency (Chen et al. 2011).

Optimization yields the following first order conditions.

$$\lambda_t^{SOE} P_{jt}^{SOE} = \lambda^m \lambda_t^{c,SOE} \tag{9}$$

$$\lambda_t^{SOE} P_t = \frac{1}{D_{jt}^{SOE}} \tag{10}$$

$$\lambda_t^{SOE} W_t = \frac{(1-\alpha)\lambda_t^{c,SOE} Y_{jt}^{SOE}}{H_{jt}^{SOE}} \tag{11}$$

$$\begin{aligned}\frac{\lambda_t^{SOE} P_t}{\varepsilon_t^{soe}} = \lambda_t^{k,SOE}[(1 - S(\frac{I_{jt}^{SOE}}{(1+g^y)I_{jt-1}^{SOE}})) - S'(\frac{I_{jt}^{SOE}}{(1+g^y)I_{jt-1}^{SOE}})\frac{I_{jt}^{SOE}}{(1+g^y)I_{jt-1}^{SOE}}] \\ +\beta E_t[\lambda_{t+1}^{k,SOE}\varepsilon_{t+1}^i S'(\frac{I_{jt+1}^{SOE}}{(1+g^y)I_{jt}^{SOE}})(\frac{I_{jt+1}^{SOE}}{(1+g^y)I_{jt}^{SOE}})^2]\end{aligned} \tag{12}$$

$$\beta E_t[\alpha\frac{\lambda_{t+1}^{c,SOE} Y_{jt+1}^{SOE}}{K_{jt+1}^{SOE}} + \lambda_{t+1}^{k,SOE}(1-\delta)] = \lambda_t^{k,SOE} \tag{13}$$

$$\beta E_t(\frac{\lambda_{t+1}^{SOE} P_{t+1}}{\lambda_t^{SOE} P_t}\frac{R_t^b}{\pi_{t+1}}) = 1 \tag{14}$$

where λ_t^{SOE}, $\lambda_t^{k,SOE}$ and $\lambda_t^{c,SOE}$ are Lagrange multipliers associated with the budget constraint (6), capital accumulation (7) and SOE intermediate good demand (8) respectively. $\Lambda_{t,t+1}^{SOE} = \beta E_t(\frac{\lambda_{t+1}^{SOE} P_{t+1}}{\lambda_t^{SOE} P_t}) = \gamma E_t\frac{D_t^{SOE}}{D_{t+1}^{SOE}}$ is the SOE discounting factor.

3.2.2 Private Entrepreneur

POEs have limited access to finance so that they have a borrowing constraint compared with state-owned producer. The POE j maximizes expected utility

$$V_{jt}^{POE} = \max_{P_{jt}^{m,POE}, D_{jt}^{POE}, H_{jt}^{POE}, I_{jt}^{POE}, K_{jt}^{POE}, B_{jt}^{POE}} \{log(D_{jt}^{POE}) + \gamma E_t(V_{jt+1}^{POE})\} \tag{15}$$

subject to budget constraint, borrowing constraint, law of motion of capital and demand of POE intermediate goods

$$P_t D_{jt}^{POE} + W_t H_{jt}^{POE} + P_t I_{jt}^{POE} + R_{t-1}^b B_{jt-1}^{POE} = B_{jt}^{POE} + P_{jt}^{POE} Y_{jt}^{POE} \tag{16}$$

$$B_{jt}^{POE} \leqslant \varepsilon_t^f P_t q_t^{POE} K_{jt}^{POE} \tag{17}$$

$$K_{jt+1}^{POE} = (1-\delta) K_{jt}^{POE} + \varepsilon_t^i [1 - S(\frac{I_{jt}^{POE}}{(1+g^y) I_{jt-1}^{POE}})] I_{jt}^{POE} \tag{18}$$

$$Y_{jt}^{POE} = Y_t (\frac{P_{jt}^{POE}}{P_t^m})^{\lambda^m/(1-\lambda^m)} \tag{19}$$

where γ is the subjective discounting factor for the POE, D_{jt}^{POE} the POE dividend, H_{jt}^{POE} is the POE labour hour, I_{jt}^{POE} the POE investment, P_{jt}^{POE} price of the POE intermediate goods, B_{jt}^{POE} POE borrowing, K_t^{POE} is the POE capital. Our modeling of borrowing implies that private firms can only borrow limited amount equal to a fraction ε_t^f of its capital. This assumption is similar to other financial constraint literature such as Chen & Song (2013) and Zetlin-Jones & Shourideh (2017). Further, we assume ε_t^f is exogenous following an AR(1) process as follows: $ln\varepsilon_t^f = (1-\rho_f) ln\varepsilon^f + \rho_f ln\varepsilon_{t-1}^f + \eta_t^f$. ε^f is the tightness of borrowing constraint in steady state and η_t^f follows i.i.d $N(0, \sigma_F^2)$.

Optimization yields the following first order conditions.

$$\lambda_t^{POE} P_{jt}^{POE} = \lambda^m \lambda_t^{c,POE} \tag{20}$$

$$\lambda_t^{POE} P_t = \frac{1}{D_{jt}^{POE}} \tag{21}$$

$$\lambda_t^{POE} W_t = \frac{(1-\alpha) \lambda_t^{c,POE} Y_{jt}^{POE}}{H_{jt}^{POE}} \tag{22}$$

$$\begin{aligned} \lambda_t^{POE} P_t = \lambda_t^{k,POE} [(1 - S(\frac{I_{jt}^{POE}}{(1+g^y) I_{jt-1}^{POE}})) - S'(\frac{I_{jt}^{POE}}{(1+g^y) I_{jt-1}^{POE}}) \frac{I_{jt}^{POE}}{(1+g^y) I_{jt-1}^{POE}}] \\ + \gamma E_t [\lambda_{t+1}^{k,POE} \varepsilon_{t+1}^i S'(\frac{I_{jt+1}^{POE}}{(1+g^y) I_{jt}^{POE}}) (\frac{I_{jt+1}^{POE}}{(1+g^y) I_{jt}^{POE}})^2] \end{aligned} \tag{23}$$

$$\lambda_t^{b,POE} \varepsilon_t^f P_t q_t^{POE} + \gamma E_t [\alpha \frac{\lambda_{t+1}^{c,POE} Y_{jt+1}^{POE}}{K_{jt+1}^{POE}} + \lambda_{t+1}^{k,POE} (1-\delta)] = \lambda_t^{k,POE} \tag{24}$$

$$\gamma E_t(\frac{\lambda_{t+1}^{POE} P_{t+1}}{\lambda_t^{POE} P_t} \frac{R_t^b}{\pi_{t+1}}) = 1 - \frac{\lambda_t^{b,POE}}{\lambda_t^{POE}} \tag{25}$$

where λ_t^{POE}, $\lambda_t^{b,POE}$, $\lambda_t^{k,POE}$ and $\lambda_t^{c,POE}$ are Lagrange multipliers associated with budget constraint (16), borrowing constraint (17), capital accumulation (18) and POE intermediate good demand (19) respectively. $\Lambda_{t,t+1}^{POE} = \gamma E_t(\frac{\lambda_{t+1}^{POE} P_{t+1}}{\lambda_t^{POE} P_t}) = \gamma E_t \frac{D_t^{POE}}{D_{t+1}^{POE}}$ is the POE discounting factor .

If $\lambda_t^{b,POE} > 0$, POEs will face a binding borrowing constraint; if $\lambda_t^{b,POE} = 0$, the borrowing constraint will not be binding and equilibrium conditions of POEs will be similar to SOEs. Given our calibration, borrowing constraint is always binding in the steady state.

3.2.3 Entrusted Lending

When entrusted lending is switched on, SOEs will have one more source of revenue; POEs will have an alternative channel of borrowing. There are changes in budget constraints for both types of producer. Moreover, SOEs and POEs jointly determine optimal entrusted credits and entrusted lending rate.

For a SOE, budget constraint (6) become as follows.

$$P_t D_{jt}^{SOE} + W_t H_{jt}^{SOE} + \frac{P_t}{\varepsilon_t^{soe}} I_{jt}^{SOE} + R_{t-1}^b B_{jt-1}^{SOE} + S_{jt}^{SOE} + \phi_t S_{jt}^{SOE} = B_{jt}^{SOE} + R_{t-1}^s S_{jt-1}^{SOE} + P_{jt}^{SOE} Y_{jt}^{SOE} \tag{26}$$

where S_{jt}^{SOE} is entrusted credits supplied by the SOE j and $\phi_t = \phi(S_t)$ is the monitoring cost in aggregate amount of entrusted credits with $\phi()' > 0$ and $\phi()'' > 0$. This captures the fact that non-financial firms (SOEs) are disadvantageous in originating credits (Allen et al. 2019) and hence they need to pay monitoring cost[7]. Alternatively, one can interpret ϕ_t as risk premium associated with entrusted lending. The larger amount of entrusted credits borrowed, the higher degree of information asymmetry faced by their lenders and hence higher risk premium is required. A convex function implies that the more entrusted credits supplied, the more marginal cost of this kind of credits. Furthermore, our modelling of entrusted lending implies that its lenders do not require collateral or guarantee, which is consistent with empirical evidence (Allen et al. 2019). In details, we assume the following functional form to model the monitoring cost.

$$\phi_t = \frac{\varepsilon^b}{1+\xi}[\frac{S_t}{P_t(1+g^y)^t}]^{1+\xi}, \qquad \xi > 0 \tag{27}$$

where ξ is elasticity of monitoring cost with respect to entrusted credits and ε^b is a parameter governing the magnitude of the monitoring cost. $P_t(1+g^y)^t$ is a scaling factor to ensure balanced growth path.
Budget constraint (16) of POEs become as follows.

$$P_t D_{jt}^{POE} + W_t H_{jt}^{POE} + P_t I_{jt}^{POE} + R_{t-1}^b B_{jt-1}^{POE} + R_{t-1}^s S_{jt-1}^{POE} = B_{jt}^{POE} + S_{jt}^{POE} + P_{jt}^{POE} Y_{jt}^{POE} \tag{28}$$

[7]For simplicity, we assume there is no monitoring cost for financial intermediary. ϕ_t can be interpreted as relative cost in originating credits for non-financial firms.

The inclusion of an entrusted lending market also adds an extra first order condition for each type of entrepreneur. For a SOE

$$R_t^s = R_t^b + \phi_t R_t^b = R_t^b + \phi_t' \tag{29}$$

where $\phi_t' = \phi_t R_t^b$ is a effective entrusted lending premium. (29) implies that entrusted lending rate is higher than bank lending rate and ϕ_t' can be interpreted as an entrusted lending premium. For a POE

$$\frac{R_t^s}{R_t^b} = \frac{1}{1 - \frac{\lambda_t^{b,POE}}{\lambda_t^{POE}}} = \frac{1}{1 - \lambda_t^{b',POE}} \tag{30}$$

where $\lambda_t^{b',POE}$ is the effective tightness of the borrowing constraint, similar to Jermann & Quadrini (2012). With $R_t^s > R_t^b$ as established above, (30) implies that $\lambda_t^{b',POE} > 0$ and there is a binding borrowing constraint for POEs. That is because entrusted credits are expensive than bank (or formal) credits so that POEs will always use up all credit rations before approaching the entrusted lending market. Equation (29) and (30) together yield the equilibrium condition of entrusted loans as follows.

$$1 + \phi(S_t) = \frac{1}{1 - \lambda_t^{b',POE}} \tag{31}$$

Equation (31) suggests a positive relationship between entrusted loans and tightness of the borrowing constraint. With a higher value of $\lambda_t^{b',POE}$, the borrowing constraint become tighter. POEs will resort to SOEs to borrow more entrusted loans. Consequently, there is a credit reallocation to POEs.

3.3 Financial Intermediary

Competitive financial intermediaries collect money at the savings rate (R_t) from households. Financial intermediaries conducts business with both types of intermediate goods producer. Due to interest rate ceiling, lending rate moves tightly with saving rate and credit premium do not have substantial fluctuations in China. Hence, we assume that lending rate is equal to saving rate $R_t^b = R_t$.

3.4 Household

The representative household derives utility from consumption and leisure, consumes and saves money with the financial intermediaries. Households supply labour measured in hours H_t, used for the production of intermediate goods.

The household faces the following problem:

$$\max E_t \sum_{l=0}^{\infty} \beta^l \varepsilon_{t+l}^p [log(C_{t+l} - bC_{t+l-1}) - \frac{\psi^s (H_{t+l}^{SOE})^{1+\eta} + \psi^p (H_{t+l}^{POE})^{1+\eta}}{1+\eta}] \tag{32}$$

subject to the budget constraint

$$P_t C_t + D_t = R_{t-1} D_{t-1} + W_t (H_t^{SOE} + H_t^{POE}) + \Pi_t^f \tag{33}$$

where C_t denotes consumption, D_t saving, R_t interest rate, and Π_t^f profit from the ownership of monopolistic competitive firms, b measures degree of external habits in consumption and η measures the elasticity of labour supply with respect to wage. ε_t^p is a preference shock following an AR(1) process: $ln\varepsilon_t^p = \rho_p ln\varepsilon_{t-1}^p + \eta_t^p$ and η_t^p follows an i.i.d $N(0, \sigma_P^2)$.

With regard to wage setting, the household supplies differentiated labour to a competitive labour agency which differentiates it, packs it into labour services, and sells labour services to intermediate goods producers. As standard in the New Keynesian literature, there is a wage rigidity and wage adjustment, based on the Calvo scheme. Households re-optimise wages with probability 1-ϵ_w in each period. With probability ϵ_w households cannot re-optimise and index past inflation to adjust the wage, $W_t = W_{t-1}\pi^{1-\iota_p}\pi_{t-1}^{\iota_p}(1+g^y)$, where ι_w is the degree of wage indexation.

3.5 Aggregation and Equilibrium

With symmetric equilibrium, we obtain the aggregate output, SOE output, private output as follows.

$$Y_t = Y_t^m = [\omega (Y_t^{SOE})^{1/\lambda^m} + (1-\omega)(Y_t^{POE})^{1/\lambda^m}]^{\lambda^m} \tag{34}$$

$$Y_t^o = A_t^o (K_t^o)^\alpha (H_t^o)^{1-\alpha}, \quad o = SOE, POE \tag{35}$$

The capital, labour, formal credit and entrusted lending markets must clear $K_t = K_t^{SOE} + K_t^{POE}$, $H_t = H_t^{SOE} + H_t^{POE}$, $D_t = B_t = B_t^{SOE} + B_t^{POE}$ and $S_t^{SOE} = S_t^{POE} = S_t$. The resource constraint is

$$Y_t = C_t + I_t + G_t \tag{36}$$

G_t[8] is a exogenous spending shock following AR(1) process: $ln\varepsilon_t^g = (1-\rho_g)g + \rho_g ln\varepsilon_{t-1}^g + \eta_t^g$ and η_t^g follows i.i.d $N(0, \sigma_G^2)$. The policy rate which is also the savings rate is given by the Taylor rule

$$R_t = R_{t-1}^{\rho_r}[R(\frac{\pi_t}{\overline{\pi}})^{\rho_\pi}(\frac{Y_t}{Y_{t-1}})^{\rho_y}]^{1-\rho_r}\varepsilon_t^m \tag{37}$$

where ε_t^m is a monetary policy shock following an AR(1) process: $ln\varepsilon_t^m = \rho_m ln\varepsilon_{t-1}^m + \eta_t^m$ and η_t^m follows an i.i.d $N(0, \sigma_M^2)$.[9]

[8]For later analysis, we focus on the efficiency unit of G_t which is defined as $\varepsilon_t^g = G_t/(1+g^y)^t$. Government spending is anchored with output so that it is unnecessary to specify government expenditure separately.

[9]The full set of equilibrium conditions are reported in the online Appendix B.

Following Chen & Song (2013), we can derive TFP using the concept of Solow Residual

$$TFP_t = (1+g^y)^t \varepsilon_t^a \underbrace{\{[\omega A^{SOE}(\frac{K_t^{SOE}}{K_t})^{\alpha}(\frac{H_t^{SOE}}{H_t})^{1-\alpha}]^{1/\lambda^m} + [(1-\omega)A^{POE}(\frac{K_t^{POE}}{K_t})^{\alpha}(\frac{H_t^{POE}}{H_t})^{1-\alpha}]^{1/\lambda^m}\}^{\lambda^m}}_{\text{the reallocation effect}} \tag{38}$$

TFP can be decomposed into three components: a trend component, a TFP shock and a reallocation effect. We can think $(\frac{K_t^o}{K_t})^{\alpha}(\frac{H_t^o}{H_t})^{1-\alpha} \quad o = SOE, POE$ as weights attached to sector-specific productivity A^p and the reallocation effect captures change in weighted averaged productivity across different types of producers. With $A^{POE} > A^{SOE}$, the reallocation effect suggests that larger SOE (POE) capital share[10] leads to more losses (gains) on productivity efficiency. Thus, changes of SOE or POE capital share add additional source of TFP fluctuation through the capital allocation channel.

4 Estimation

In this section, we report our results for the Bayesian estimation and simulation of our DSGE model. This framework allows data to assist in the determination of the structural parameters. Simulations are then carried out, using the estimated parameters to measure the different responses from the economies to multiple shocks.

4.1 Data

Our sample period is 1997Q1 to 2017Q4. This period is selected for two reasons. Firstly, China's quarterly time-series for major macroeconomic indicators are notoriously rare, with availability beginning in the mid-1990s. Secondly, in terms of economic structure, China has become a more market-oriented economy since late the 1990s, with significant growth in the private sector. We use nine macroeconomic variables as observables for estimation: GDP growth, consumption growth, investment growth, SOE investment growth, hours worked, wages growth, GDP deflator inflation, the policy interest rate and non-financial corporate loans growth.[11]

4.2 Calibration

In this section, we present our calibration of the structural parameters. Calibration is carried out where values of certain structural parameters are considered 'known' in the literature, and has the benefit of limiting the number of parameters that we are required to estimate through Bayesian techniques.

Table 2 shows calibrated parameters. These parameters are well-identified in existing literature, for example Chang et al. (2015) and Dai et al. (2015). Labour income share α is set as 0.5, in line with Hsieh

[10]Note that labour shares $(\frac{H_t^o}{H_t})^{1-\alpha}$ across different types of producers are constant since we assume the same wage.

[11]For more details of the observable variables used in our estimation, please refer to Appendix A.

Table 2: Calibrated parameters

Parameters	Description	Value
α	capital share	0.5
β	SOE and household discount factor	0.995
γ	POE discount factor	0.97
δ	capital depreciation	0.02
λ^m	intermediate good mark-up	1.1
λ^w	wage mark-up	1.1
Steady-State		
$1+g^y$	ss per capita GDP growth	1.022
G/Y	ss exo. demand share	0.18
ω	ss SOE output share	1/3
ϵ^f	ss borrowing constraint parameter	1.1
ϕ	ss entrusted lending premium	7.9%
A^{SOE}	SOE productivity	1
A^{POE}	POE productivity	1.67

& Klenow (2009). The discount factor β is calibrated as 0.995 to match the averaged 3-month policy saving rate in China. We give the POE discount factor γ 0.97. This value implies that the internal rate of return for POEs is almost doubled as SOEs, consistent with firm-level evidence (see Wu (2018) among others).[12] The intermediate goods mark-up and wage mark-up are calibrated as 1.1 and 1.1 respectively which are in line with existing literature e.g., Chang et al. (2015) and Dai et al. (2015). We set capital depreciation rate equal to 0.02 which is the median level in existing studies.

The lower part of Table 2 shows the calibrated value of steady-state parameters based on data over 1997-2017. The average per capita GDP growth rate is about 2.2% for China and hence we calibrate g^y as 2.2%. The exogenous demand[13] to output ratio is calibrated as 18%. The SOE production share ω is calibrated as 1/3 based on industrial output data[14]. The borrowing constraint parameter ϵ^f is set to 1.1 to match debt to asset ratio for POEs (52.3%). The steady state entrusted lending premium is set as 7.9% based on Allen et al. (2019). In terms of two productivity parameters, we normalize A^{SOE} to unity and calibrate A^{POE} as 1.67. These two values are consistent with relative productivity between POEs and SOEs based on Chinese Industrial Enterprises Database. Moreover, our calibration of TFP difference falls in the range (1.4 to 2.3) suggest by existing literature.[15]

[12] A lower value of γ than β also implies POEs have binding borrowing constraint at steady state even when entrusted lending is shut down.

[13] The exogenous demand includes government spending and net export.

[14] The total SOE output data is not available for the whole sample period. Chang et al. (2019) calibrates SOE share as 0.3 which is not significantly different from us.

[15] Brandt et al. (2008) and Brandt & Zhu (2010) find relatively high TFP gap which is 1.8 and 2.3 respectively. Chang et al. (2019) use a relatively low value (1.42). Hsieh & Klenow (2009) find that productivity for SOEs is 42% lower than POEs in China, implying A^{POE} as 1.72 which does not significantly differ from our calibration.

4.3 Estimation Results

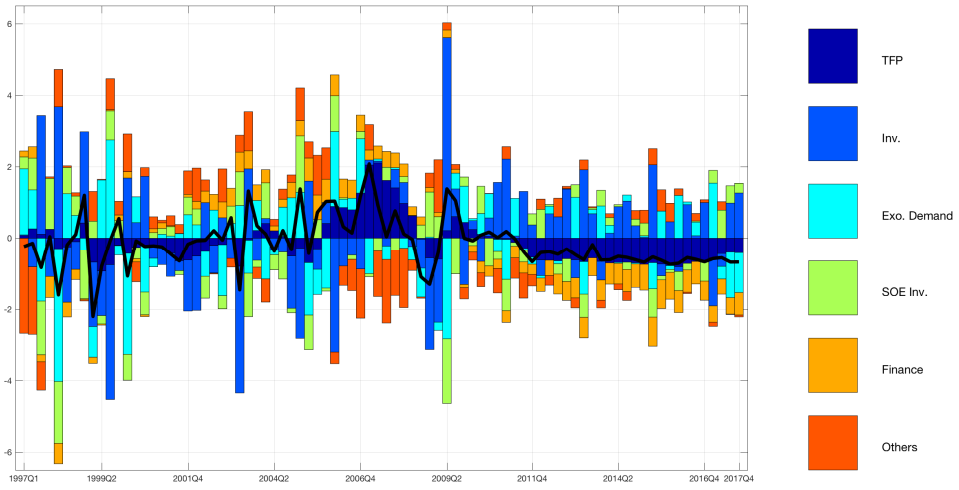
The choice of prior distributions is similar to those used in Smets & Wouters (2007) except for ξ which is not presented in that model. We use a gamma distribution with a mean of 1 and a standard deviation of 0.4. The unity prior mean implies a quadratic function of entrusted lending rate in the amount of entrusted credits. A quadratic function is often used to model financial costs and hence unity should be a reasonable prior mean of ξ. For the standard deviation of ξ, we choose 0.4 which is quite loose so that we can "let the data speak". Our estimation results (see Table 3) are similar to those in the literature. With regards to shock processes, Table 3 suggests that volatile shocks hit the Chinese economy including particularly two investment shocks and private financial shock.

Table 3: Prior and posterior distribution of structural parameters and shock processes

Parameters	Prior			Posterior
	Distribution	Mean	St.Dev.	Mean [5, 95]
b habit	Beta	0.7	0.1	0.78 [0.69, 0.86]
ϵ_p calvo price	Beta	0.5	0.1	0.74 [0.67, 0.82]
ι_p price indexation	Beta	0.5	0.15	0.44 [0.22, 0.65]
ϵ_w calvo wage	Beta	0.7	0.1	0.83 [0.74, 0.92]
ι_w wage indexation	Beta	0.5	0.15	0.49 [0.27, 0.73]
η labour elasticity	Gamma	2	0.5	2.10 [1.38, 2.81]
s" Invest. adj. cost	Gamma	5	1	5.12 [3.46, 6.86]
ρ_r taylor smoothing	Beta	0.7	0.15	0.97 [0.96, 0.98]
ρ_π taylor parameter	Normal	1.5	0.25	1.90 [1.59, 2.16]
ρ_y taylor parameter	Normal	0.3	0.1	0.31 [0.15, 0.44]
ξ entrusted credit elasticity	Gamma	1	0.4	4.91 [3.60, 6.30]
ρ_a per. of exo. TFP	Beta	0.5	0.2	0.98 [0.97, 0.99]
ρ_d per. of preference	Beta	0.5	0.2	0.29 [0.06, 0.53]
ρ_m per. of mon. policy	Beta	0.5	0.2	0.34 [0.22, 0.47]
ρ_s per. of price mark-up	Beta	0.5	0.2	0.88 [0.81, 0.95]
ρ_w per. of wage mark-up	Beta	0.5	0.2	0.47 [0.20, 0.84]
ρ_i per. of inv. efficiency	Beta	0.5	0.2	0.67 [0.56, 0.79]
ρ_g per. of exo. demand	Beta	0.5	0.2	0.96 [0.95, 0.99]
ρ_{soe} per. of soe inv.	Beta	0.5	0.2	0.40 [0.18, 0.62]
ρ_f per. of financial	Beta	0.5	0.2	0.99 [0.98, 0.99]
σ_a std. of exo. TFP	Inv_Gamma	0.1	2	0.82 [0.72, 0.92]
σ_d std. of preference	Inv_Gamma	0.1	2	3.81 [1.63, 5.84]
σ_m std. of mon. policy	Inv_Gamma	0.1	2	0.04 [0.04, 0.05]
σ_s std. of price mark-up	Inv_Gamma	0.1	2	0.37 [0.26, 0.48]
σ_w std. of wage mark-up	Inv_Gamma	0.1	2	0.62 [0.47, 0.75]
σ_i std. of inv. efficiency	Inv_Gamma	0.1	2	1.55 [1.27, 1.85]
σ_g std. of exo. demand	Inv_Gamma	0.1	2	1.31 [1.16, 1.46]
σ_soe std. of soe inv.	Inv_Gamma	0.1	2	2.75 [1.88, 3.47]
σ_f std. of financial	Inv_Gamma	0.1	2	3.90 [3.34, 4.41]

Note: 90% HPD in bracket.

Figure 3: Historical variance decomposition of output growth



Next we show relative importance of shocks for our sample period, using historical decomposition for output growth in Figure 3. We highlight contributions of TFP, investment and private financial shocks which are the three most important shocks driven economic growth in China. The importance of these three shocks in the Chinese business cycles is also identified using unconditional variance decomposition. Specifically, these three shocks together account for 75% of output and investment variations, 67% of consumption variation and 96% of TFP variation. More details can be found from Table 1 in an online appendix. In addition, we find SOE investment shock has some counter-cyclical contributions to output growth especially in the Asian Financial Crisis (1998-1999) and the Global Financial Crisis (2008-2009) periods.

Figure 3 also shows a pattern of growth slowdown in China since 2011. Our estimation results suggest that the slowdown is mainly attributed to negative and persistent contributions from TFP and private financial shocks. The former result confirms findings from existing literature while the latter shows that financial factors play an important role in growth slowdown in recent China.

5 Impulse Response Analysis

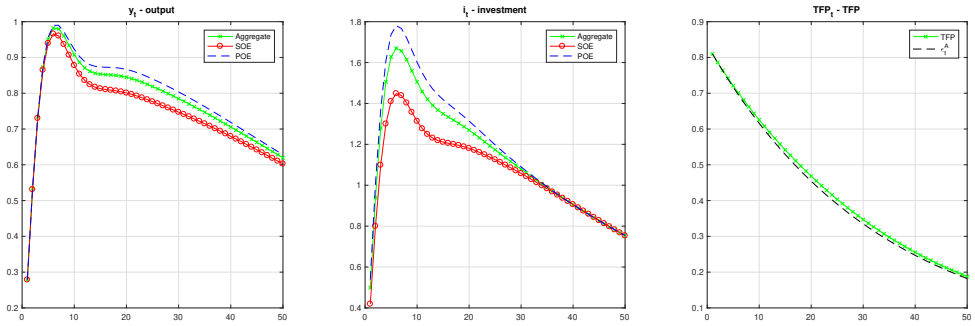
In this section, we use impulse response functions (IRFs) to show mechanisms how SOEs affect business cycles in China through privileged access to credits, the entrusted lending and SOE investment shock.

5.1 Privileged Access to Credits and Entrusted Lending

We focus on TFP, investment and private financial shocks to explain the mechanism. These three shocks are selected because Section 4.3 has established their importance in driven macroeconomic fluctuations in China.

Figure 4: Impulse response to TFP shock (1 std)

(a) SOE vs POE



(b) With entrusted vs w/o entrusted lending

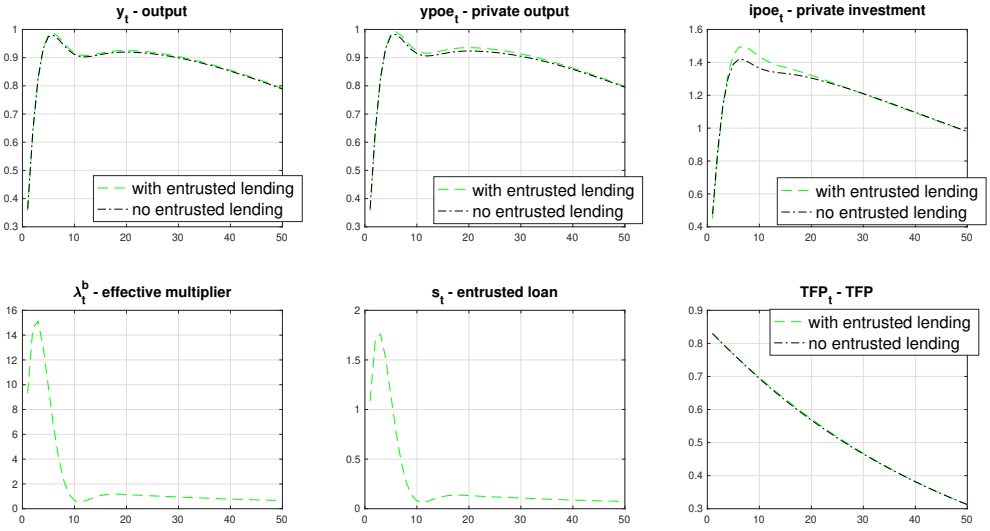
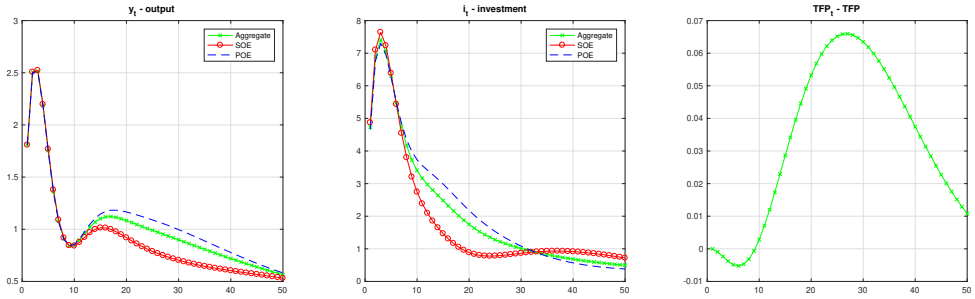


Figure 4(a) plots impulse responses of some key variables to a positive TFP shock. Higher productivity encourages both SOEs and POEs to increase outputs and investment. For POEs, increased productivity stimulates their capital, which expands debt capacity. With more debts, POEs can further expand production and accumulate more capital, thus entering an upward spiral. This creates a financial acceleration effect on POE output and investment. While SOEs are not subject to borrowing constraint and hence their output and investment respond less aggressively. Since POEs invest more than SOEs, private capital share $\frac{K_t^{POE}}{K_t}$ increases, resulting in a positive reallocation effect and hence the response of TFP is amplified. Moreover, our findings are in line with existing literature in terms of financial acceleration effect (e.g., Wang et al. (2018)) and reallocation effect (e.g., Chen & Song (2013)). Overall, the fluctuation of aggregate output is dampened but that of TFP is magnified due to SOEs' privileged access to credits and lower productivity.

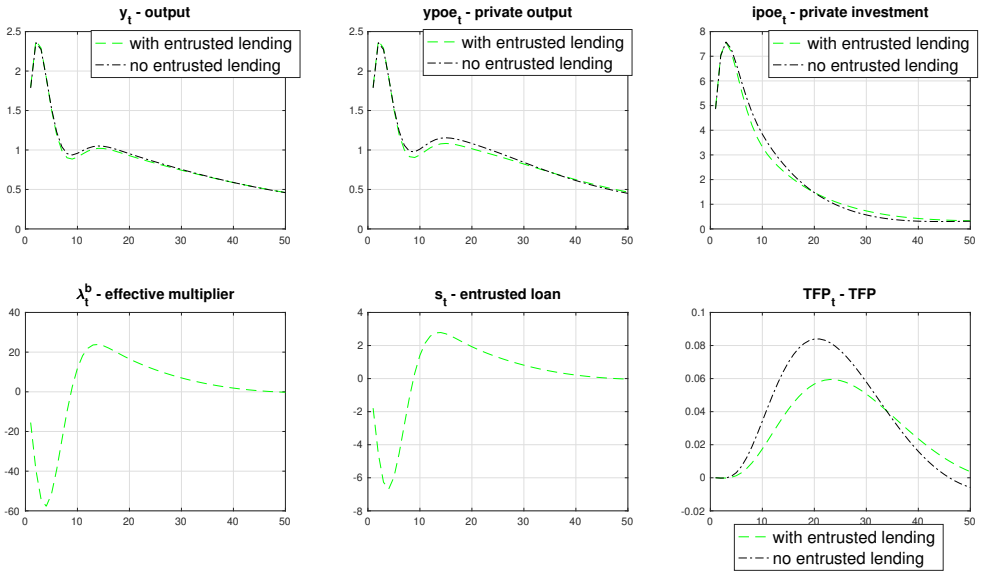
Figure 4(b)[16] further compares IRFs in two cases: with and without entrusted lending. Following a positive TFP shock, $\lambda_t^{b',POE}$ increases meaning a tighter POE borrowing constraint, which is consistent with Jermann & Quadrini (2012). That is because POEs demand more funding for expanding their business but capital accumulated slowly. This difference between funding demand and debt capacity leads to a tighter borrowing constraint. With the alternative funding option, POEs resort to SOEs for entrusted lending. Consequently, POEs own more budget funds, invest and produce relatively more; responses of output and investment are amplified compared with no entrusted lending case. In addition, the response of TFP is slightly amplified since the difference in the capital between POEs and SOEs is widened.

Figure 5: Impulse response to investment shock (1 std)

(a) SOE vs POE



(b) With entrusted vs w/o entrusted lending

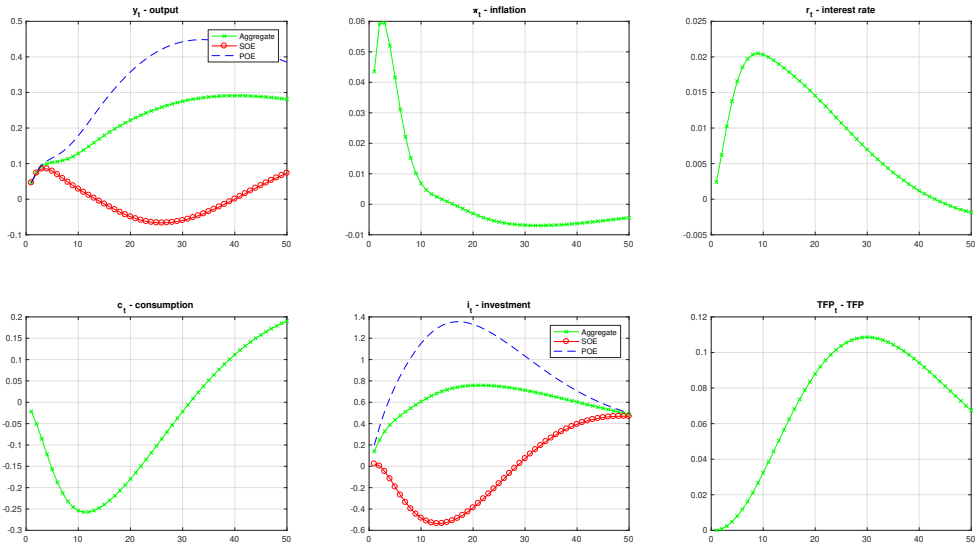


In terms of a positive investment shock, Figure 5(a) shows that SOE output and investment have positive but less aggressive responses than POEs. This is similar to the IRFs of the TFP shock because SOEs are not subject to the financial acceleration effect. Moreover, POE investment share increases, which leads to a

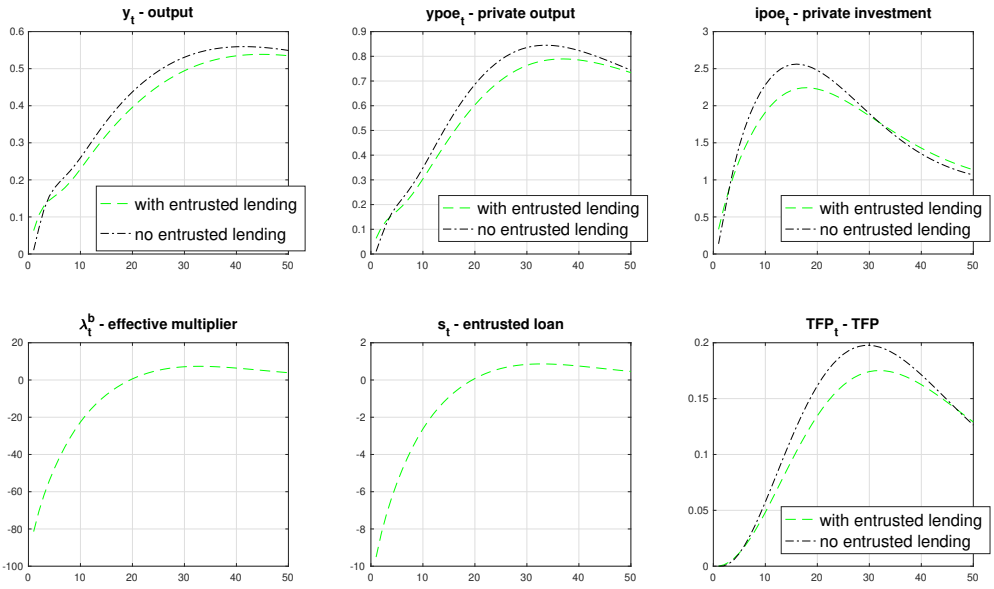
[16]When entrusted lending is shut down, s_t in Figures 4(b), 5(b) and 6(b) becomes zero for all time horizons.

Figure 6: Impulse response to POE financial shock (1 std)

(a) SOE vs POE



(b) With entrusted vs w/o entrusted lending



positive reallocation effect and TFP increases.

If the entrusted lending channel is switched on, entrusted credits will decrease (Figure 5(b)), which is a different story compared with the TFP shock. That is because an increase of investment efficiency immediately spurs capital accumulation, which releases POE borrowing constraint and hence $\lambda_t^{b',POE}$ drops. Consequently, POEs reduce the use of entrusted credits and the addition of the entrusted lending dampens budget funds of POEs. In this case, POEs invest and produce relatively less; responses of output and investment are dampened compared with no entrusted lending case. In addition, the reallocation effect is weakened and the response of TFP is dampened since POEs shift away from entrusted lending.

With regard to private financial shock, Figure 6(a) shows different pictures in terms of responses of SOEs and POEs. A positive private financial shock releases financial constraint for POEs. Consequently, POEs borrow more credits to produce and invest; the economy is expanded and interest rate rises. The latter effect is transmitted to the state sector, leading to a crowding-out effect on SOEs' output and investment. Moreover, different movement of investment between SOEs and POEs triggers positive reallocation effect which significantly rises TFP.

Figure 6(b) shows that entrusted credits decrease in response to the positive private financial shock. Due to easier access to formal credits, POEs shift to cheaper bank loans and reduce borrowing from SOEs. The movement of POE budget fund is dampened and hence the increases of both investment and output are dampened as well. Moreover, the reallocation effect is weakened so that the increase of TFP is not as large as in the case without entrusted lending.

In summary, the above impulse response analyses suggest that different impacts of SOEs and entrusted lending on business cycles. With privileged access to credits (and low productivity), SOEs reduce the variation of output but amplifies that of TFP. However, the presence of entrusted lending has unidirectional but dual effects on the variation of output and TFP. If POE borrowing constraint is released in expansion, such as cases of investment shock and private financial shock, the response of entrusted credits is opposite to that of output; both the financial acceleration effect and the reallocation effect are weakened, resulting in variation of output and TFP being dampened. In contrast, if POE borrowing constraint becomes tightened in expansion, such as the case of TFP shock, responses of entrusted credits and output are in the same direction; both the financial acceleration effect and the reallocation effect are strengthened, which leads to magnified variations of output and TFP. Therefore, the dual effect of entrusted lending depends on the nature of shocks.

In order to further understand the quantitative importance of SOEs and entrusted credits, we compare macroeconomic volatility in the baseline model with two cases: one without SOEs and another one without entrusted credits. Table 4 reports relative volatility between the benchmark and the two counter-factual cases for output, investment and TFP. These statistics are computed for TFP shock, investment shock, financial shock individually, the three shocks together and all shocks together. Table 4(a) shows that the presence of SOE decreases overall volatility of output and investment but increases that of TFP; as suggested by the"All"

Table 4: Comparing volatility

(a) Effects of SOEs

Variables	Shocks				
	All	ϵ^a,ϵ^i, ϵ^f	ϵ^a	ϵ^i	ϵ^f
y	0.833	0.812	0.994	0.975	0.675
i	0.835	0.810	0.992	0.970	0.674
tfp	1.096	1.067	1.012	1.944	1.869

Note: Statistics represent the standard deviation of the variable in the baseline model relative to that in the counter-factual economy without SOE. An entry above (below) 1 implies that SOE amplifies (dampens) the volatility of the variable after the shock(s).

(b) Effects of entrusted lending

Variables	Shocks				
	All	ϵ^a, ϵ^i, ϵ^f	ϵ^a	ϵ^i	ϵ^f
y	0.995	0.992	1.004	0.988	0.986
i	0.992	0.986	1.007	0.984	0.982
tfp	0.997	0.996	1.003	0.745	0.966

Note: Statistics represent the standard deviation of the variable in the baseline model relative to that in the counter-factual economy without entrusted lending. An entry above (below) 1 implies that entrusted lending amplifies (dampens) the volatility of the variable after the shock(s).

column, SOE dampens 16% of volatility of both output and investment but amplifies 10% of TFP volatility. This is mainly explained by effects from the three important shocks in the Chinese business cycles, especially the private financial shock which generates 24% less volatile output and investment but 87% more volatile TFP in the benchmark case.[17]

Shifting attention to another comparison between the benchmark and the case without entrusted lending, Table 4(b) shows that there are marginal differences in overall volatility of output, investment and TFP between the two cases (see the "All" and the "ϵ^a, ϵ^i, ϵ^f" columns). Despite this finding, we still find significantly different volatility between the two cases based on individual shocks. For example the private financial shock, the presence of entrusted lending dampens 1.4% of output volatility, 1.8% of investment volatility and 3.4% of TFP volatility. Given the importance of this shock in slowing down economic growth in China, we further assess how entrusted lending interacts with the financial shock to affect growth in China since 2010, as explored in Section 6.1.

5.2 SOE Investment Shock

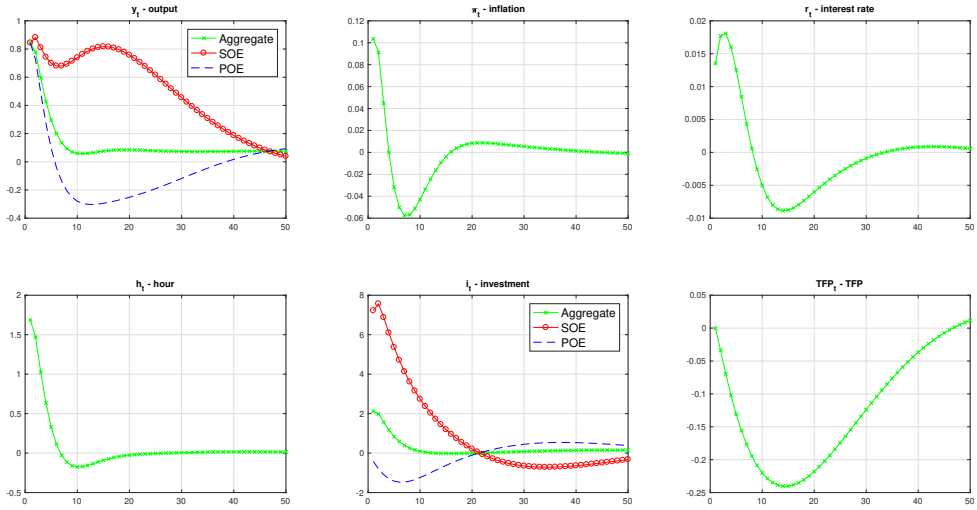
In this subsection, we investigate transmission mechanism of a SOE investment shock.

Figure 7 shows that, following a positive SOE investment shock, SOE investment and output dramatically increase in the short run. The increase of SOE output boosts aggregate labour hour, which produces a positive spillover effect on the private sector, increasing POE output in the short run. However, POE investment is crowded out, dragging POE output below zero in the mid-to-long run. As a result, there is significant capital misallocation which leads to a persistent slowdown in TFP. Similar to the effect of privileged access to credits, investment subsidies could also lead to the trade-off between output and TFP volatility, given that implementation of investment subsidies is on a counter-cyclical basis.

In order to compare different implications of the two forms of preferential financial treatment, we compute dampening and amplification effects result from the two factors. Specifically, dampening effects due to

[17]Note that the private financial shock explains 13% of TFP volatility in variance decomposition.

Figure 7: Impulse response to SOE investment shock (1 std)



privileged access to credits can be extracted by differencing y_t^{poe} and y_t in Figures (4) to (6)[18] while that effect due to investment subsidies is y_t in Figure (7). TFP or difference between TFP and ϵ_t^a are amplification effects in each case.[19] We calculate accumulated dampening and amplification effects at different time horizons. Results are reported in Table 5.

Table 5: Comparing effects of privileged access to credits and investment subsides

Shocks	ϵ_t^a			ϵ_t^i			ϵ_t^f			ϵ_t^{soe} Inv. Subsidies		
Horizons	1-8	1-20	1-50	1-8	1-20	1-50	1-8	1-20	1-50	1-8	1-20	1-50
Dampening	0.022	0.128	0.372	0.029	0.720	2.328	0.159	1.970	11.271	2.441	3.084	4.661
Amplification	0.014	0.083	0.241	0.019	0.467	1.510	0.103	1.278	7.310	1.011	3.932	5.114
Amp/Damp	0.649	0.649	0.649	0.649	0.649	0.649	0.649	0.649	0.649	**0.414**	**1.275**	**1.097**

Note: Dampening and Amplification are accumulated effects in percentage. Time horizons are denoted by quarters. Each entry in Amp/Damp is a quotient between Dampening and Amplification, suggesting x% of TFP amplified as cost of 1% of output dampened.

A sharp difference is shown in the last row of Table 5. Investment subsidies have pronounced adverse effects (on magnifying TFP variation) which is even quantitatively larger than benefits (on dampening output variation) in medium-to-long run. Particularly, investment subsidies could magnify 1.3% of TFP per 1% of output saved 20 quarters after the implementation. In contrast, privileged access to credits have a relatively much smaller cost; the magnification effect is equivalent to about 2/3 of output variation being dampened. These results suggest that investment subsidies play an aggressive role which constitutes major costs of SOEs.

[18] Without privileged access to finance, y_t will be equal to y_t^{poe}

[19] Similar to Chen & Song (2013), capital reallocation will be shut down if different producers are subject to the same degree of financial constraint.

With these quantitative differences, we further interpret two recent recessions in China, as explored in Section 6.2.

6 SOEs, Entrusted Lending and Growth

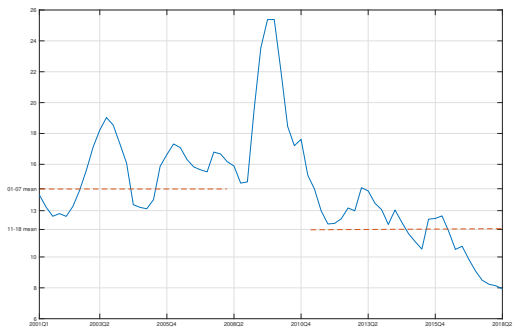
Over the last two decades, there were three periods with relatively low growth rates in China, including the Asian Financial Crisis (AFC) period (1998-1999), Global Financial Crisis (GFC) period (2008-2009) and 2010s. In the first two periods, China experienced recessions and SOEs' investment was intervened for recovery. In the third period, China entered a "New Normality" with relatively low growth and at the same time, there was rapid development of shadow banking activities. It is interesting to study implications of SOEs or entrusted lending for growth in the three periods in light of our model features.

6.1 Entrusted Lending and Growth Slowdown

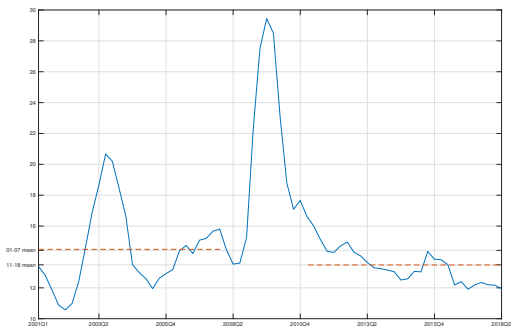
The above analyses suggest that entrusted lending can significantly dampen propagation of private financial shock which is one of the major forces leading to the economic slowdown in recent China. We further study how the financial shock and entrusted lending affect growth in China since 2010.

Figure 8: Money and loan growth

(a) M2 4-quarter growth



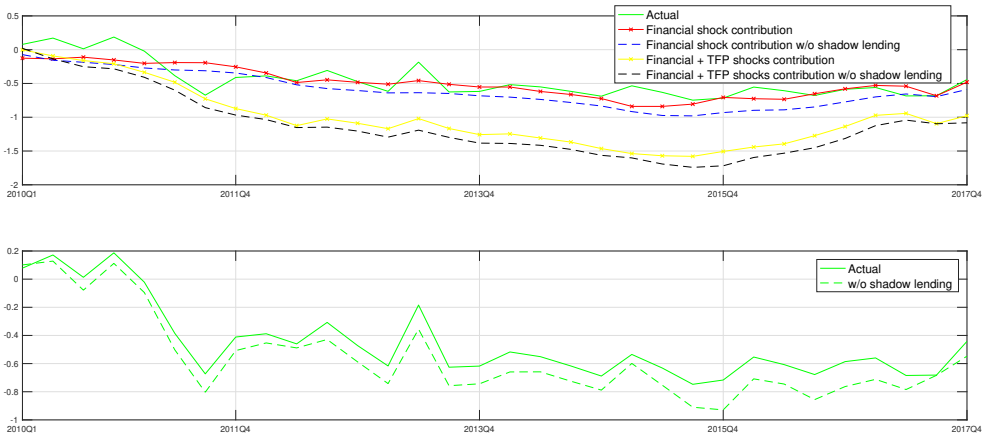
(b) Loan 4-quarter growth



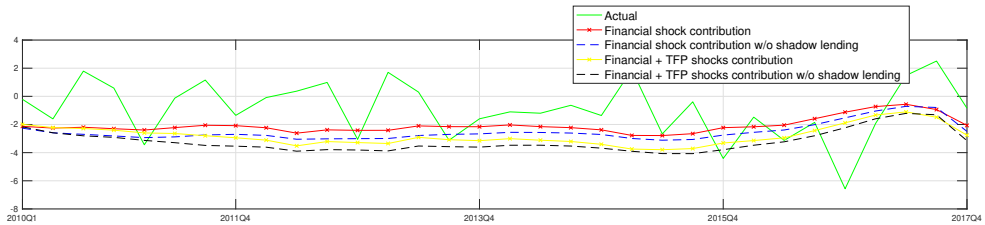
The Chinese economy started a deleveraging process and adopted tightened monetary policies, especially quantity-based measures, after the GFC. Figure 8 shows that monetary supply, measured by M2 growth, and credits, measured by loan growth, gradually declined in the 2010s. Particularly, the average growth rate of M2 and loans dropped from 15.43% and 14.42% over 2001-2007 to 11.78% and 13.49% over 2011-2018 respectively. It is very likely that the financial shock captured effects of the quantity-based monetary policy so that this shock generated persistent and negative contributions to output growth (see Figure 3). In addition, shadow banking especially entrusted credits boomed during that period. It is likely that entrusted lending played some important roles in the recent economic slowdown.

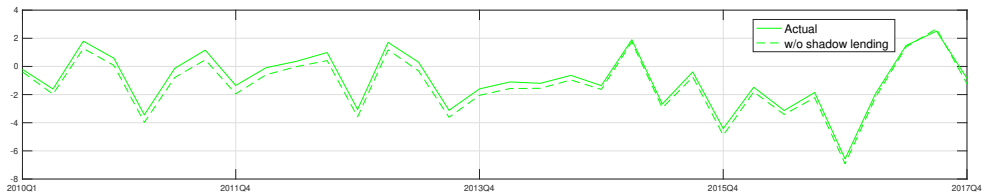
Figure 9: Comparing growth: effects of entrusted lending

(a) Output growth

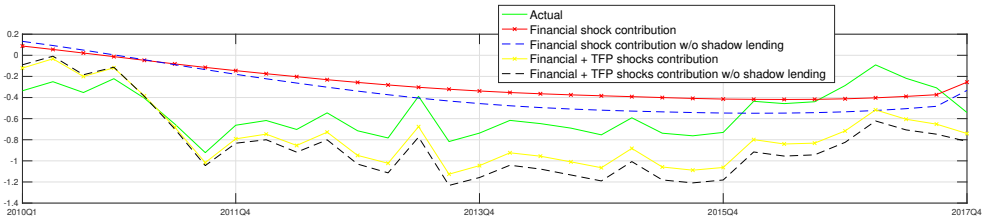


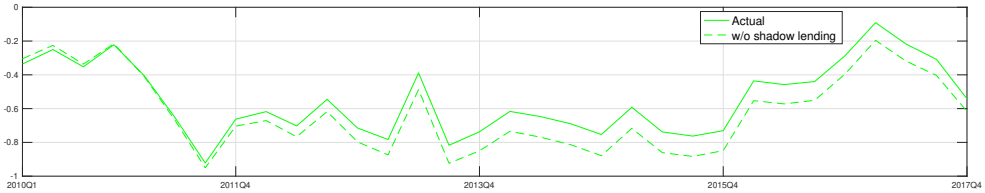
(b) Investment growth





(c) TFP growth





In order to understand effects of entrusted lending on the recent growth slowdown, we perform counter-factual experiments to compare the actual economy with a counter-factual case without shadow lending in the form of entrusted loans. Some key variables including output growth, investment growth and TFP growth are reported in Figure (9).[20] Upper panels of each subfigure are used for comparing contributions of individual shocks while lower panels are used for comparing overall growth. Starting from output growth, Figure (9a) suggests that negative contribution from the private financial shock is significantly dampened in the actual case (see the red and blue lines). When the effect of TFP shock is accounted, the pattern of dampening effect still exists (see the yellow and black lines). Similarly, Figure (9b) and (9c) suggest mitigation effects on negative contributions to investment and TFP growth in the actual case. Furthermore, lower panels of Figure (9) suggest that overall growth rate of output, investment and TFP could be lower with the absence of entrusted credits. Particularly, we find that output growth could be reduced by about 0.3% annually on average over 2011-2017. This magnitude is by no means trivial because such a decrease is able to move economic growth away from growth target (interval). For example, the actual growth rate was 6.7% in 2016 and a 0.3% decrease would depress the growth rate below the lower bound of the growth target (6.5%). The failure of achieving the target could further give rise to panic among investors and pose threats to social stability (Chen et al. 2018). Moreover, since the absence of entrusted lending reduces TFP growth, China's transition to a productivity-driven economy could be delayed. Considering that the Chinese government is likely to continue tightened monetary policies (PBOC 2019), the financial shock would continue its negative effects on output and TFP growth. Thus, the presence of entrusted lending is important for channelling credits to productive POEs and contributes to maintaining productivity-based economic growth. In this sense, our model provides a useful framework to address the issue of how to alleviate the downward pressure on China's economic growth.

6.2 SOEs and Growth in Recessions

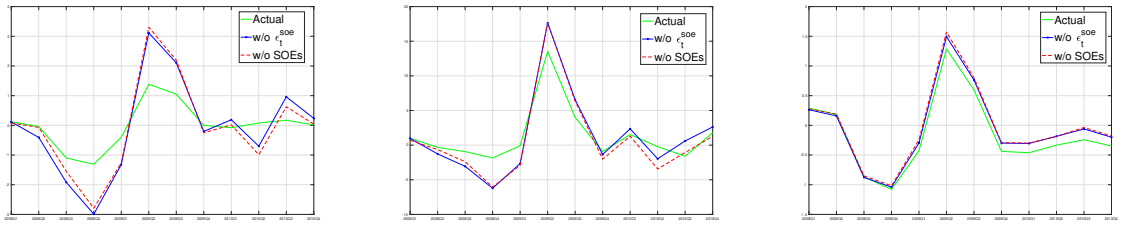
In this section, we investigate effects of SOEs on China's economic recovery with particular a focus on two recessions in AFC and GFC based on mechanisms provided in the above analyses. To this end, we compare output growth, investment growth and TFP growth with their simulated counterparts in two counter-factual cases: one without SOE investment shock and another one without the SOE sector. These results are reported in Figure (10) and (11). The solid green lines refer to the actual case while the red dash lines and blue star line refer to the two counter-factual cases respectively. We interpret the difference between the red and the blue lines as effects of privileged access to credits.

Overall, Figure (10) and (11) suggest that the presence of SOEs prevented China from a deep recession at the cost of TFP growth. In terms of the GFC period, Figure (10) shows that SOEs largely contribute to maintaining output growth and investment growth, especially through investment subsidies. If SOEs were

[20] Figure (9c) shows that Chinese TFP growth in 2010s is persistently lower than the sample average. Such a pattern of TFP slowdown is found in other studies, e.g., Chen et al. (2019).

Figure 10: Comparing growth: effects of SOEs in 2008-2010

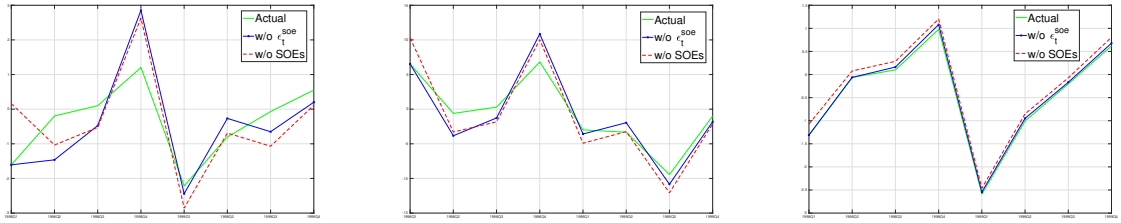
(a) Output growth (b) Investment growth (c) TFP growth



removed from the economy, loss of both output growth and investment growth could be doubled. For example, the output growth would be reduced by 2.7% over 2008Q1-2008Q4 in the case without SOE while the actual loss was 1.3%. Despite the dampening effects provided by SOEs, Figure (10c) shows that TFP growth in the actual case was lower than the two counter-factual cases and the divergences became significant since 2008Q4. This timing coincided with the implementation of the Chinese economic stimulus plan including subsidies for SOE investment. Moreover, Figure (10c) shows that the TFP growth gaps (between green and two other lines) were gradually widened over time. This is because, on the one hand, the SOE investment shock has persistent effects on TFP growth as suggested by the impulse response analysis. On the other hand, there were several rounds of stimulus measures (Zilibotti 2017) which further exacerbated the loss on TFP growth.

Figure 11: Comparing growth: effects of SOEs in 1998-1999

(a) Output growth (b) Investment growth (c) TFP growth



For the AFC recession over 1998 to 1999, similar effects of SOEs can be found from Figure (11). A major difference is that investment subsidies played a dominant role in the GFC recession while privileged access to credits was more important in the AFC recession. For instance, in 1999Q1, SOE's privileged access to credits saved 0.4% (the difference between blue and red lines) of output growth, almost double than that through investment subsidies (0.2%–the difference between green and blue lines.). There is a more pronounced difference for TFP growth gap comparing the two recessions; that in the AFC period is almost entirely owing to SOE's privileged access to credits (see Figure (11c)). These results suggest that SOE intervention in the AFC recession was less heavy than in the GFC one. This is also confirmed by Figure (3) indicating smaller

contributions of SOE investment shock to output growth in 1998-1999 than in 2008-2010. Although the Chinese government implemented some SOE investment subsidies in 1998 (WorldBank 1999), government spending was more heavily used over 1998-1999.

7 Robustness Checks

In this section, we check robustness of our results by considering entrusted lending data in estimation and two trend variations including permanent TFP change and SOE reforms.[21]

7.1 Trend TFP Shock

In the post-crisis period, China entered a new era with relatively low economic and TFP growth. The above analysis suggest that persistent low TFP growth contribute to lower economic growth in 2010s. Considering that changes of TFP in China may have permanent nature, we replace the temporary TFP shock ε_t^a in the model with a permanent TFP shock similar to Christiano et al. (2014). Equation (3) becomes $A_t^p = A^p(1+g^y)^t\varepsilon_t^z, \;\; p = SOE, POE$ where ε_t^z is the permanent TFP shock and its growth rate ($g_t^z = \Delta ln\varepsilon_t^z$) follows a stationary AR(1) process: $lng_t^z = \rho_z lng_{t-1}^z + \eta_t^z$. η_t^z follows i.i.d $N(0, \sigma_Z^2)$.

Then we estimate the model based on the same dataset. Overall, we do not find fundamental changes in our major results. More importantly, the presence of trend TFP shock does not alter the important role of entrusted lending for maintaining economic growth in recent China (see Figure (1) in online Appendix).

7.2 Time-varying SOE share

In this subsection, we focus on the SOE sector to address an issue of whether our results are sensitive to SOE reforms in China. Our baseline calibration suggests one-third as the share of the SOE sector in the economy. However, data suggest that this share has a downward trend. A potential impact is that the model might not be fully consistent with data, which may lead to inaccurate estimation results for SOE investment shock. With this concern, we adjust the SOE investment data using SOE investment share and replace the unadjusted one with share-adjusted SOE investment growth. Overall, we do not find fundamental changes in our results.

7.3 Adding Entrusted Lending data

This subsection considers an extension of estimation with entrusted credit growth data and an entrusted lending shock. Particularly, we allow entrusted lending premium parameter ε^b to be time-varying and follows an AR(1) process as follows: $ln\varepsilon_t^b = (1-\rho_b)ln\varepsilon^b + \rho_b ln\varepsilon_{t-1}^b + \eta_t^b$. η_t^b follows i.i.d $N(0, \sigma_B^2)$. By including

[21] Some key results are reported in online Appendix. For the reason of brevity, we do not report full results about robustness check but they are available upon request.

this shock, we are able to fit the model with entrusted loan data and avoid the issue of stochastic singularity. This data is not used for the main analysis because it is only available between 2002Q1 and 2017Q4 and we want to keep the sample size as large as possible.

Our new estimation results suggest that there is no significant difference compared with the main results. Particularly, entrusted lending elasticity ϕ has similar value compared with the benchmark estimation. Moreover, we find entrusted lending does not amplify macroeconomic volatility and contributes to maintaining both economic growth and TFP growth in the 2010s (see Figure (2) in online Appendix).

8 Conclusion

In this study we investigate macroeconomic implications of a key economic structure in China, namely coexistence of SOEs and entrusted loan-based shadow lending. To this end, we build and estimate a DSGE model with SOEs who receive investment subsidies and privileged access to credits, but also direct credits to financially constrained POEs. Our findings suggest that SOEs lead to a trade-off in business cycles by dampening variation of output but amplifying that of TFP while the presence of entrusted lending could dampen variation of both output and TFP, hence mitigating the cost of SOEs.

In light of model features, we further interpret two recent recessions (1998-1999 and 2008-2009) and economic slowdown in China. Based on counter-factual experiments, we show that SOEs prevented the economy from a deep recession in both periods at the cost of TFP. The loss in 1998-1999 was mainly caused by privileged access to credits which creates a moderate trade-off between output and TFP. Hence TFP loss was relatively insignificant. Whilst the cost in 2008-2009 was primarily due to investment subsidies which lead to the TFP loss more significant and persistent. Focusing on the recent growth slowdown in the 2010s, we further show that entrusted lending was able to dampen negative contributions from the tightened financial situation, particularly by mitigating capital misallocation, and hence contribute to maintaining both economic growth and TFP growth in recent China.

Finally, our analysis sheds light on the development strategy of China's transition to a productivity-driven economy. In order to attain this target, stable macroeconomic environment and sustained TFP growth are indispensable. Although they could be achieved by developing the official financial system and private firms, yet this strategy alone requires long-time efforts with great challenges. With this consideration, it is complementary for the Chinese economy to also maintain the coexistence of SOEs as business entities and entrusted loan-based shadow finance, to exploit their benefits through stabilization and reallocation effects.

References

Allen, F., Qian, Y., Tu, G. & Yu, F. (2019), 'Entrusted loans: A close look at China's shadow banking system', *Journal of Financial Economics* .

Anzoategui, D., Chivakul, M. & Maliszewski, W. (2015), 'Financial distortions in China: A general equilibrium approach', *IMF Working Paper* **15**(274).

Anzoategui, D., Comin, D., Gertler, M. & Martinez, J. (2019), 'Endogenous technology adoption and R&D as sources of business cycle persistence', *American Economic Journal: Macroeconomics* **11**(3), 67–110.

Avdjiev, S., Chui, M. K. & Shin, H. S. (2014), 'Non-financial corporations from emerging market economies and capital flows', *BIS Quarterly Review* .

Ayyagari, M., Demirgüç-Kunt, A. & Maksimovic, V. (2010), 'Formal versus informal finance: evidence from China', *Review of Financial Studies* **23**(8), 3048–3097.

Bernanke, B. S., Gertler, M. & Gilchrist, S. (1999), 'The financial accelerator in a quantitative business cycle framework'.

Bleck, A. & Liu, X. (2018), 'Credit expansion and credit misallocation', *Journal of Monetary Economics* **94**, 27–40.

Brandt, L., Hsieh, C.-T. & Zhu, X. (2008), 'Growth and structural transformation in China', *China's great economic transformation* pp. 683–728.

Brandt, L. & Zhu, X. (2010), 'Accounting for China's growth', *IZA Discussion Paper* (4764).

Calvo, G. A. (1983), 'Staggered prices in a utility-maximizing framework', *Journal of Eonetary Economics* **12**(3), 383–398.

Chang, C., Chen, K., Waggoner, D. F. & Zha, T. (2016), 'Trends and cycles in China's macroeconomy', *NBER Macroeconomics Annual* **30**(1), 1–84.

Chang, C., Liu, Z. & Spiegel, M. M. (2015), 'Capital controls and optimal chinese monetary policy', *Journal of Monetary Economics* **74**, 1–15.

Chang, C., Liu, Z., Spiegel, M. M. & Zhang, J. (2019), 'Reserve requirements and optimal Chinese stabilization policy', *Journal of Monetary Economics* **103**, 33–51.

Chen, K., Ren, J. & Zha, T. (2018), 'The nexus of monetary policy and shadow banking in China', *American Economic Review* **108**(12), 3891–3936.

Chen, K. & Song, Z. (2013), 'Financial frictions on capital allocation: A transmission mechanism of tfp fluctuations', *Journal of Monetary Economics* **60**(6), 683–703.

Chen, S., Sun, Z., Tang, S. & Wu, D. (2011), 'Government intervention and investment efficiency: Evidence from China', *Journal of Corporate Finance* **17**(2), 259–271.

Chen, W., Chen, X., Hsieh, C.-T. & Song, Z. M. (2019), 'A forensic examination of China's national accounts'.

Christiano, L. J., Motto, R. & Rostagno, M. (2014), 'Risk shocks', *American Economic Review* **104**(1), 27–65.

Cong, L. W., Gao, H., Ponticelli, J. & Yang, X. (2019), 'Credit allocation under economic stimulus: Evidence from china', *The Review of Financial Studies* **32**(9), 3412–3460.

Dai, L., Minford, P. & Zhou, P. (2015), 'A DSGE model of China', *Applied Economics* **47**(59), 6438–6460.

Ehlers, T., Kong, S. & Zhu, F. (2018), 'Mapping shadow banking in China: structure and dynamics', *BIS Working Paper* (701).

Higgins, P. & Zha, T. (2015), 'China's macroeconomic time series: Methods and implications', *Federal Reserve Bank of Atlanta* .

Hsieh, C.-T. & Klenow, P. J. (2009), 'Misallocation and manufacturing TFP in China and India', *The Quarterly Journal of Economics* **124**(4), 1403–1448.

Jermann, U. & Quadrini, V. (2012), 'Macroeconomic effects of financial shocks', *American Economic Review* **102**(1), 238–71.

Lu, Y., Guo, H., Kao, E. H. & Fung, H.-G. (2015), 'Shadow banking and firm financing in China', *International Review of Economics & Finance* **36**, 40–53.

Moody's (2017), *Quarterly China Shadow Banking Monitor.*, Moody's Investors Services, New York.

PBOC (2019), China monetary policy report, quarter two, 2019, Technical report, People's Bank of China.

Smets, F. & Wouters, R. (2007), 'Shocks and frictions in us business cycles: A Bayesian DSGE approach', *American Economic Review* **97**(3), 586–606.

Song, Z., Storesletten, K. & Zilibotti, F. (2011), 'Growing like China', *American Economic Review* **101**(1), 196–233.

Wang, P., Wen, Y. & Xu, Z. (2018), 'Financial development and long-run volatility trends', *Review of Economic Dynamics* **28**, 221–251.

Wen, Y. & Wu, J. (2019), 'Withstanding the great recession like China', *The Manchester School* **87**(2), 138–182.

WorldBank (1999), China: weathering the storm and learning the lessons, Technical report, Washington, DC: World Bank.

Wu, G. L. (2018), 'Capital misallocation in China: Financial frictions or policy distortions?', *Journal of Development Economics* **130**, 203–223.

Zetlin-Jones, A. & Shourideh, A. (2017), 'External financing and the role of financial frictions over the business cycle: Measurement and theory', *Journal of Monetary Economics* **92**, 1–15.

Zilibotti, F. (2017), 'Growing and slowing down like China', *Journal of the European Economic Association* **15**(5), 943–988.

Appendix A Data

Table 6: Descriptions and sources for observables used in estimation

Variables	Observables-China	Sources
gdp GDP	per capita real GDP	National Bureau of Statistics, China
c Consumption	per capita real household consumption expenditure	Chang et al. (2016)
i Investment	per capita real enterprise capital formation	Chang et al. (2016)
i^{SOE} SOE Inv.	per capita real SOE capital formation	Chang et al. (2016)
π Inflation	GDP Deflator	Chang et al. (2016)
r Interest rate	3-month base policy saving rate	The People's Bank of China
h Labour	per capita employment	Chang et al. (2016)
	hour worked	The People's Bank of China
w Wage	aggregate real wage	Chang et al. (2016)
b loans	new bank loans to non-financial enterprises	Chang et al. (2016)
s entrusted loans	new entrusted credits	Chang et al. (2016)
Population	total population	Chang et al. (2016)

All nominal variables are adjusted by GDP deflator. GDP, consumption, overall investment, SOE investment, loans and entrusted loans are divided by population and taken log-difference. Real wage is taken log-difference. Employment is multiplied by hour worked and divided by population. Finally, we remove sample means for each variables separately as similar to Christiano et al. (2014).

Chinese quarterly consumption, GDP deflator, wage, employment level, new bank loans to non-financial enterprises, new entrusted credits and population data are from Chang et al. (2016). Details about construction of data can be refereed to Higgins & Zha (2015). Hour worked data for China is unavailable in Chang et al. (2016) and we obtain this data from the People's Bank of China.