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Pushing on a String: State-Owned Enterprises and Monetary Policy Transmission in China*

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Abstract

This paper studies whether monetary transmission in China is asymmetric. While researchers have found an asymmetric transmis-sion in the US and other economies, China offers a specific rationale for asymmetries: the presence of state-owned enterprises (SOEs) with preferential access to financing. To study the consequences of SOEs for monetary policy transmission, we differentiate between expansionary and restrictive policy shocks and argue that SOEs generally suffer less from a policy tightening and benefit more from a policy easing. Based on sector-specific macroeconomic time series and a large firm-level da-ta set, we provide evidence of a systematic and sizeable asymmetry in the transmission of monetary policy shocks in China. The nature of the asymmetry is consistent with the notion of explicit or implicit govern-ment guarantees of SOEs and has consequences for the adjustment of aggregate variables. In contrast to other central banks, the People's Bank of China seems able to "push on a string".

Keywords: monetary transmission, state-owned enterprises, financial system, VAR, state-dependent local projections, firm-level data

JEL classification: E32, E44, G3

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1. Introduction

It is often argued that monetary policy is unable to "push on a string". By using this metaphor, market participants and central bank observers describe the notion that tighter monetary policy can pull the economy into a recession when financing constraints are binding. Easier monetary conditions, however, can only relax financial constraints but cannot push the economy into an expansion. The available empirical evidence for the US supports this notion (see, among others, Tenreyro and Thwaites, 2016).[1] As a result, tightening shocks should have larger effect on the real economy than easing shocks. As a motivation for asymmetric effects, the literature refers to downward nominal rigidities or one-sided financing constraints.

In this paper, we study whether a "pushing on a string" phenomenon can be found for China. The case of China is particularly interesting because it offers a specific rationale for an asymmetry policy transmission that is absent in other economies: the large role of state-owned enterprises (SOEs). SOEs are typically clustered in heavy industries such as steel and shipbuilding and, even after decades of economic reforms, account for about 40% of total firm assets. SOEs have regained economic importance after 2008, when the Chinese authorities implemented the large stimulus program mostly through their control over state-owned firms. The literature, much of which is surveyed below, find two main properties of SOEs compared to private firms: First, SOEs are generally perceived to be inefficient compared to private firms in terms of the allocation of capital. They are believed to make larger losses and incur higher debt. Second, despite their structural weaknesses, they are perceived to have preferential access to finances, often channeled through state-owned banks. In fact, the combination of these two properties is one of

[1] Weise (1999) finds that money supply shocks have stronger effects when output is below its potential. Ravn and Sola (2004) use a Markov-switching model to show that negative surprise money supply shocks have larger real effects than positive ones. Lo and Piger (2005) find that shocks have stronger effects in recessions compared to booms, while they do not find an asymmetry with regard to the sign of the policy shock. Barnichon and Matthes (2016) also show that a contractionary shock has stronger effects on unemployment. Finally, Angrist et al. (2017) provide evidence suggesting that monetary accommodation generates less pronounced effects than tightening. While all contributions differ in their methodologies, they broadly agree on the nature of the asymmetry.

the stylized facts of SOEs and is often used as a core assumption in macroeconomic models for the Chinese economy (e.g. Song et al. 2011).
If SOEs are subject to governmental interference and face preferential access to financial resources, they should respond differently to monetary policy impulses than privately owned firms. In addition, the large SOE sector should also affect the way monetary policy affects the aggregate real economy. In this light, it is surprising that the role of SOEs for the transmission of monetary policy has not yet been studied. We fill this gap and study the transmission of policy shocks using disaggregated data for SOEs and private firms, respectively.

Our main hypothesis is that the presence of SOEs gives rise to an asymmetric adjustment to monetary policy shocks. Suppose SOEs are indeed characterised by (i) government interference into their operations and (ii) preferential access to finances. A policy tightening should have stronger effects on private firms and smaller effects on SOEs, since the latter is not equally exposed to an inward shift in credit supply as a consequence of the policy move. Now think of a policy easing: the state-owned sector might expand more than the private sector because authorities could interfere into the management of SOEs in order to use SOEs as a vehicle to support expansionary policies. As a result, SOE activity should expand more strongly than economic activity of private firms.
How does this translate to the aggregate level? If SOEs are a large part of the economy, as they are in China, this should translate into an asymmetry on the aggregate level. In fact, this should imply that easing shocks are more effective in driving GDP than tightening shocks – a pattern that is the opposite of what researchers found for the US and other economies. In this sense, monetary policy in China is "pushing on a string".

We organise our contribution in three main steps: First, we estimate a series of linear vector autoregressive (VAR) models that include aggregate business cycle variables but also relative sectoral information. The latter is either the change in leverage of SOEs relative to that of private firms or the growth rate of SOE investment relative to the growth rate of private investment. A monetary policy shock is identified using restrictions on the sign of the impulse responses (Uhlig, 2005). Although the model is symmetric, the responses of the relative variables are informative about asymmetries in the adjustment to monetary policy. We find that a monetary policy shock has significantly stronger ef-

fects on SOE investment and leverage compared to private firms. Both investment and leverage expand stronger after a policy easing than in the case of private firms.

Second, we use local projections in the spirit of Tenreyro and Thwaites (2011) to shed light on the asymmetric reaction to easing and tightening shocks, respectively. Owing to the fact that the previously used model is linear, we cannot use it to study whether sectoral policy transmission is asymmetric. In particular, the VAR is not able to reveal whether the responses to a policy tightening are similar in absolute terms to the responses to a policy easing. We believe this distinction to be important in order to understand the asymmetric policy transmission. To quantify the asymmetry, we estimate a series of local projections (Jordà 2005), which we extend to allow for different effects of positive and negative policy shocks, respectively. Local projections provide a very flexible alternative to VAR models and are ideally suited to analyse nonlinearities and asymmetries.
Using the exogenous change in M2 growth identified by Chen et al. (2016) as our measure of monetary policy shocks, we find that on a sectoral level a monetary policy easing benefits SOEs more than private firms. For a monetary tightening, the results are less clear-cut, but tend to suggest that SOEs activity is reduced less compared to private firms. Thus, these asymmetries are in line with the hypothesis put forward before and support the notion of preferential refinancing conditions of the state-owned sector. These sectoral asymmetries also translate into the adjustment of aggregate variables such as GDP, electricity consumption and office space sold. In the aggregate, a policy easing is more effective than a policy tightening. Interestingly, however, the nature of the asymmetries is remarkably different from the US and other economies. In China, monetary policy *is* able to push on a string.

Third, we use firm-level survey data on 160,000 firms from 37 two-digit manufacturing industries. The data is assembled by the Chinese National Bureau of Statistics (NBS), and contains information on firms' balance sheets such as total liabilities, total assets, as well as the ownership structure of the firm and several other control variables. We use this data to study the monetary policy impact on firm leverage for SOEs and non-SOEs. We also differentiate between a policy tightening and a policy easing. The results suggest that in general, SOEs' leverage increases when monetary policy is loosened. However,

the leverage of non-SOEs decreases. The same is true when monetary policy tightens. The existence of SOEs fundamentally changes the transmission of monetary policy.

This paper contributes to the literature on asymmetries in the transmission of monetary policy, see Tenreyro and Thwaites (2016) and others. We study the potential asymmetries against the backdrop of the large share of SOEs in China. Recent papers by Fernald et al. (2014), Chen, Chow and Tillmann (2017) and Chang et al. (2017) argue that monetary policy in China is difficult to interpret as the PBoC uses more than one instrument to implement its policy and the policymaking process remains opaque. These papers propose ways to deal with the multitude of instruments in empirical studies. Fernald et al. (2014) and Chen, Chow and Tillmann (2017) claim that while the policy implementation stage in China is different from other countries, the transmission mechanism is similar. In this paper, we focus on the transmission mechanism and argue that the asymmetry involved is an important distinction with regard to the transmission process in other economies.

It should be noted that asymmetric responses to monetary policy shocks could also result from factors other than the ownership structure or the access to financing, respectively. Research for other countries finds that firms in different sectors or firms of different size respond differently to the same policy shock. Since SOEs are typically large firms clustered in heavy industries, the resulting asymmetries could also be observed even if SOEs and non-SOEs would face identical financing conditions. While the macro data does not allow us to control for firm properties other than ownership, the micro data used in this paper addresses this issue. We control for firm size and firms' asset structure in order to isolate the effect of ownership and, through ownership, the effect of access to financing. Unfortunately, however, we cannot control for industry-specific effects since the data does not allow us to associate a firm with a specific industry.

This paper also contributes to the literature on the risk-taking channel of monetary policy transmission. One of the main objectives of a monetary policy easing is to encourage firms to take more risk and increase investment. However, after a recession or a financial crisis, banks are reluctant to grant riskier loans, and firms are reluctant to take more risk, even in the presence of monetary policy easing. The result of this is that central

banks try to "push on a string" in order to escape the recession, which is not effective in many cases. The existence of SOEs with implicit government guarantee can help resolve this short run problem. Of course, the possible long-run cost is that SOEs could be less efficient.

This paper is organised as follows: section 2 summarizes the main characteristics of SOEs highlighted in the literature. Section 3 introduces the data series used in the paper. The VAR model is discussed in section 4, while section 5 introduces state-dependent local projections. Section 6 completes the analysis with an analysis of firm-level data. Finally, section 7 summarizes the findings and draws conclusions.

2. The role of state-owned enterprises

In this section we sketch the main characteristics of SOEs in China and derive the main hypothesis to be tested below.[2] State-owned firms remain quantitatively important in China, even after more than two decades of economic reforms. They play an important role for the long-run growth performance of China and the Chinese business cycle (see Peng et al., 2016). Figure (1) plots information about the size of the state-owned sector and its balance sheet. We see that the share of SOEs in the total number of firms sharply declined in recent years. Their relative size of the balance sheet, that is total assets of SOEs relative to total assets of all firms, still remains at 40%. Although the number of SOEs fell, the remaining SOEs have very large asset positions. State-owned firms remain clustered in heavy manufacturing industries such as steel, shipbuilding and heavy machinery. The right panel of Figure (1) plots leverage for both SOEs and private firms. Leverage is defined as total liabilities divided by total assets. The more remarkable observation is the divergence after 2008. Since then, leverage of SOEs increased strongly until 2012, while private firm leverage is on a downward trajectory. We will come back to this structural break below.

A large literature has studied the properties of SOEs and their contribution to economic development. Researchers typically find an inefficient allocation of capital between state-owned and private firms (Ljungqvist et al., 2015) and a large productivity gap between both types of firms, with SOEs being less productive than private firms (Hsieh and

[2] For a more comprehensive survey of SOEs in China, their role during the economic transformation and their likely future, see Hsieh and Song (2015).

Klenow, 2009). Hsieh and Song (2015) argue that a more efficient allocation of capital would be a boost for future growth in Total Factor Productivity. Due to the government's immediate control over SOEs, state-owned firms have been the primary vehicle through which Chinese authorities implemented the large stimulus package of 2008/09 (*The Financial Times*, February 29, 2016). In fact, the structural break in SOE leverage in 2008 is likely to reflect the additional credit obtained as a consequence of the package. Bai et al. (2016) point out that in the long run the expansion of relatively unproductive SOEs in 2008/09 could result in a drag on potential growth in the future.

If the government ultimately controls firms, they might face more favourable financing and refinancing conditions. Researchers typically find that state-owned enterprises have better access to capital than private firms (see, among others, Su, 2016). This results from the fact that Chinese banks favour state-owned enterprises over private firms (Wei and Wang, 1997) or from the fact that bureaucrats are better able to evaluate the credit risk of SOEs (Cull and Xu 2000, 2005). Cull et al. (2015) use the degree of government intervention in the appointment of CEOs of Chinese firms as a measure of government control. They find that stronger government intervention is associated with significantly better access to bank credit. Direct evidence on credit constraints is provided by Poncet et al. (2010). Based on firm-level data, these authors find that private Chinese firms are credit constrained while state-owned firms are not.

In fact, it is now widely accepted that favourable access of SOEs to funding is a stylized fact of the Chinese economy. For example, the 'Growing like China' paper of Song et al. (2011) considers this as a core element of their model. They argue that state-owned firms are less productive but survive because of better access to credit. Likewise, the models of Peng et al. (2016) and Chang et al. (2016) assume that SOEs have superior access to bank loans due to government guarantees despite their low productivity.[3]

One important implication from this differential access to finances is that monetary policy should have different effects on both types of firms. If SOEs have better access to

[3] An interesting topic for future research is the role of the expanding shadow banking system and the process of financial deregulation for the financing conditions of firms and the differential access to finances for different types of firms. Elliott et al. (2015) provide a very useful description of the shadow banking system in China.

funding, they should reduce output, employment and investment less if policy tightens.[4] For private firms, however, a change in refinancing conditions triggered by monetary policy should have larger effects. Moreover, the differential access to financing together with government interference in firms' financing and investment decisions also implies an asymmetry: a policy tightening should have stronger effects on private firms than on SOEs. A policy easing should lead to a stronger expansion of SOEs than private firms. This is because the government can direct firms to support the policy easing with an increase in lending and output. In this regard, monetary policy is able to "push on a string". In the aggregate, this would translate into an aggregate adjustment of macroeconomic time series. Since SOEs account for a large fraction of economic activity, any asymmetric response of SOEs to tightening and easing shocks, respectively, should be visible in the aggregate.

The literature on monetary policy transmission in China has found important asymmetries: Chen, Higgins, Waggoner and Zha (2016) find asymmetric output effects in different business cycle states. Chen, Ren and Zha (2017) find that a policy tightening is much less effective than a policy easing. One factor that might explain these asymmetries is the large presence of SOEs. Furthermore, Fernald et al. (2014) survey the literature and argue that due to the structural transformation and financial development, the effectiveness of monetary policy in China changed over time. They cite several papers suggesting that the effectiveness of monetary policy in China has increased over time. One mechanism behind this finding might be the decline in the share of SOEs.

Finally, there is a growing literature on local fiscal policy in China using firm-level data on leverage and investment for different types of firms. This literature typically finds that an expansion of local government debt affects SOEs and privately owned firms differently. Liang et al. (2017) show that higher local government debt crowds out the leverage of private firms while SOE leverage increases. Similarly, Huang et al. (2017) find a crowding out of private investment following an increase in public debt. The crowding-out increases in the dependence of privately owned firms on external financing.

3. Data

[4] Based on a large sample for firm-year observations, Yang et al. (2017) find that monetary policy is less effective for state-owned enterprises.

We use Chinese time series data obtained from the CEIC database. The data frequency is monthly and the sample begins in 2000:01 and ends in 2017:06. Since the exogenous shock series used below is available until 2016:06, some specifications cover the period 2000:01 to 2016:06 only. The aggregate data series we use are real investment, CPI inflation, PPI inflation, real loan volume, M2, the consumption of electricity, the overall freight volume and the amount of office space sold. The latter three variables are often used as alternative measure of real economic activity in light of concerns about the quality of official GDP. All variables are used in year-on-year percentage growth rates. The reason for this is that data availability is much better for growth rates than for levels. Real GDP is available on a quarterly frequency only and is therefore interpolated to monthly frequency.[5]

Investment, both the aggregate series and the sectoral data, is the only variable which has not been taken from CEIC. Instead, we use data available on the Atlanta Fed time series database on China.[6] The nominal growth rates of Gross Fixed Capital Formation are transformed into real series by subtracting the associated change in the price level of fixed capital investment. To obtain a monthly frequency of year-on-year growth rates, the growth rates are finally interpolated.

An important characteristic of Chinese data are the Chinese New Year celebrations, which are held at the end of January and beginning of February. These celebrations are reflected in obvious outliers in most growth rates. We follow Fernald et al. (2014) and replace the January and February entries of the data series taken from CEIC with the average of December and March, thus leading to a yearly growth rate that is equal in January and February.

From CEIC we also obtain sectoral growth rates of value-added, investment and leverage, that is, total liabilities over total assets. All three series are available for state-owned firms, which we use below. In addition, the series are also available for private firms. The CEIC database uses an inconsistent classification of sectors. For some series, the subcategories "private" and "state-owned" are available, while for other series "share-

[5] We obtain very similar results if we use the monthly aggregate value-added instead.

[6] The data set is available at https://www.frbatlanta.org/cqer/research/china-macroeconomy.aspx?panel=1

owned" and "state-owned" are available. Below, we use data on "share-owned" firms for value-added and leverage and data on "private" firms for investment. For the different sectors, the three series are plotted in Figure (2)

4. Evidence from a VAR model

As mentioned before, we analyse potential asymmetries from different angles. The first approach, which we present in this section, builds on a conventional, symmetric VAR model. Although the model itself is symmetric, the results are informative about asymmetries as we put the ratios of sectoral variables into the model.

To be specific, let the vector of endogenous variables, Y_t, follow a VAR process with q lags

$$Y_t = \left[\Delta GDP_t \;\; \Delta CPI_t \;\; \Delta M2_t \;\; \Delta Inv_t \;\; \Delta Lev_t \;\; \left(\Delta Lev_t^{SOE} - \Delta Lev_t^{priv}\right)\right]'.$$

This vector contains the standard business cycle indicators such as the growth rate of real GDP, the CPI inflation rate, the change in M2 and the aggregate growth rate of investment. These variables are included in year-on-year percentage growth rates. Aggregate leverage is expressed in percentage points and, hence, is included in first differences, not in logs. Our deviation from the conventional VAR framework frequently used for other economies is the choice of the last endogenous variable. The vector Y_t includes the first difference of leverage of state-owned enterprises, ΔLev_t^{SOE}, minus the first difference of leverage of private firms, ΔLev_t^{priv}. A shock that significantly affects $\Delta Lev_t^{SOE} - \Delta Lev_t^{priv}$ is transmitted asymmetrically through the economy as it benefits one sector over the other. In an alternative specification, we replace the relative change in leverage by the change in investment of state-owned enterprises minus the change in investment of privately owned enterprises, $\Delta Inv_t^{SOE} - \Delta Inv_t^{priv}$. The inclusion of relative variables offers a straightforward way to study asymmetries in an otherwise symmetric model. Note that the asymmetry analysed here does not yet pertain to the distinction between easing and tightening shocks. This perspective is discussed in the next section as it requires a different empirical framework.

In this model, monetary policy is reflected by the year-on-year growth rate of M2, $\Delta M2_t$. Since we want to be consistent with the subsequent sections, in which we mainly use an

identified shocks series that corresponds to the exogenous change in M2, we choose M2 as the instrument reflecting monetary policy. The model is estimated with $q=6$ lags. Our sample covers a period from 2000:1 to 2017:6 and is based on monthly observations.
To identify monetary policy shocks, that is, an unexpected change in the stance of monetary policy, we resort to sign restrictions (Uhlig, 2005) imposed on the impulse responses. We impose the restriction that a monetary policy shock is one that raises the growth rate of M2, the growth rate of real GDP and the inflation rate in the first three quarters after the shock. Note that we restrict the sign of the response only, not its magnitude or its shape. All other variables' responses remain unrestricted. In particular, we do not impose any constraint on the adjustment of relative leverage and relative investment, respectively. Table (1) summarizes the constraints for both estimated model specifications.

Table 1: Sign restrictions to identify a monetary policy shock

model I	ΔGDP_t	ΔCPI_t	$\Delta M2_t$	ΔInv_t	ΔLev_t	$\Delta Lev_t^{SOE} - \Delta Lev_t^{priv}$
	+	+	+		unrestricted	
model II	ΔGDP_t	ΔCPI_t	$\Delta M2_t$	ΔInv_t	ΔLev_t	$\Delta Inv_t^{SOE} - \Delta Inv_t^{priv}$
	+	+	+		unrestricted	

Notes: The restrictions are imposed for three consecutive months.

The constraints imposed here should be relatively innocuous, as they require only consensus properties of any monetary policy shocks. An expansionary monetary policy should eventually drive inflation, output and money supply up despite the peculiarities of the policymaking process in China with all their differences with respect to monetary policy in Western economies. These restrictions are very similar to those regularly imposed to identify shocks to Federal Reserve, Bank of England or ECB policy.

The resulting impulse response functions are shown in Figures (3) and (4) for the two estimated models, respectively. Each figure reports the median response of all draws at a given horizon (solid line) with 68% confidence bands surrounding it as well as the median target responses as in Fry and Pagan (2011). The latter reflects the single response that is closest to the median across all draws (dotted line). By construction, an expansionary monetary policy raises inflation, M2 and output growth. It also leads to an

increase in aggregate leverage growth, while the response of real investment growth in the second model, see Figure (4), is not different from zero. Importantly, the monetary policy shock also raises the change of leverage of state-owned firms relative to private firms. Thus, SOEs are more strongly affected by monetary policy than privately owned firms. This pattern is consistent with the notion of preferential access to financing by SOEs. Below we will shed more light on this by disentangling expansionary and tightening shocks. In Figure (4), we see that a monetary policy shock also leads to an increase in the relative growth rate of investment. Real investment of state-owned firms increases by more than investment of private firms. In this case, the response of the growth rate-differential is large, about one percentage point after one year, and persistent.

Both sets of impulse responses suggest that the state-owned sector responds more strongly to monetary policy. The responses of the relative growth rates are sizeable and economically relevant. Thus far, however, the model is symmetric, that is positive and negative shocks have been equally effective. The next step is to adopt a suitable model framework that allows us to distinguish expansionary and tightening monetary policy shocks.

5. Asymmetric responses to easing and tightening shocks

Having studied the response of relative growth rates in an otherwise symmetric model, we now take the next step and estimate a state-dependent model, which allows for all parameters to differ according to the sign of the monetary policy shock. Since our main conjecture postulates that SOEs suffer less from a policy tightening and might even benefit more from a policy easing, we need an empirical model that distinguishes the sign of the monetary policy impulse and the following dynamics. For that purpose, we resort to local projections (Jordà, 2005). We will extend the symmetric projection by allowing for state-dependent effects, where the state refers to the sign of the policy shock as in Tenreyro and Thwaites (2016).

5.1 State-dependent local projections

Consider a dependent variable, y_t, whose current and future realisations are supposedly affected by the monetary policy shock in period t. The following symmetric specification regresses the change of y_{t+h} on the policy shock ΔM_t for $h = 0, 1, \dots, H$

$$\Delta y_{t+h} = \alpha_h + \beta_h \, \Delta M_t + \delta_h \sum_{i=1}^{q} \Delta \boldsymbol{X}'_{t-i} + \tau_h D^{2009} + \varepsilon_{t+h} \,,$$

where α_h is a constant. Here ΔM_t is the change in the stance of monetary policy to be defined below. If $\Delta M_t > 0$, the policy stance becomes more expansionary. If $\Delta M_t < 0$, the economy faces a policy tightening. The coefficient β_h measures the effect of monetary policy on the dependent variable at time t for h periods ahead. Plotting β_h as a function of h provides us with an impulse response function. The vector $\boldsymbol{X}_t$ contains control variables, among them lags of the dependent variable and the coefficient vector δ_h, which reflects the impact of the control variables on the dependent variable. In the estimation below, we will set *q = 1*. We include a dummy variable, D^{2009}, which reflects the large stimulus package adopted in November 2008. The dummy variable is equal to one between November 2008 and December 2009, and zero otherwise.

It remains to specify our measure of monetary policy changes, ΔM_t. One of the characteristics of monetary policy in China is the fact that the PBoC uses more than one instrument at a time to implement monetary policy. Hence, focusing on one indicator alone would give an insufficient description of the policymaking process. Considering that local projections, in contrast to VAR models, are not able to identify policy shocks in the sense of disentangling the effects of policy from the endogenous feedback from the economy to monetary policy, identification needs to be addressed outside the estimated model. Our measure of policy is a series of identified policy shocks from Chen, Higgins, Waggoner and Zha (2016) and Chen, Ren and Zha (2017). These authors estimate a regime-dependent Taylor rule that takes account of institutional peculiarities of the policymaking proves in China. They interpret M2 growth as the primary policy instrument and show that exogenous changes in M2 encompass changes of other instruments, such as RRR and official interest rates. This variable is used as our benchmark policy shock throughout this paper and is shown in Figure (5).[7]

[7] Since the series of policy shocks is quarterly, we interpolate the series to monthly frequency. Results based on alternative measures of monetary policy are available upon request.

Our main tool is an extension of the previously discussed model, which allows for state-dependent effects. Consider the following equation

$$\Delta y_{t+h} = \alpha_h + \beta_h^+ max[0, \Delta M_t] + \beta_h^- min[0, \Delta M_t] + \delta_h \sum_{i=1}^{q} \Delta \boldsymbol{X}'_{t-i} + \tau_h D^{2009} + \varepsilon_{t+h} ,$$

where now β_h^+ reflects the impact h periods ahead of policy easing, i.e. a positive ΔM_t, and β_h^- captures the effect of a policy tightening, i.e. $\Delta M_t < 0$. The decisive characteristic of the model is that it allows for the responses to be state-dependent, where the two alternative states are deterministic, observable and correspond to the sign of the policy shock. A perfect symmetric transmission of policy would imply $\beta_h^+ = \beta_h^-$. In this case, a policy tightening would have (in absolute terms) the same effect as a policy easing. Any deviation from this would signal an asymmetric nature of the policy transmission. To facilitate the interpretation, in particular for tightening shocks, we will plot below β_h^+ and $(-1) \times \beta_h^-$, such that the series of coefficients could be interpreted as the change in the dependent variable itself, following either an expansionary or a tightening shock, respectively. Further, we allow the constant in the regression and the vector of coefficients on the control variables to be different depending on the sign of the monetary policy shock. In order to avoid a clumsy notation, we do not include these state-dependencies in the regression equation presented before.

The dependent variables, also measured in year-on-year growth rates, are the following: sectoral valued-added, leverage and investment as used before, CPI and PPI inflation, credit, M2 and real GDP. Since data on real GDP for China are notoriously questioned on grounds of reliability, we also use three widely used alternative indictors of economic activity, which are the growth rate of electricity consumption, the growth rate of cargo freight and the percentage change of sold office space. The control variables include sectoral real economic activity such as measures by the growth in value-added as well as the inflation rate.

One of the main advantages of using local projections rather than more established VAR approaches is their ability to easily accommodate asymmetries, as modelled above, as well as nonlinearities and other deviations from the linear benchmark model. This is particularly attractive for the purposes of this paper. In addition, it is worth mentioning that the derivation of impulse response functions does not involve an iteration of coeffi-

cient matrices such as in the derivation of impulse responses based on the moving average representation of VAR models. This means that we do not need to assume that the economy remains in a given state, i.e. a policy easing or tightening, forever. This is an assumption that plagues state-dependent VAR models such as Markov-switching models. Figure (6) presents the resulting impulse response functions for an alternative measure of real economic activity, based on the exogenous growth rate of M2 as our baseline monetary policy shock. The figure, as well as all remaining figures, presents the estimated β_h^+ coefficient and the β_h^- coefficient multiplied by -1. It also plots error bands consisting of 1.65 standard errors around the estimates. These standard errors are Newey-West corrected in order to account for the serial correlation of the residuals. We find that an easing shock significantly raises GDP as well as the alternative indicators of activity, such as electricity consumption, floor space sold and fright volume. A contractionary shock, in contrast, has barely any effect. Hence, the response of real activity exhibits a strong asymmetry in the response to policy shocks.

Figure (7) contains the responses of sectoral time series to an exogenous change in M2 growth. The results are consistent with the aggregate responses shown in Figure (6). A policy easing strongly raises value-added, investment and leverage in the state-owned sector. A policy tightening, however, does not lead to an equally sized adjustment of the state-owned sector. Only for the response of leverage of state-owned firms, we find a policy tightening to be as effective as a policy easing. Moreover, the magnitude of the responses differ across sectors. The accommodative shock that raises the growth rate of investment of SOEs by 10 percentage points increases private investment growth by only 5 percentage points. While a policy tightening reduced private investment growth by up to 10 percentage points, the growth rate of SOE investment is not significantly reduced.

The responses of alternative inflation measures, loan growth and M2 growth are shown in Figure (8). In these series, the asymmetry shows up as well: a policy easing raises both consumer price and producer price inflation whereas a tightening does not reduce them. Aggregate loan growth increases after an expansionary monetary policy shock by about 1.5pp to 2pp. The growth rate of real loans does not, however, fall in the event of a policy tightening. This suggests that credit conditions do not significantly deteriorate in

the aftermath of a tightening. For money supply, i.e. the growth rate of M2, the adjustment appears to be symmetric.

As a bottom line of this section, we can conclude that monetary policy affects state-owned and private firms differently. A policy easing benefits investment and leverage in the state-owned sector more than in the private sector. A tightening, on the other hand, has stronger effects on the private sector, while the state sector seems to be shielded from large contractions.

5 Evidence from micro data

An analysis using aggregate macro data to study the nature of the transmission mechanism stands in the tradition of a large literature on empirical monetary policy analysis. While aggregate data is informative about the broad characteristics of the business cycle, however, it is naturally too blunt to provide deeper insights into firms' financing conditions. Firm-level data is another important piece of information about the asymmetries involved in monetary transmission in China.

In the following, we exploit a large firm-level data set and look at the cross section of firms during policy easing and tightening cycles, respectively. We use a Chinese firm-level panel data set, assembled by the Chinese National Bureau of Statistics, in an annual survey of manufacturing enterprises. The data set contains annual firm-level observations for the sample period 1998 to 2013. Due to missing data, we have to exclude the years 2008-2010. Although this is unfortunate as these are interesting years because of the large stimulus package introduced in 2008, we are nevertheless confident that the data is informative for our purposes. In fact, it might even be advantageous to have a data set purged of the effect of fiscal stimulus that gives a clearer picture of the effects of monetary policy.

Specifically, the data set includes more than 3.1 million observations, covering more than 160,000 manufacturing firms per year from 37 two-digit manufacturing industries and 31 provinces every year. The number of firms more than doubled from 165,118 in 1998 to 344,875 in 2013. It encompasses two types of manufacturing firms: first, all state-owned enterprises and, second, non-SOEs whose annual sales are more than five

million renminbi (which is equivalent to around US$781,000 under the current exchange rate). The non-SOEs could also be multinationals. The data set covers firms' balance sheets, with financial variables such as total assets and total liabilities, as well as information on the ownership structure, from which we can identify state-owned, collectively-owned, private and foreign firms. We classify a firm as an SOE if the state holds the controlling share.

Although this data set contains rich information, a few variables in the data set are noisy and misleading due, in large part, to the misreporting by some firms. Hence, we need to clean the sample and eliminate outliers. We drop observations if any of the following is true: (1) liquid assets are larger than total assets, (2) total fixed assets are larger than total assets, (3) the net value of fixed assets is higher than total assets and (4) the firm's identification number is missing. Moreover, we winsorize all financial variables used in the regression at the 1% end.

Based on the characteristics of SOEs described in section two, one possible conjecture is that during tightening episodes of monetary policy, though total lending would decrease, banks would lend relatively more to the less risky SOEs than non-SOEs. As a result, leverage of non-SOEs would decrease while that of SOEs decreases less or even increases. During a monetary policy easing, more credit is allocated to SOEs and thus their leverage responds more strongly to the monetary policy shock than that of non-SOEs. To test this conjecture, we estimate the following regression using the firm-level data set:

$$Lev_{i,t} = \beta_0 + \beta_1 \Delta MP_t + \beta_2 \Delta MP_t \times SOE_i + \beta_3 \Delta MP_t \times SOE_i \times Ease_t + \beta_4 \Delta MP_t \times Ease_t + \beta_5 SOE_i \times Ease_t + Control_{i,t} + \alpha_i + \varepsilon_{i,t} ,$$

where the monetary policy shock is denoted ΔMP_t, again with a positive ΔMP_t implying a policy easing, and $Ease_t$ equals one during a policy easing and zero otherwise. The dependent variable is leverage of firm *i* at time *t*, defined as total liabilities over total assets, which is consistent with literature. The explanatory variables of primary interest are an ownership dummy, SOE_i, which is one if the firm is state-owned, and zero otherwise, and an annualized measure of the change in the monetary policy stance, ΔMP_t. The latter is captured by the annualized exogenous growth rate of M2 used before. This series is constructed from the original, quarterly series.

As control variables, we include the following national, provincial and firm-level variables: the first variable is firm size, measured as the logarithm of firm's total asset. The second is tangibility, a proxy for the availability of collateral. This is measured as a firm's fixed assets divided by total assets. The third is sales growth, measured as the annual growth rate of a firm's sales revenue. As a fourth variable, we include provincial per capita GDP, which measures the heterogeneous economic developments of provinces where firms are located. Finally, we include the growth rate of national GDP, which is a proxy for the national business cycle. The estimation allows for firm-specific effects in order to control for fixed firm-specific characteristics.

To identify the asymmetric effect of monetary policy between SOEs and non-SOEs, we include several interaction terms in the regression. The coefficient on $\Delta MP_t \times SOE_i$ measures the differential effects of monetary policy on SOEs during tightening periods. The coefficient on $\Delta MP_t \times SOE_i \times Ease_t$, on the other hand, measures the effect during easing periods. The terms $\Delta MP_t \times Ease_t$ and $SOE_i \times Ease_t$, respectively, control for the potential asymmetry of the impact on leverage of a monetary tightening and easing and between SOEs and non-SOEs.

Table (3) presents the regression results. In each column, we present results for a different combination of control variables. It is interesting to see that for non-SOEs, leverage decreases for both tightening and easing periods. For a monetary policy tightening, ΔMP_t is negative and β_1 is positive, which makes the overall impact negative. For a monetary policy easing, ΔMP_t is positive and $\beta_1 + \beta_4$ is negative, which also makes the overall impact negative. The possible explanation is that for a monetary policy tightening, the liabilities of on-SOEs shrink faster that the asset value, and vice versa.

For SOEs, the results are different. For a monetary policy tightening, ΔMP_t is negative and $\beta_1 + \beta_2$ are also negative, which makes the overall effect on leverage $(\beta_1 + \beta_2) * \Delta MP_t$ positive. For a monetary policy easing, ΔMP_t is positive and $\beta_1 + \beta_2 + \beta_3 + \beta_4$ is positive. Therefore, the overall effect $(\beta_1 + \beta_2 + \beta_3 + \beta_4) * \Delta MP_t$ is positive. This shows the leverage of SOEs increases both under tightening and easing. The possible explanation is SOEs have better access to credit. Their liabilities grow faster than their assets under

both monetary policy conditions. The absolute value of $\beta_1 + \beta_2 + \beta_3 + \beta_4$ is much larger than that of $\beta_1 + \beta_2$. This shows that a monetary easing drives up SOE leverage by a larger amount than a monetary tightening. From β_5 it can be seen that when monetary policy eases, SOE leverage increases.

The above results show that a monetary policy tightening does not constrain SOEs as much as non-SOEs. On the aggregate level, this is reflected in the fact that a monetary easing is more effective in stimulating output and employment than a monetary tightening in cooling down the economy. In this sense, the PBoC seems to be able to "push on a string".

As regards the control variables, we see that a larger size and a higher tangibility reduce leverage. Based on the definition of leverage as the ratio of total liabilities over total assets, it seems that for larger firms with more tangible assets, asset value increase by more than that of liabilities, such that overall leverage declines.

6 Conclusions

This paper studied the asymmetric transmission of monetary policy impulses in China. An asymmetric transmission has been found for other countries, most notably the US economy, and researchers use the "pushing on a string" metaphor to describe that the Fed can drag the economy into a recession but cannot pull it into an expansion. Studying the case of China is particularly interesting. This is because China offers an alternative rationale for an asymmetric transmission: the important role that state-owned enterprises play in the Chinese economy and in policymaking in Beijing. State-owned enterprises enjoy favourable financing and refinancing conditions due to implicit or explicit government guarantees. This should make them less sensitive to monetary policy shocks. In addition, the government's control over state-owned enterprises potentially allows monetary policy to "push on a string".

We proposed three alternative ways of modelling the potentially asymmetric transmission. First, otherwise symmetric VAR models that included the relative change of activity in the state-owned sector and the private sector show that investment and leverage of state-owned enterprises respond more strongly to a monetary policy shock. Second, we

distinguished expansionary from tightening shocks and used state-dependent local projections to trace out the response to either shock. We showed that SOEs benefitted from easing shocks in a way that exceeds the response of private firms. Following a tightening shock, however, SOEs feel less pressure to restrain their activities. Third, a large set of firm-level data was used to show that the leverage of SOE increases more than that of non-SOE during a monetary easing. The effect of monetary easing is much stronger than that of monetary tightening.

Overall, we find that easing shocks have stronger effects on SOEs than tightening shocks. This translates into an asymmetric response of Chinese GDP and other measures of real activity. Thus, in contrast to other advanced economies, monetary policy is able to "push on a string" and is more effective when it provides additional stimulus compared to a situation where policy tightens.

The results derived in this paper matter for four reasons. First, they contribute to our understanding of Chinese monetary policy and its effect on the business cycle. This is particularly relevant as the measures taken by the PBoC receive increasing attention while the underlying institutional framework is still evolving. Second, with China being a major player in the world economy, monetary policy implemented by the PBoC has effects not just on China, but also on the rest of the world. An asymmetric transmission does not only influence Chinese exports and imports, but also global growth and financial conditions. The results presented here contribute to our understanding of the likely impact the PBoC's monetary policy measures might have. Third, the results indirectly provide information about the role of state-owned enterprises and the corresponding scale of preferential access to financing by state-owned firms. Fourth, the large share of state-owned enterprises and, hence, the implied asymmetry in the transmission, might make empirical estimates about the transmission process of Chinese monetary policy less comparable with that of other advanced economies.

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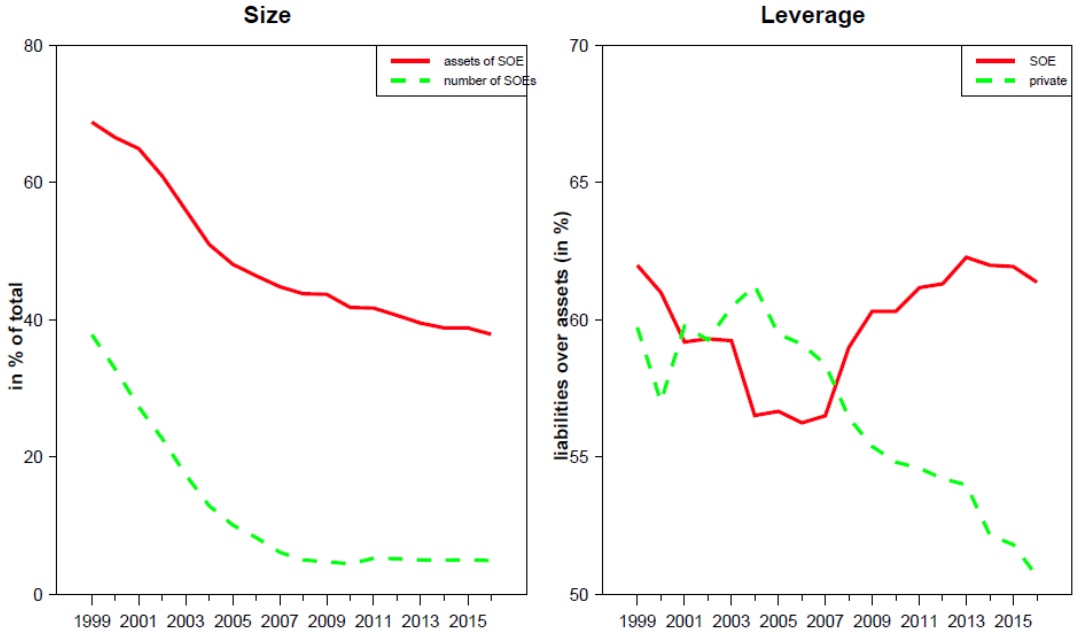
Table 3 Firm-level regression

	Dependent Variable: Leverage			
	(1)	(2)	(3)	(4)
ΔMP (β_1)	0.00783***	0.00710***	0.00493**	0.00460**
	(0.00181)	(0.00192)	(0.00195)	(0.00195)
ΔMP*SOE (β_2)	-0.0200***	-0.0164***	-0.0187***	-0.0180***
	(0.00318)	(0.00329)	(0.00331)	(0.00331)
ΔMP*SOE*Ease (β_3)	0.0690***	0.0578***	0.0586***	0.0571***
	(0.00643)	(0.00655)	(0.00655)	(0.00655)
ΔMP*Ease (β_4)	-0.0374***	-0.0303***	-0.0252***	-0.0237***
	(0.00377)	(0.00408)	(0.00413)	(0.00414)
SOE*Ease (β_5)	0.00346***	0.00382***	0.00440***	0.00483***
	(0.00131)	(0.00134)	(0.00134)	(0.00134)
Size	-0.00502***	-0.0111***	-0.0124***	-0.0118***
	(0.000381)	(0.000457)	(0.000493)	(0.000499)
Tangibility	-0.00403***	-0.00233***	-0.00232***	-0.00232***
	(0.000312)	(0.000295)	(0.000295)	(0.000295)
Sales Growth		0.001***	0.00102***	0.00102***
		(0.000155)	(0.000155)	(0.000155)
Prov. pc GDP			0.000269***	0.000796***
			(0.000037)	(0.000083)
ΔGDP				-0.00196***
				(0.000275)
Constant	0.641***	0.706***	0.713***	0.914***
	(0.00375)	(0.00458)	(0.00468)	(0.0286)
Firm FE	Yes	Yes	Yes	Yes
# of Obs.	1,856,298	1,399,687	1,399,575	1,399,575
R^2	0.001	0.001	0.001	0.001

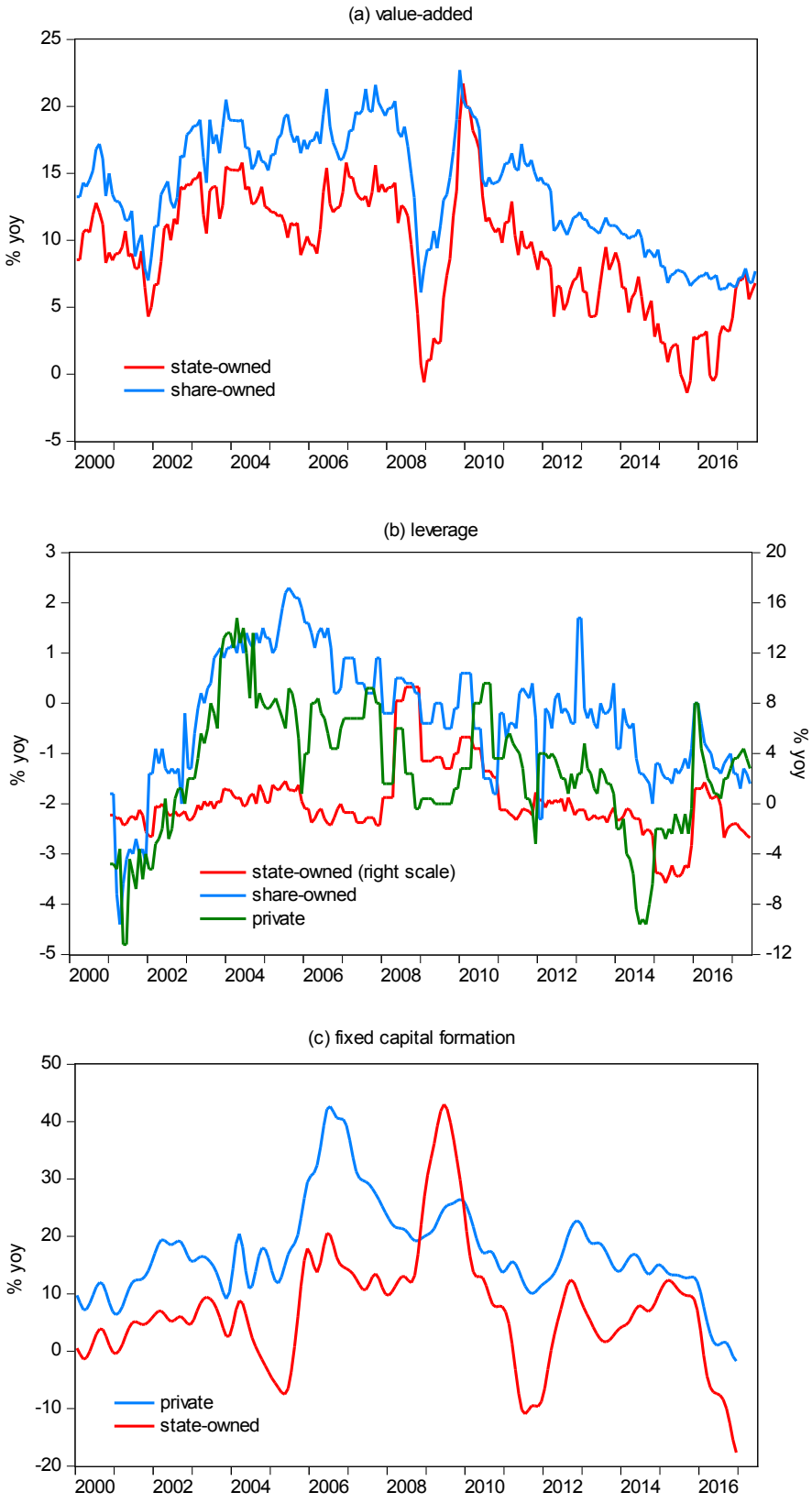
Notes: $Leverage$ is defined as total liabilities over total assets; ΔMP is the annualized exogenous growth rate of M2; $Ease_t$ is one if $\Delta MP > 0$ in a given year; SOE equals one if the state holds the controlling share of the firm. Estimated by panel OLS. A 1% (5%) significance level is indicated by *** (**).

Figure 1: The role of state-owned enterprises



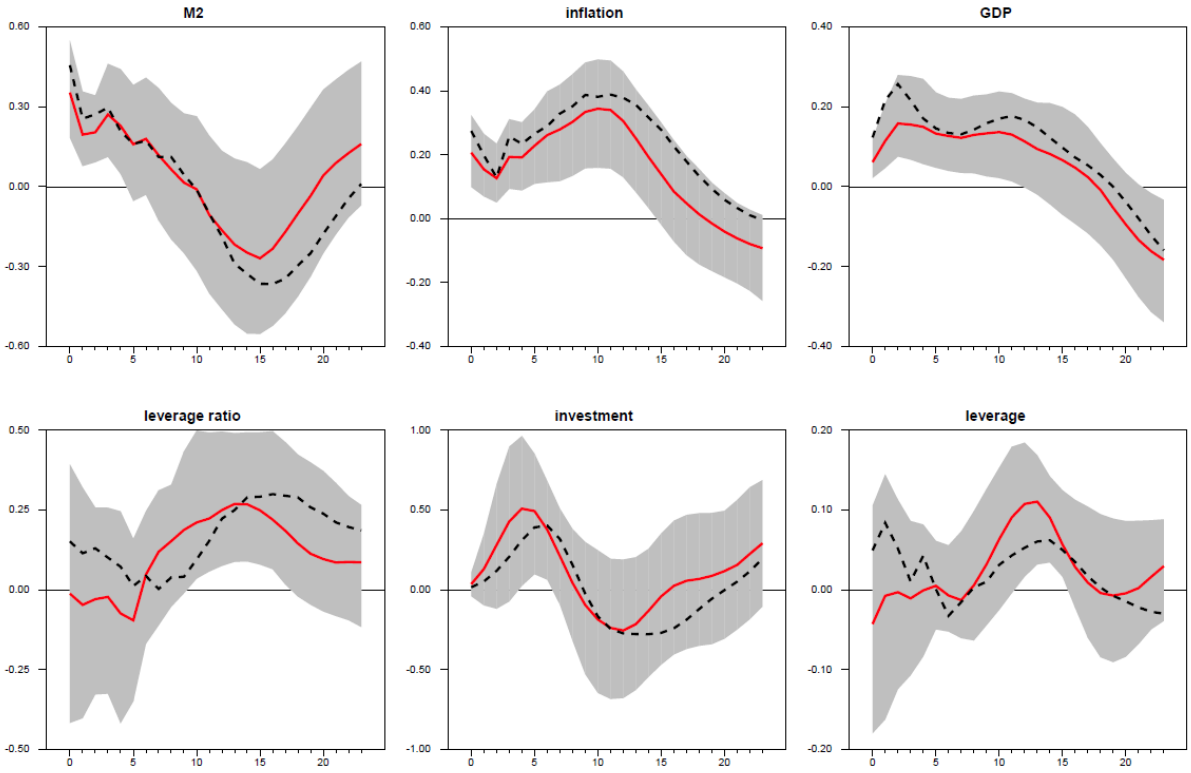
Notes: Leverage is defined as total liabilities relative to total assets. The data comes from the CEIC database.

Figure 2: Sector-specific macroeconomic time series



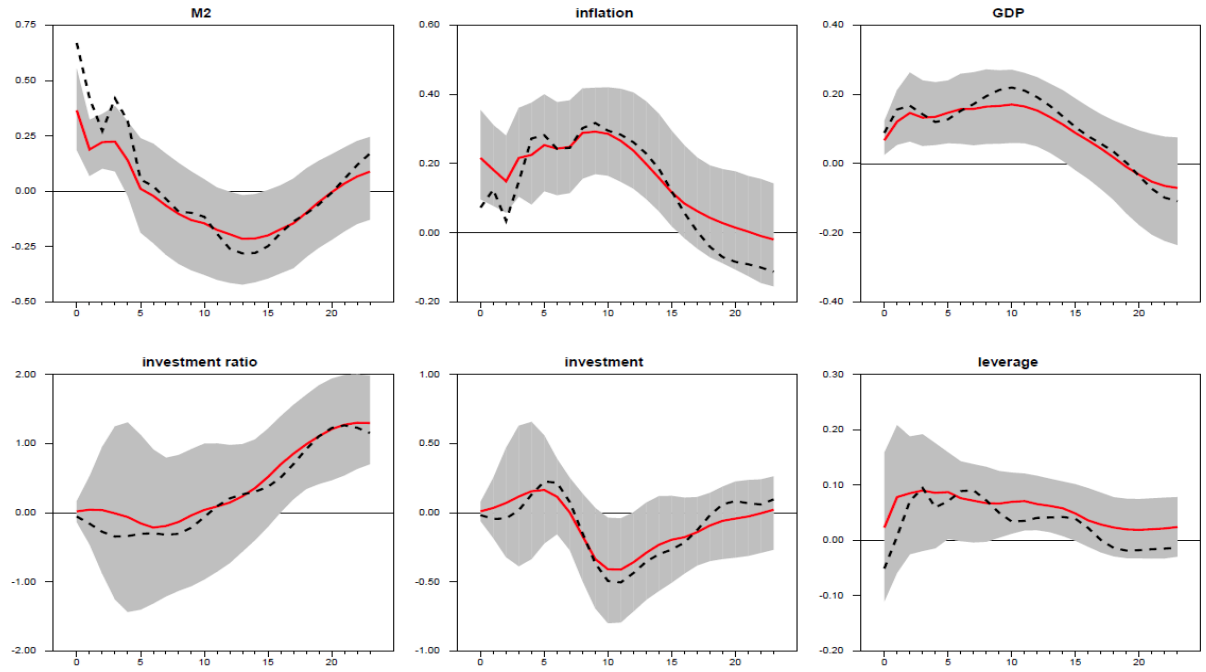
Notes: The data in (a) and (b) comes from the CEIC database. The data in (c) is interpolated from quarterly data and is taken from the Atlanta Fed Chinese time-series database.

Figure 3: Impulse responses for model with relative leverage growth



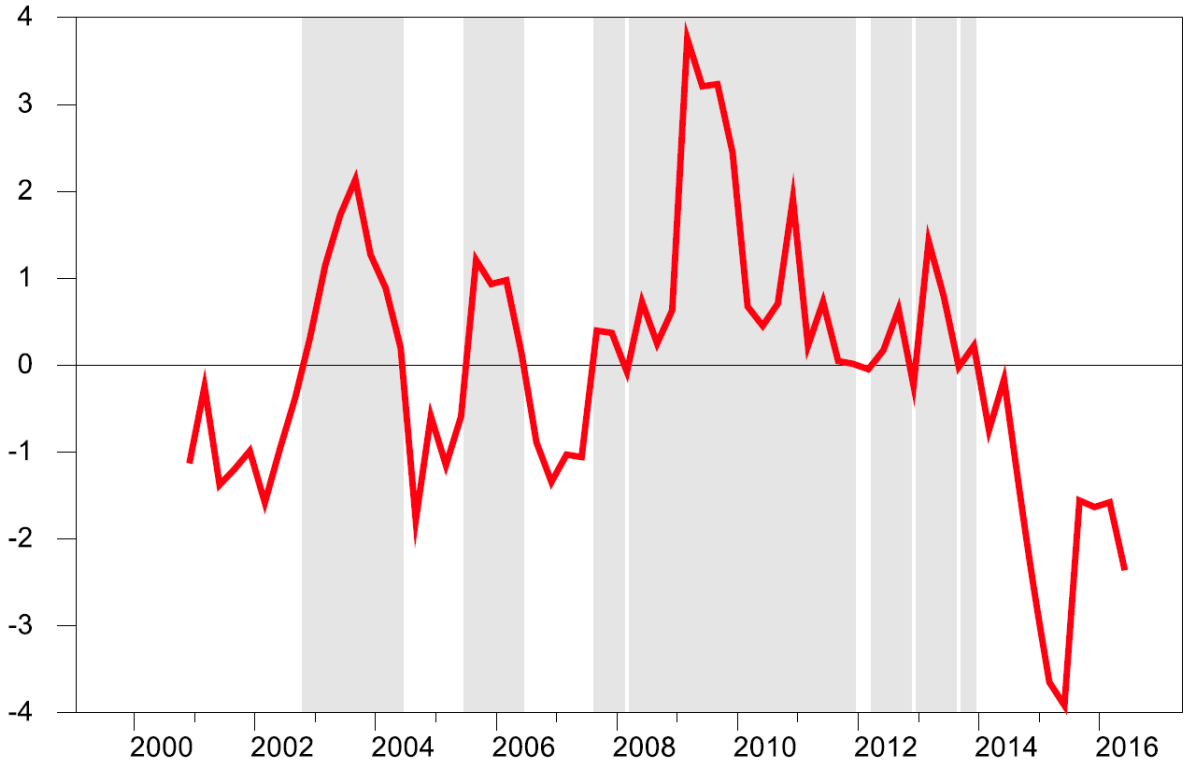
Notes: The red (solid) line is the mean response. The black (dotted) line is the Fry-Pagan mean target response. Error bands are shown in grey.

Figure 4: Impulse responses for model with relative investment growth



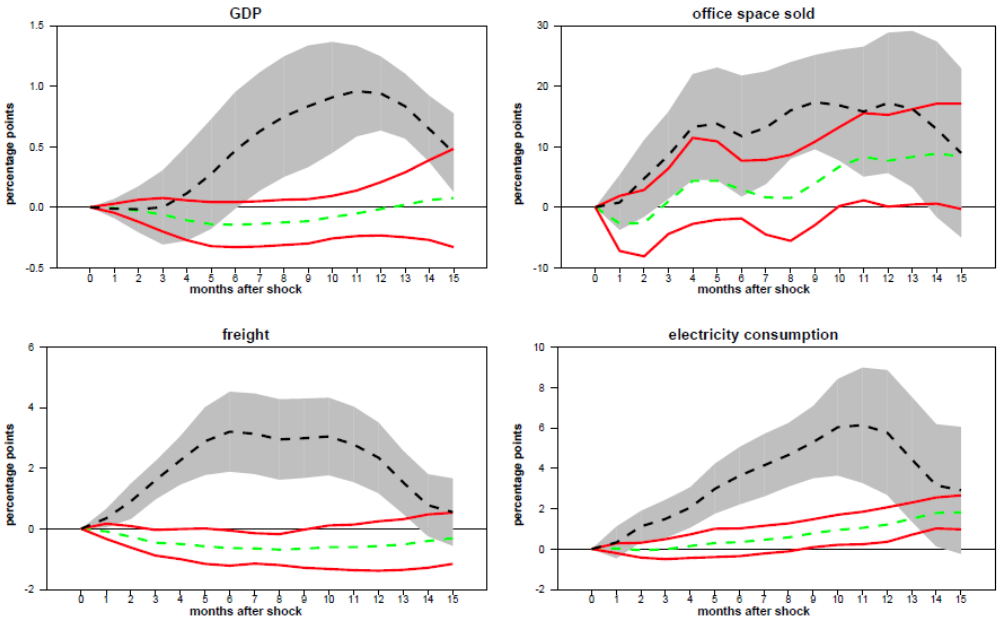
Notes: The red (solid) line is the mean response. The black (dotted) line is the Fry-Pagan mean target response. Error bands are shown in grey.

Figure 5: Shock series used in local projections



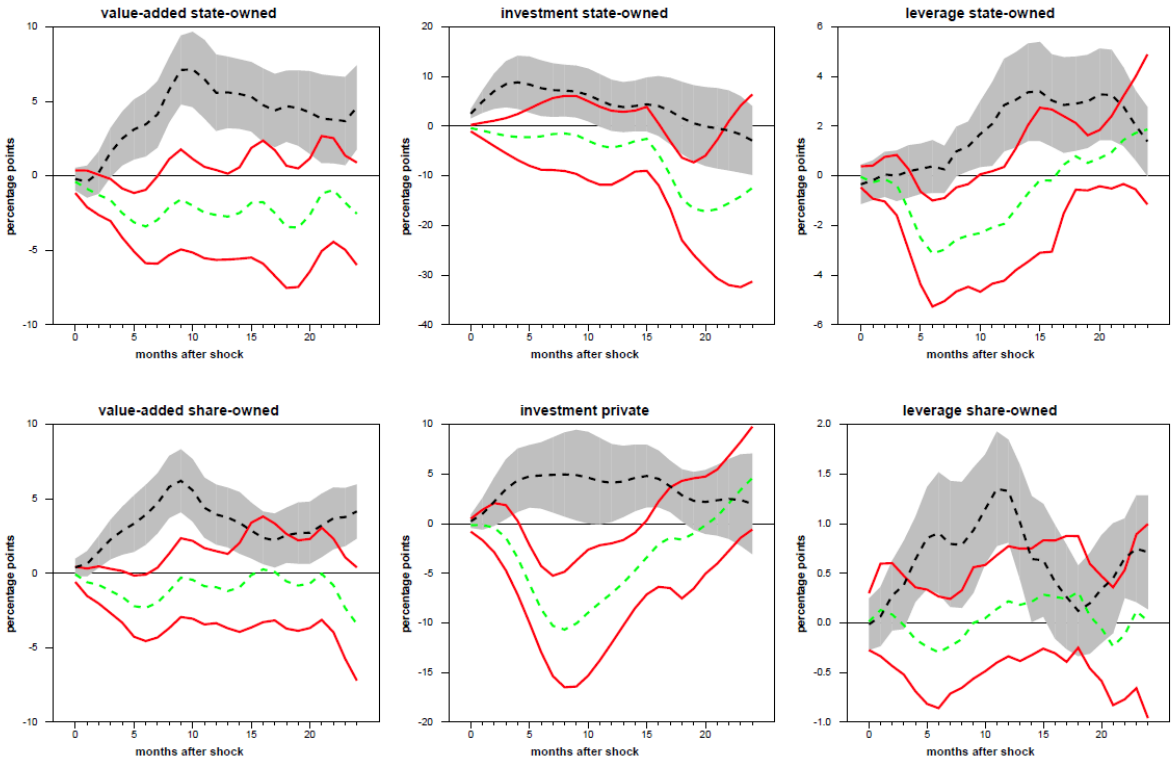
Notes: The exogenous M2 growth is the interpolated series derived by Chen, Higgins, Waggoner and Zha (2016) and Chen, Ren and Zha (2017). This series has been flipped, such an increase in all three series corresponds to a tightening step. The shaded areas indicate periods of policy easing.

Figure 6: Response of aggregate economic activity to exogenous M2 growth



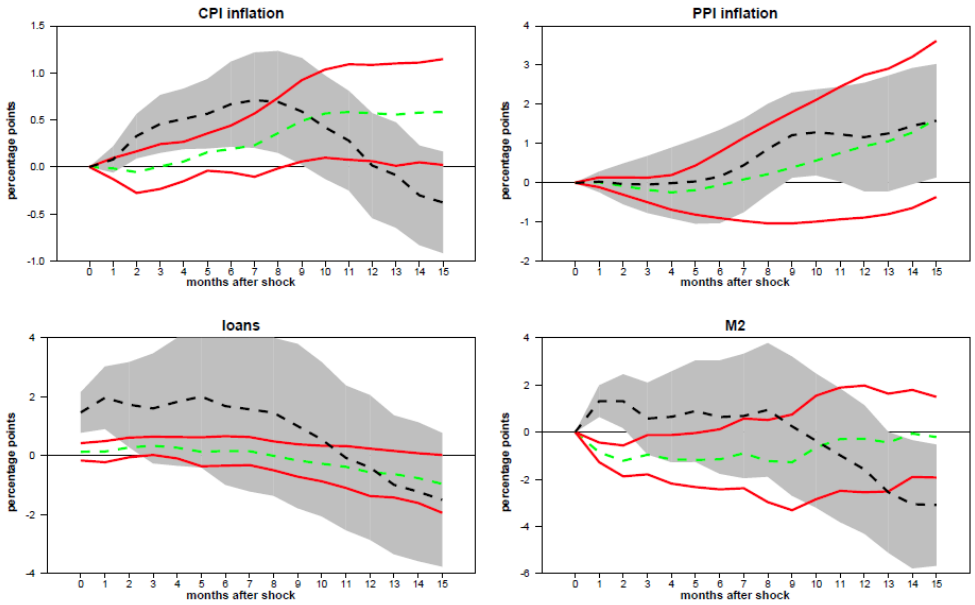
Notes: The black line is the response to a policy easing, while the green line is the response to a policy tightening. The grey and red bands, respectively, give error bands of 1.65 standard deviations.

Figure 7: Response of sectoral activity to exogenous M2 growth



Notes: The black line is the response to a policy easing, while the green line is the response to a policy tightening. The grey and red bands, respectively, give error bands of 1.65 standard deviations.

Figure 8: Response of inflation and credit to exogenous M2 growth



Notes: The black line is the response to a policy easing, while the green line is the response to a policy tightening. The grey and red bands, respectively, give error bands of 1.65 standard deviations.