



CFDS Discussion Paper Series

Regional Effects of Monetary Policy in China

Makram El-Shagi, Kiril Tochkov

Discussion Paper 2024/1

AUTHORS

Makram El-Shagi

HenU Center for Financial Development and Stability
Henan University
E-mail: makram.el-shagi@cfds.henucon.education

Kiril Tochkov

Texas Christian University
Fort Worth, TX, US
Email: k.tochkov@tcu.edu

The responsibility for discussion papers lies solely with the individual authors. The views expressed herein do not necessarily represent those of the CFDS. The papers represent preliminary work and are circulated to encourage discussion with the authors. Citation of the discussion papers should account for their provisional character; a revised version may be available directly from the authors. Comments and suggestions on the methods and results presented are welcome.

IMPRESSUM

© CFDS, 2024

HenU Center for Financial Development and Stability
Dongliuzhai Building, 85 Minglun Street
Henan University, Minglun Campus
Shunhe, Kaifeng, Henan, China
Tel. +86 (30) 897 89-0
<http://cfds.henucon.education>

Papers can be downloaded free of charge from the CFDS website:
<http://cfds.henucon.education/index.php/research>

Regional Effects of Monetary Policy in China

Makram El-Shagi¹ and Kiril Tochkov²

¹Center for Financial Development and Stability, School of
Economics, Henan University

²Department of Economics, Texas Christian University

March 20, 2024

Abstract

Unitary monetary policy in large emerging economies with substantial regional disparities is likely to have heterogeneous effects with unintended consequences. This paper explores the regional effects of monetary policy in China by estimating the response of a series of provincial variables to a national monetary policy shock using quarterly data over the period 1999-2022. Regional heterogeneity is assessed by comparing the results from a fixed-effects and a mean-group estimator. The response of consumer prices and loans is found to be homogeneous across provinces, while that of output and property prices exhibits significant regional variation. Further analysis of the differential response for two provincial clusters indicates that output in Western China experiences faster drops after a contractionary monetary policy shock and takes longer to recover than in Eastern and Central China. In the same context, property prices react with a delay and endure a more gradual recovery after the shock. The advancement of market institutions, the share of state-owned enterprises, and the size of the private sector are identified as potential determinants of the differential response across the two regional clusters.

Keywords: monetary policy, regional effects, China

JEL: E52; E58

1 Introduction

Monetary authorities rely on data aggregated at the national level to formulate their policy targets in response to aggregate shocks. However, regional and local economies deviate in various aspects and to a differing degree from the national average, which increases their vulnerability to asymmetric shocks. The larger the extent of the heterogeneity, the more diverse the regional impact of a national monetary policy shock is likely to be, making it harder for monetary authorities to achieve their objectives. Large developing and emerging economies are particularly susceptible to this issue because they generally exhibit greater structural differences across regions due to uneven developmental strategies, industrial policies, or international trade linkages, among others.

This paper explores the regional effects of monetary policy in China, where large regional disparities prevail and are well-documented in the literature. Wang et al. (2023) show that only a few provincial business cycles coincide with the national one, while most idiosyncratic contractions at the regional level differ in timing. Moreover, energy-related regions seem more likely to have independent business cycles. Gatfaoui and Girardin (2015) also report that only coastal provinces have synchronized their cycles with the national one. Searching for an explanation, Poncet and Barthélemy (2008) point out that differences in the industrial structure and international trade intensity of Chinese provinces reduce business cycle co-movements, while inter-provincial trade and national fiscal coordination promote business cycle synchronization.

In this study, the regional effects of monetary policy in China are investigated in an empirical framework that estimates the response of a series of provincial variables to monetary policy shocks using quarterly data over the period 1999-2022. First, we identify the monetary policy shocks as deviations from a monetary policy rule, which is estimated across several different specifications. Next, we test for regional heterogeneity in the provincial response to these shocks by comparing the impulse response function (IRF) of a given provincial variable across the fixed-effects (FE) and the mean-group (MG) estimators via a Hausman test. If the null hypothesis of regional homogeneity is rejected, indicating the superiority of the MG estimator, we split the provinces into two clusters based on the similarity of their response to the shock and explore the difference between their IRFs for each variable. Lastly, we employ a probit model to explore potential determinants of regional heterogeneity.

The literature on regional monetary policy has grown rapidly since the 1970s but it focuses almost exclusively on the developed economies in North America and Western Europe, especially in the context of the European Monetary Union (for a survey of the literature, see Rodriguez-Fuentes (2006) and Dominguez-Torres and Hierro (2019)). Recent studies on emerging economies, including Indonesia (Aginta and Someya, 2022), Mexico (Torres-Preciado, 2021), Pakistan (Faraz and Iftikhar, 2020), and Poland (Anagnostou and Gajewski, 2019), reveal a heterogeneous response of regional output, inflation, and unemployment to monetary policy shocks, pointing to industrial structure, firm size, and demography as potential sources of the cross-regional variation. Studies on China

report similar findings. Cortes and Kong (2007) show that the output of coastal provinces exhibits a stronger response to shocks than for inland provinces. Guo and Masron (2014, 2017) confirm the presence of regional heterogeneity in a structural VAR framework, indicating that spillover effects across provinces play an important role in the short run. Using city-level data, Yu and Huang (2016) suggest that M2 shocks have a greater impact on housing prices in Eastern China than in the central or western parts of the country.

The literature identifies bank lending as one of the leading channels of the asymmetric effect of monetary policy shocks across Chinese provinces. Cortes and Kong (2007) show that the share of loans to industrial enterprises magnifies the accumulated impulse response of provincial output, while Guo and Masron (2017) find that provinces with a large proportion of small enterprises and a small concentration of state-owned enterprises (SOEs) are more sensitive to monetary policy shocks, arguing that SOEs are less responsive because they face soft-budget constraints. Emphasizing the role of institutional factors, Liao and Wang (2021) promote the argument that inter-provincial competition and incentives for local cadres to stimulate growth are responsible for the heterogeneous response to monetary policy shocks. In particular, provincial governments facing fierce competition from neighboring regions are less concerned with national policy targets and seek to boost growth by relaxing budget constraints and extending credit to enterprises with the help of local banks, thereby weakening the effectiveness of national monetary policy.

Our study contributes to the literature and improves on existing research in several ways. Most of the earlier works use annual data, which severely restricts the time dimension of the sample, and the period under investigation often begins in the late 1970s, covering a time when standard monetary policy was still in its infancy during the transition to a market economy. Instead, we employ quarterly data over the last two decades, including also the pandemic period and its aftermath. During this time, monetary policy in China has become more effective as international standards were adopted and the targeting of monetary aggregates was gradually replaced with an interest-based policy framework (Kim and Chen, 2022). In terms of methodology, previous studies favor VAR models, which, while helpful in exploring spillover effects, have certain disadvantages, such as being data intensive. Structural VAR models impose restrictions, while in global VAR models cross-regional variation is determined by the weight matrix. By comparison, we take an agnostic approach that makes fewer assumptions about the response to a monetary shock, allowing the data to determine the effect. Furthermore, we examine the IRFs of output, consumer prices, loans, and property prices, whereas existing research typically focuses on a single variable. While loans are generally treated in the literature only as a transmission channel for asymmetric shocks, we explore loans as a variable responding to monetary policy shocks in its own right.

The rest of the paper is structured as follows. The next section presents the methodology, while Section 3 describes the data. Section 4 discusses the results, and Section 5 provides some conclusions.

2 Methodology

We begin with the identification of monetary policy shocks. In line with the seminal paper by Chen et al. (2018), among others, we interpret shocks as deviations from an estimated monetary policy rule. The corresponding empirical specification is given by:

$$mp_t = \beta_0 + \beta_1 mp_{t-1} + \beta_2 \pi_{t-1} + \beta_3 y_{t-1} + \varepsilon_t \quad (1)$$

where mp is a measure of monetary policy, π is the national inflation rate, and y is the growth rate of aggregate output. We opt for a backward-looking model due to the lack of quarterly forecasts over the entire sample period and employ OLS to estimate Eq.(1). While some papers use different methods, it has recently been shown by Carvalho et al. (2021) that (under relatively weak assumptions) even in the face of endogeneity, OLS is superior to IV for the estimation of monetary policy reaction functions. Our preferred specification uses the CHIBOR rate but we estimate policy rules for a range of different potential monetary policy measures, including the growth rate of monetary aggregates and other interest rates.

In the next step, we test for heterogeneity in the provincial response of various macroeconomic variables to the national monetary policy shocks, $\hat{\varepsilon}_t$, obtained from Eq.(1). This is accomplished by first estimating impulse response functions (IRFs) through local projections in the spirit of Jordà (2005) and then comparing these IRFs over eight quarters using an estimator that allows for regional heterogeneity to one that does not. The baseline estimator precluding regional heterogeneity is a simple fixed effects (FE) model that only allows the intercepts to differ across provinces but constrains the other coefficients to be the same. The second estimator that allows for heterogeneity is a mean group (MG) estimator, suggested by Pesaran and Smith (1995), that conducts the estimation for each province separately and reports the cross-provincial averages of coefficients. Accordingly, we compare:

$$x_{i,t+h} = \beta_1 x_{i,t-1} + \beta_2 \hat{\varepsilon}_{i,t} + \gamma_i + u_{i,t} \quad (2)$$

to

$$x_{i,t+h} = \beta_{1,i} x_{i,t-1} + \beta_{2,i} \hat{\varepsilon}_{i,t} + \gamma_i + u_{i,t}, \quad (3)$$

where x is a given provincial variable, h is the forecast horizon, and γ_i are province fixed effects. It is worth noting that neither model includes time fixed effects, which would be preferable to control for national effects. However, the time fixed effects have to be omitted to avoid perfect multicollinearity with the policy shock. This yields vastly underestimated standard errors. We, therefore, use this model exclusively to test for heterogeneity, i.e. we ask how much residuals are reduced by allowing for heterogeneity, but abstain from economic interpretation of the results.

To determine heterogeneity in the response of Chinese provinces to national monetary policy shocks, we compare the two aforementioned estimators via

a Hausman test. If the response is homogeneous, then both estimators are consistent but only the FE is efficient (null hypothesis). If provinces react differently, MG is consistent while FE is not (alternative hypothesis), since it imposes an inappropriate restriction. In other words, if the Hausman test fails to reject the null hypothesis, then the FE estimator is preferable to MG. If we reject the null hypothesis, then the MG estimator is superior to FE, which means that we need to explore regional heterogeneity in more detail.

The Hausman test is conducted separately for each provincial variable across each forecast horizon (one through eight quarters). We then employ Fisher's aggregation method to obtain the p-value for the Hausman test for each variable across all forecast horizons and ultimately across all variables.

Given that the null hypothesis is rejected, indicating the presence of regional differences, we divide provinces into groups with a similar response to national monetary policy shocks with the help of the k-means algorithm, which generates clusters by minimizing the within-cluster variance. To ensure that the subsequent clustering is not driven by a few periods with extreme results, we standardize the IRFs cross-sectionally by dividing through the cross-sectional standard deviation for every period.

Differences between the IRF of the various clusters are determined by estimating a FE model for each provincial variable given by:

$$x_{i,t+h} = \beta_1 x_{i,t-1} + \sum_{k=2}^K \beta_k \hat{\varepsilon}_t D_k + \gamma_i + \eta_t + u_{i,t} \quad (4)$$

where x is a given provincial variable, h is the forecast horizon, k is a given cluster with $k = 2, \dots, K$, $\hat{\varepsilon}_t$ is the national monetary policy shock in quarter t , and D_k is a dummy variable that takes the value of one, if the province is in cluster k . Besides the province fixed effects (γ_i), we also include time fixed effects (η_t), which control for any factors that are constant across Chinese provinces but vary across time. Accordingly, the national monetary policy shock is absorbed by the time fixed effects but we can still assess its impact by introducing a term into Eq.(4) that interacts the dummy variable for a given cluster with the monetary policy shock. The main coefficient of interest is β_k , which can be interpreted as the difference in the response of a given provincial variable to the national monetary policy shock between a given cluster k ($k = 2, \dots, K$) and the control group represented by cluster $k = 1$. To ensure a consistent interpretation, all clusterings are rearranged, assigning the cluster that includes Shanghai the role of a benchmark. In other words, we effectively assess whether IRFs of a certain provincial cluster deviate from the control group containing China's main economic and financial center.

To have a reference point, we estimate the model:

$$\bar{x}_{t+h} = \beta_0 + \beta_1 \bar{x}_{t-1} + \beta_2 \hat{\varepsilon}_t + u_t. \quad (5)$$

where \bar{x} is the mean of the given provincial variable. We prefer the provincial average specification in Eq.(5) to estimating the aggregate response with Chi-

nese national data, because it provides a more natural comparison to provincial impulse responses, whereas national data is dominated by few large provinces.

The last part of the analysis is aimed at explaining the association of provinces with a particular cluster, which ultimately helps us determine the factors that contribute to the regional heterogeneity in the provincial response to monetary policy shocks. For this purpose, we estimate a probit model that explains whether a province belongs to the Shanghai cluster or not for a two-group clustering. Depending on the provincial variable in question, the model includes potentially relevant variables, such as trade openness, financial deepening, state ownership of industrial enterprises, the extent of marketization, and the development of factor and product markets.

3 Data

We employ quarterly data for 30 (out of a total of 31) Chinese provinces over the period 1999q4-2022q4, excluding Tibet due to the lack of data. For the estimation of the monetary shock, we obtain national statistics on the monetary aggregate M2, three short-run (3-month) interest rates (China Interbank Offered Rate (CHIBOR), Shanghai Interbank Offered Rate (SHIBOR), and China Interbank Bond Collateral Repo Rate), CPI, and real GDP. We estimate the impulse response functions of four provincial variables, expressed as quarter-over-quarter growth rates. Monthly CPI and property prices (average square-meter price of residential real estate) cover the entire sample period, while quarterly real GDP is available from 2000q2 onwards and monthly loans (total social financing) from 2004q2 onwards. All variables are collected from the CEIC database and seasonally adjusted using the X-13 ARIMA procedure. Monthly data are transformed into quarterly by taking the corresponding three-month average.

4 Results

4.1 Monetary policy reaction function

The estimation of the monetary policy reaction function in Eq. (1) requires us to specify the monetary policy instrument, which is not a straightforward task because the People’s Bank of China (PBC) uses multiple tools, ranging from open market operations and required reserves to central bank lending and administrative measures. Existing research addresses this issue in various ways. Some studies estimate a standard Taylor rule, focusing on short-run interest rates like CHIBOR (Xie and Luo, 2002; Zheng et al., 2012). A second group opts for M2 growth as the response variable, arguing that, especially in earlier periods, interest rates did not play an important role due to the underdeveloped financial markets (Chen et al., 2018).

A third group adopts a hybrid approach, pointing out that neither the Taylor rule nor the McCallum rule provide an accurate description of Chinese monetary policy because until recently there was no short-term interest rate to anchor

Table 1: Monetary policy reaction functions

	M2 growth	Shibor	Chibor	Repo
Constant	1.575*** (0.342)	0.090 (0.199)	0.571** (0.242)	0.155 (0.181)
mpi_{t-1}	0.572*** (0.088)	0.850*** (0.053)	0.749*** (0.055)	0.845*** (0.049)
y_{t-1}	-0.030 (0.052)	0.090*** (0.024)	0.057** (0.029)	0.072*** (0.025)
π_{t-1}	-0.122 (0.171)	0.372*** (0.098)	0.373*** (0.095)	0.336*** (0.084)
Obs.	94	64	94	94
R^2	0.327	0.842	0.690	0.807
$adjR^2$	0.304	0.834	0.680	0.800
AIC	279.32	92.28	169.31	140.25

Note: Reported coefficients are estimates from the model in Eq.(1). Standard deviation in parenthesis. *** $p < .01$; ** $p < .05$; * $p < .10$.

price expectations and M2 growth is an intermediate policy target rather than an instrument under the control of the PBC. Accordingly, Girardin et al. (2017) devise for their empirical model a composite index that combines price-based, quantity-based, and administrative tools of monetary policy in China, while Mehrotra and Sanchez-Fung (2010) and Nuutilainen (2015) estimate McCallum-Taylor hybrid models following Hall and Mankiw (1994). Kamber and Mohanty (2018) and Das and Song (2022) abandon the reaction function framework altogether and obtain monetary policy shocks for China directly from the daily movements of the 7-day repo rate around policy announcements.

Given the diversity of monetary policy instruments and intermediate targets in China, we estimate four different specifications of Eq.(1) that involve quantity-based (M2 growth) and price-based (interest rates) measures. The results in Table 1 suggest that over the sample period the growth of broad money does not respond significantly to lagged changes in output and inflation, dismissing this model as an appropriate way for identifying monetary policy shocks in China. By contrast, all three specifications involving interest rates exhibit positive and significant coefficients for the lagged output growth and inflation and the magnitudes are relatively similar, especially for inflation. These findings are broadly in line with recent changes in China’s monetary policy framework that de-emphasize M2 growth as an intermediary target and increasingly promote interest rates as instruments and targets of monetary policy (Harjes, 2017; People’s Bank of China, 2020).

Our preferred specification in Table 1 uses CHIBOR as response variable, mainly because as the first market-based interest rate indicator in China it has data availability over the entire sample period and has been employed as a proxy for monetary policy in the literature (Ren et al., 2020; Xie and Luo, 2002; Zheng

Table 2: Correlations between monetary policy shocks across specifications

	M2 growth	SHIBOR	CHIBOR	Repo	Chen et al. (2018)
M2 growth	1.00				
SHIBOR	-0.30	1.00			
CHIBOR	-0.28	0.83	1.00		
Repo	-0.33	0.82	0.55	1.00	
Chen et al. (2018)	0.74	-0.35	-0.24	-0.38	1.00

Note: Correlation coefficients between monetary policy shocks obtained from the estimation of Eq.(1) with different monetary policy instruments.

et al., 2012). Moreover, the long-term coefficient for inflation in the CHIBOR specification is 1.49, which satisfies the Taylor principle. SHIBOR is more in line with modern standards as it is based on a quote mechanism but it is reported only since 2007.

We further justify our choice of CHIBOR by examining the correlation between monetary policy shocks obtained from the different models. The matrix in Table 2 indicates that the CHIBOR shocks are highly correlated with SHIBOR (0.82) and repo (0.55) shocks. In addition, we compare our shocks across all models with those from the seminal study by Chen et al. (2018) who use the growth of broad money as their monetary policy instrument. The strong correlation (0.74) regarding M2 growth and the moderate negative correlations between M2 growth and interest rate shocks lend further support to the validity of our empirical specifications.

4.2 Regional IRFs

Our next objective is to check for potential heterogeneity in the provincial response to the monetary policy shocks identified in the previous section. For this purpose, the IRFs for provincial output, consumer prices, loans, and property prices are compared across the FE and MG estimators with the help of a Hausman test. The corresponding p-values of the test statistic for each forecast horizon are aggregated using Fisher’s method and presented in Table 3.

Table 3: Results of the Hausman test comparing FE and MG estimator

Variable	p-value	Variable	p-value
Output	0.000***	Loans	0.999
CPI	0.999	Property prices	0.000***

Note: The p-values of the Hausman test statistic are aggregated with the Fisher’s method across the eight forecast horizons. *** $p < .01$; ** $p < .05$; * $p < .10$.

It is evident that for output and property prices the null hypothesis of re-

gional homogeneity is rejected, indicating the superiority of the MG estimator. For consumer prices and loans, the FE estimator is the preferred choice, meaning that the coefficient measuring the effect of the monetary policy shock is identical across provinces (see Eq.(2)). These results concur with the findings of previous studies revealing a differential response of provincial output to monetary policy shocks (Cortes and Kong, 2007; Guo and Masron, 2017). Moreover, Yu and Huang (2016) also detect regional heterogeneity in the reaction of property prices across Chinese cities. The lack of regional variation in loan growth points to a relatively integrated financial market in China. The four largest commercial banks in China are state-owned and their presence across provinces reduces differences in the response of provincial variables because their actions are likely to be consistent with the national monetary policy (Guo and Masron, 2017).

We proceed with the investigation of regional heterogeneity by dividing provinces into clusters using the k-means algorithm and then comparing the IRFs across clusters for each of the four variables. After experimenting with various numbers of clusters, we determine that creating more than two clusters does not bring additional benefits as IRFs are very similar.¹ On the map of China in Figure 1, the benchmark group identified by a lighter (blue) color includes mostly provinces in Eastern and Central China. The darker (black) color is reserved for the second provincial cluster, which consists predominantly of provinces in the southwest, northwest, and northeast of the country. Although the second cluster generally exhibits lower levels of per-capita income, there are exceptions, such as the coastal provinces of Liaoning, Tianjin, Fujian, and Hainan, which seem to be more similar to the poorer landlocked regions in terms of their response to a monetary shock.²

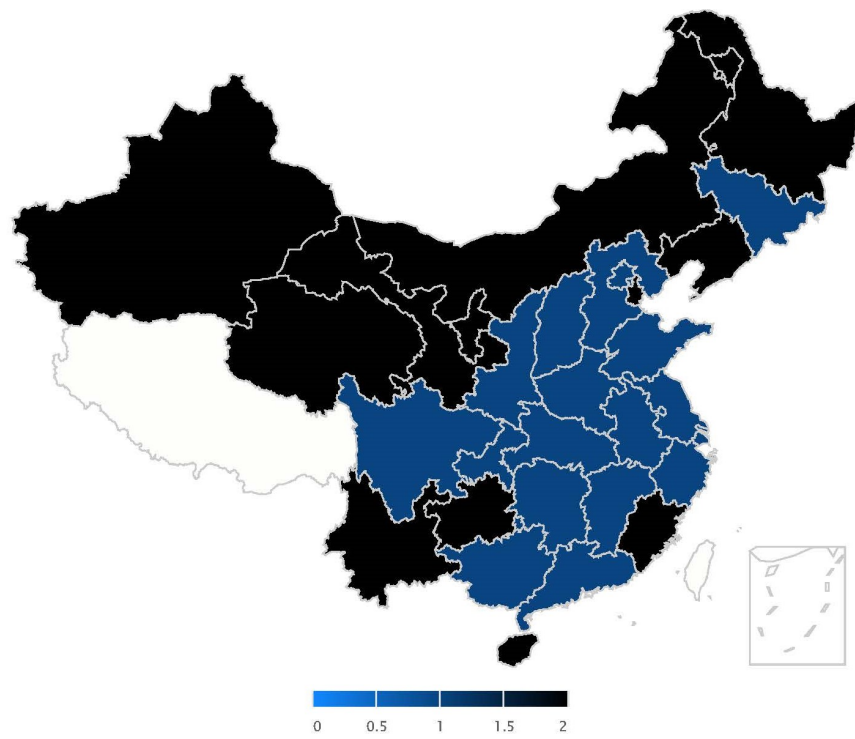
Figure 2 shows the impulse response of the provincial mean of the four variables to a one percentage point increase in CHIBOR. Our purpose is to ensure first that the variables respond in an economically plausible way. The contractionary monetary shock leads to a drop in all four variables as expected. Output declines for three consecutive quarters following the shock and experiences another drop in the 6th quarter before recovering. CPI records a sharp drop only in the 4th quarter, followed by a gradual recovery. By contrast, loans and property prices drop instantaneously and significantly, while the subsequent recovery is interrupted by another dip in the 7th quarter.

Our main results are presented in Figure 3. The IRFs of output and property prices (which were found to have a heterogeneous response across provinces in Table 3) are estimated from Eq.(4) and represent the response of the second cluster to a one percentage point increase in CHIBOR *relative* to the response of the benchmark group. Output drops instantaneously, suggesting that the second cluster experiences a more severe contractionary effect than the benchmark

¹The results for three and four clusters are available from the authors upon request.

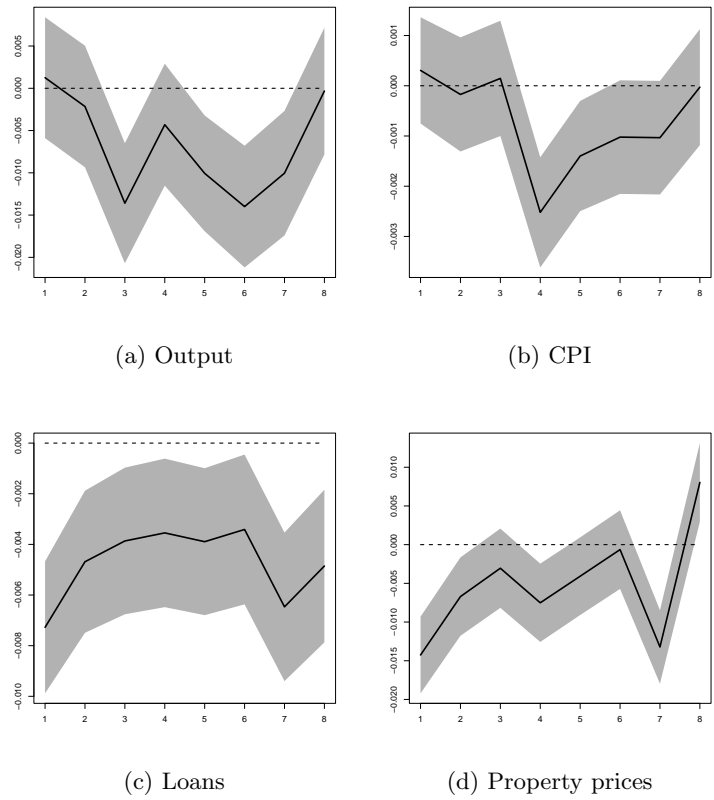
²One common feature of these provinces is that although relatively rich and developed, they are overshadowed by their wealthier and more economically dynamic neighbors. For instance, Fujian is located between the economic powerhouses of Guangdong and Zhejiang, while Tianjin is adjacent to the capital Beijing.

Figure 1: The two provincial clusters of China, 1999q4-2022q4



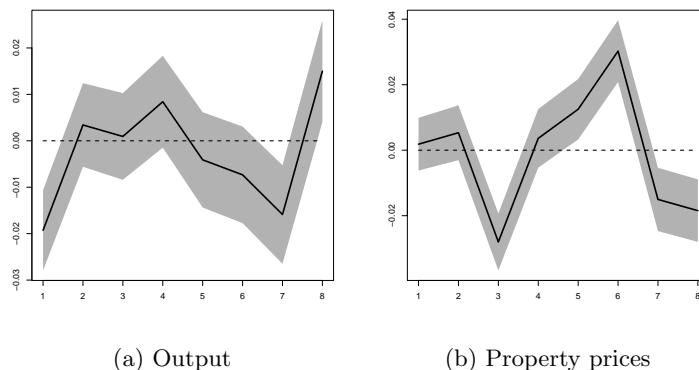
Note: The benchmark provincial cluster containing Shanghai is displayed in blue and the second cluster is in black. Tibet (in white) is excluded from the sample.

Figure 2: Impulse response functions of the provincial mean



Note: The IRFs (with 95% confidence bounds) represent the mean response across all provinces in the sample over a forecast horizon of 8 quarters.

Figure 3: Impulse response function differences between clusters



Note: The IRFs (with 95% confidence bounds) represent the response of the second cluster relative to the benchmark (Shanghai cluster) over a forecast horizon of 8 quarters.

immediately after the shock. But after a quick recovery the difference between the two clusters turns insignificant. In the 7th quarter, output declines again significantly relative to the benchmark before recovering in the 8th quarter.

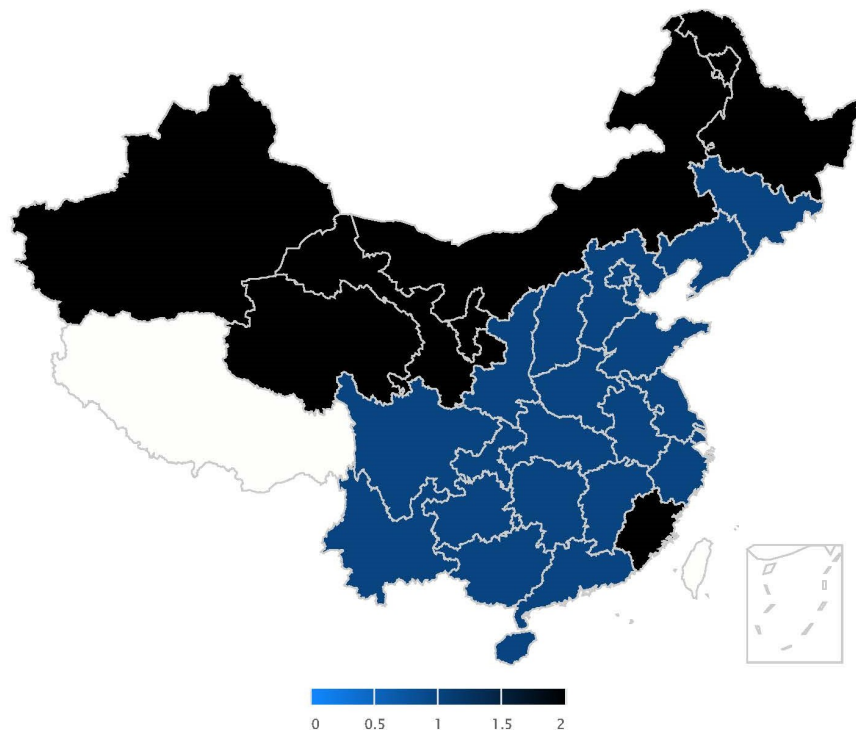
As we know from Figure 2, property prices decrease instantaneously but in Figure 3 the difference between the clusters is insignificant until the 3rd quarter when the second cluster records a deep drop relative to the benchmark. However, in subsequent quarters the difference reverses, turning positive and reaching a highpoint in the 6th quarter. This suggests that property prices in the second cluster initially recover at a significantly slower pace than the benchmark but then catch up with the Shanghai cluster and even overshoot.

4.3 Robustness

Our sample period includes the COVID-19 pandemic, which caused severe disruptions to the Chinese economy. We test the robustness of our results by excluding the pandemic years and limiting our sample period to 1999q4-2019q4. The map in Figure 4 suggests that the clustering has remain broadly the same. Tianjin, Liaoning, and Hainan shift to the benchmark group, while Fujian continues to be part of the second cluster. In other words, the differentiation between the coastal/central vs northwestern/northeastern provinces is more clear cut in the pre-pandemic period.

The IRFs of the four variables in Figure 5 are almost identical to the ones in Figure 2. More importantly, the IRF differences for output and property prices in Figure 6 are very similar to those in Figure 3, confirming the robustness of our findings. One detectable difference is that the output of the second cluster

Figure 4: The two provincial clusters in the pre-pandemic period, 1999q4-2019q4

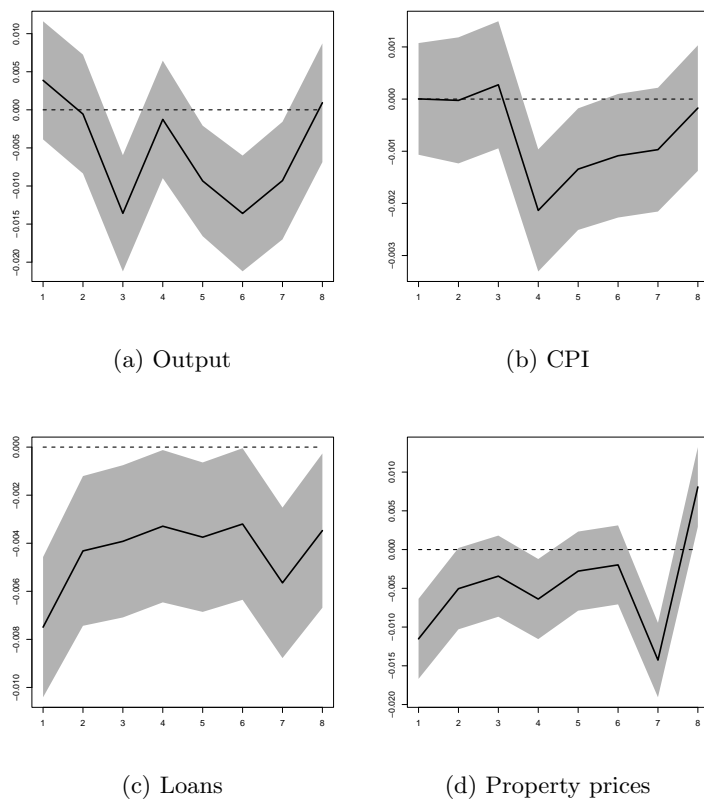


Note: The benchmark provincial cluster containing Shanghai is displayed in blue and the second cluster is in black. Tibet (in white) is excluded from the sample.

recovers somewhat faster relative to the benchmark in the pre-pandemic period than over the entire sample period.

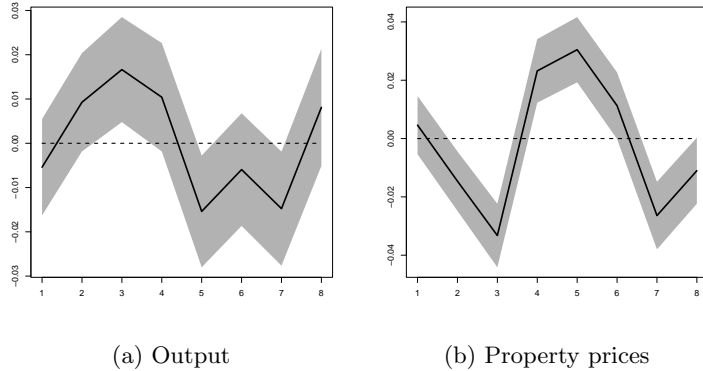
As described in the data section, our time series begin in different years for some of the variables. For instance, monthly statistics on loans by province are available only from 2004 onwards. As a second robustness test, we conduct the analysis over the period 2004q2-2022q4, making sure that all variables are observed over the same sample period. It is evident from the map in Figure 7 that cluster membership remains largely the same. Tianjin and Liaoning join the benchmark cluster, while Shanxi switches to the second cluster. The patterns of the IRFs for the provincial means in Figure 8 and the IRFs of the second cluster relative to the benchmark in Figure 9 remain consistent with our major findings.

Figure 5: Impulse response functions for all provinces, pre-pandemic period



Note: The IRFs (with 95% confidence bounds) represent the mean response across all provinces in the sample over a forecast horizon of 8 quarters.

Figure 6: Impulse response function differences between clusters, pre-pandemic period



Note: The IRFs (with 95% confidence bounds) represent the response of the second cluster relative to the benchmark (Shanghai cluster) over a forecast horizon of 8 quarters.

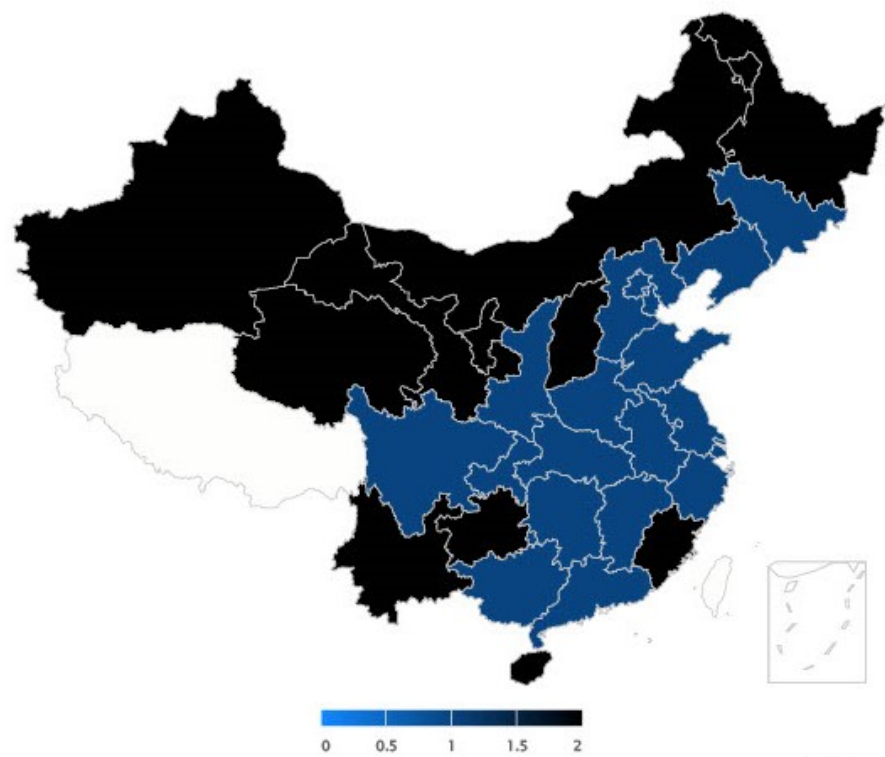
4.4 Determinants of regional clusters

Since we reveal regional heterogeneity in our results, we seek to identify the factors that determine the provincial composition of the two clusters, thereby explaining the variation in the regional response to monetary policy shocks. For this purpose, we employ a univariate probit regression where the dependent variable takes the value of one, if the province is part of the second cluster, and zero if it is in the benchmark cluster. The relevant statistics for the independent variables are collected from the CEIC database and the annual values for each province are averaged over the sample period.

Table 4 presents the results for various potential determinants. The coefficient for the share of SOEs in total enterprises is positive and significant, while the one for the share of foreign enterprises is negative but insignificant. Previous studies show that SOEs decrease the sensitivity of the provincial response to monetary policy shocks because these enterprises face a soft-budget constraint (Cortes and Kong, 2007; Guo and Masron, 2017). By contrast, foreign enterprises in general cannot rely on comparable financial support from the local governments in China. Our results indicate that the second cluster has more SOEs and fewer foreign enterprises than the benchmark, which is sensible given that foreign investment is concentrated in Eastern and Central China.

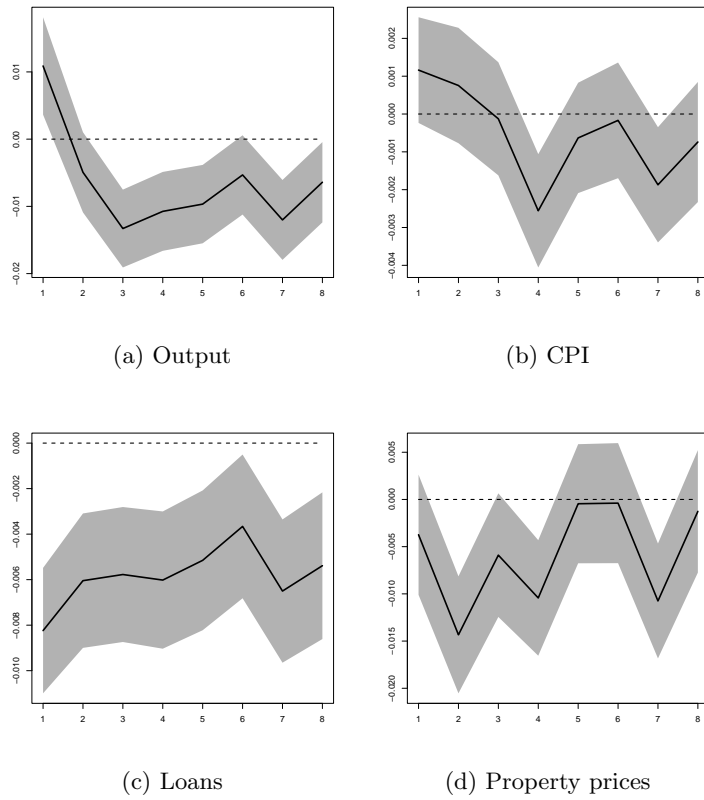
The GDP shares of industry and trade (exports plus imports) have a negative (albeit insignificant) impact on membership in the second cluster. The majority of provinces in that cluster are landlocked and remote, making it more difficult for them to benefit from international linkages. Regarding the importance of

Figure 7: The two provincial clusters in the pre-pandemic period, 2004q2-2022q4



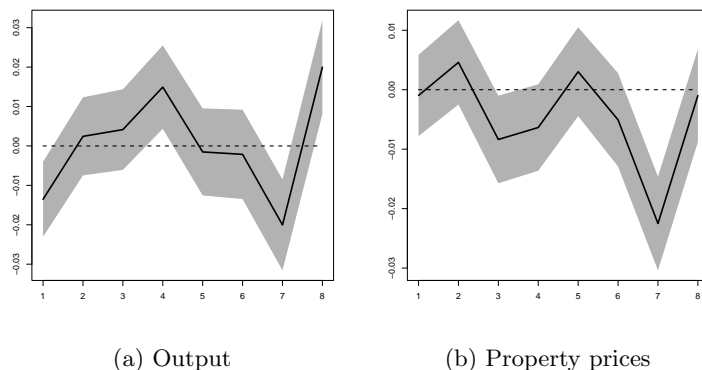
Note: The benchmark provincial cluster containing Shanghai is displayed in blue and the second cluster is in black. Tibet (in white) is excluded from the sample.

Figure 8: Impulse response functions for all provinces, 2004-2022



Note: The IRFs (with 95% confidence bounds) represent the mean response across all provinces in the sample over a forecast horizon of 8 quarters.

Figure 9: Impulse response function differences between clusters, 2004-2022



Note: The IRFs (with 95% confidence bounds) represent the response of the second cluster relative to the benchmark (Shanghai cluster) over a forecast horizon of 8 quarters.

industry, the second cluster is rather diverse, which might be causing the lack of statistical significance. Provinces like Heilongjiang have a large secondary sector, while others like Qinghai have one of the smallest in China.

Financial deepening defined as the share of total loans in GDP has a positive and significant impact, indicating that provinces in the second cluster benefit from larger amounts of credit. This effect seems to be driven by poor Western provinces, like Gansu, Ningxia, and Qinghai, which can probably be explained by the Great Western Development Program launched by the Chinese government in 2000 and the focus on poverty alleviation and the development of the hinterlands since 2013. These government programs have provided generous funding and have made it easier to obtain loans in less developed regions concentrated mostly in Western China (El-Shagi and Jiang, 2020).

We also explore the role of institutional factors proxied by the NERI (National Economic Research Institute) Marketization Index, which measures the advancement of the market economy in each province (Fan and Wang, 2001; Wang et al., 2021). The overall marketization index as well as its four sub-indices exhibit significantly negative coefficients, decreasing the probability of membership in the second cluster. Market expansion focuses on lowering the tax burden on enterprises, reducing bureaucratic procedures and red tape, and scaling down the government apparatus. The advancement of the factor markets looks at the mobility of labor, access to foreign capital, and competitiveness in the banking sector. The development of product markets explores the extent to which prices are set by the market and the magnitude of regional trade barriers. The development of the private sector is assessed via the share of privately-owned industrial enterprises, and non-government fixed investment

Table 4: Results of the univariate probit regression

<i>SOE share</i>	8.744*** (3.248)
<i>Foreign firms</i>	-1.825 (3.911)
<i>Industry share</i>	-4.192 (3.428)
<i>Fin. deepening</i>	0.013* (0.008)
<i>Trade</i>	-0.007 (0.008)
<i>Marketization</i>	-0.437** (0.176)
<i>Market expansion</i>	-0.564*** (0.220)
<i>Factor markets</i>	-0.229* (0.122)
<i>Private sector</i>	-0.318** (0.134)
<i>Product markets</i>	-0.428** (0.211)
<i>Obs.</i>	29

Note: Reported coefficients from univariate probit regression with dependent variable taking the value of 1 if a province is in the second cluster. Standard errors in parentheses. Chongqing is excluded from the sample due to missing data. *** $p < .01$; ** $p < .05$; * $p < .10$.

and employment. The negative effect for the private sector is consistent with the positive effect for the share of SOEs.

In summary, the provinces in the second cluster are marked by a less developed market economy with a large state sector and a small private sector. Bureaucratic procedures and a heavy tax burden on enterprises, less access to foreign capital and higher trade barriers further characterize these provinces. A larger share of loans in GDP is more likely to be an indicator of beneficial poverty alleviation policies by the central government than a sign of a vibrant and competitive financial sector in the region.

5 Conclusion

Monetary policy in large emerging economies with substantial regional disparities is likely to have heterogeneous effects with unintended consequences. We examine this issue in China, contributing to the existing literature by using quarterly data over the period 1999-2022, evaluating the response of a larger

number of macroeconomic variables, and adopting a more flexible estimation approach that imposes less restrictions, allowing the data to determine the effect.

Our results indicate that interest rates are the more appropriate monetary policy instrument for the estimation of the monetary policy reaction function in China than broad money. Comparing the results of the fixed effects and mean group estimator, we determine that the response of consumer prices and loans to a monetary policy shock is homogeneous across provinces, while output and property prices exhibit significant regional heterogeneity. Accordingly, we split the provincial sample into two clusters based on the similarity of their responses to a monetary policy shock. The benchmark cluster contains mostly provinces from Eastern and Central China, while the second cluster concentrates on the western, northwestern, and northeastern parts of the country.

After ensuring that all four variables behave in an economically plausible manner, we proceed to explore the differential response for the variables with regional heterogeneity. Our findings suggest that the output for the second cluster experiences faster drops in response to contractionary monetary policy and takes longer to recover than the benchmark. Property prices in the second cluster exhibit more volatility and recover slower after the shock than the benchmark. These results remain largely robust when we exclude the COVID-19 pandemic period and when we observe all variables across the same time range.

Lastly, we seek to explain the regional heterogeneity with the help of a probit model. Provinces in the second cluster are found to have a less advanced market economy with a larger share of SOEs and a smaller private sector. Market institutions are significantly less developed, allowing state intervention and red tape to prevail. Although our results show a more prominent role of credit in the second cluster, this is probably due to national poverty alleviation policies that have targeted poor regions in Western China rather than an indication of financial development.

Regional heterogeneity in the response of output and property prices to monetary policy in China sheds light on a major issue in large emerging economies. In the pursuit of smoothing the national business cycle, monetary policy can have differential effects across regional economies, magnifying disparities and hindering the synchronization of local business cycles. In addition, the property market has become a major engine of growth in China and we show that it is subject to asymmetric effects from a monetary policy shock. Accordingly, the policy recommendation is for the PBC to consider incorporating regional economic conditions (output and property prices in particular) in its monetary policy framework. There is some evidence that the PBC has already successfully implemented a regionally diversified policy that targeted specific counties in the context of poverty alleviation (El-Shagi and Jiang, 2020). This valuable experience can be useful in expanding the role of regional factors in monetary decision making in China.

References

- Aginta, H. and Someya, M. (2022). Regional economic structure and heterogeneous effects of monetary policy: Evidence from Indonesian provinces, *Journal of Economic Structures* **11**: 1.
- Anagnostou, A. and Gajewski, P. (2019). Heterogeneous impact of monetary policy on regional economic activity: Empirical evidence for Poland, *Emerging Markets Finance and Trade* **55**(8): 1893–1906.
- Carvalho, C., Nechio, F. and Tristão, T. (2021). Taylor rule estimation by ols, *Journal of Monetary Economics* **124**: 140–154.
- Chen, K., Ren, J. and Zha, T. (2018). The nexus of monetary policy and shadow banking in China, *American Economic Review* **108**(12): 3891–3936.
- Cortes, B. and Kong, D. (2007). Regional effects of Chinese monetary policy, *International Journal of Economic Policy Studies* **2**: 15–18.
- Das, S. and Song, W. (2022). Monetary policy transmission and policy coordination in China, *Working Paper 74*, IMF.
- Dominguez-Torres, H. and Hierro, L. (2019). The regional effects of monetary policy: A survey of the empirical literature, *Journal of Economic Surveys* **33**(2): 604–638.
- El-Shagi, M. and Jiang, L. (2020). One Country - Two Monetary Policies: Evidence from a new indicator of the PBoC’s monetary policy support for poor regions, *CFDS Discussion Paper Series 2020/5*, Center for Financial Development and Stability at Henan University, Kaifeng, Henan, China.
- Fan, G. and Wang, X. (2001). *NERI index of marketization for China’s provinces*, Economic Science Press, Beijing.
- Faraz, N. and Iftikhar, Z. (2020). The regional asymmetric responses to central bank’s monetary policy in Pakistan, *The Singapore Economic Review* **65**(2): 351–364.
- Gatfaoui, J. and Girardin, E. (2015). Comovement of Chinese provincial business cycles, *Economic Modelling* **44**: 294–306.
- Girardin, E., Lunven, S. and Ma, G. (2017). China’s evolving monetary policy rule: From inflation-accommodating to anti-inflation policy, *BIS Working Paper 641*, Bank for International Settlements.
- Guo, X. and Masron, T. (2014). Regional effects of monetary policy in China: The role of spillover effects, *Asian Academy of Management Journal* **19**(1): 113–146.

- Guo, X. and Masron, T. (2017). Regional effects of monetary policy in china: Evidence from china's provinces, *Bulletin of Economic Research* **69**(2): 178–208.
- Hall, R. and Mankiw, G. (1994). Nominal income targeting, in G. Mankiw (ed.), *Monetary Policy*, University of Chicago Press, Chicago, pp. 71–94.
- Harjes, T. (2017). A market-based monetary policy approach for China, *China: Selected issues paper*, Vol. 248 of *IMF Country Report*, International Monetary Fund, Washington, DC, pp. 34–40.
- Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections, *American economic review* **95**(1): 161–182.
- Kamber, G. and Mohanty, M. (2018). Do interest rates play a major role in monetary policy transmission in China?, *BIS Working Paper 714*, Bank for International Settlements.
- Kim, S. and Chen, H. (2022). From a quantity to an interest rate-based framework: Multiple monetary policy instruments and their effects in China, *Journal of Money, Credit and Banking* **54**(7): 2103–2123.
- Liao, C. and Wang, S. (2021). The political economy of the differential regional effects of monetary policy: Evidence from China, *The Developing Economies* **59**(4): 351–370.
- Mehrotra, A. and Sanchez-Fung, J. (2010). China's monetary policy and the exchange rate, *Comparative Economic Studies* **52**(4): 497–514.
- Nuutilainen, R. (2015). Contemporary monetary policy in China: An empirical assessment, *Pacific Economic Review* **20**(3): 461–486.
- People's Bank of China (2020). Participating in international benchmark interest rate reform and improving China's benchmark interest rate system, *White paper*, People's Bank of China.
- Pesaran, M. and Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels, *Journal of Econometrics* **68**(1): 79–113.
- Poncet, S. and Barthélemy, J. (2008). China as an integrated area?, *Journal of Economic Integration* **23**(4): 896–926.
- Ren, Y., Guo, Q., Zhu, H. and Ying, W. (2020). The effects of economic policy uncertainty on China's economy: evidence from time-varying parameter FAVAR, *Applied Economics* **52**(29): 3167–3185.
- Rodriguez-Fuentes, C. (2006). *Regional Monetary Policy*, Routledge, London.
- Torres-Preciado, V. (2021). Monetary policy and regional economic performance in Mexico: A structural panel VAR approach, *Growth and Change* **52**(1): 195–223.

- Wang, X., Hu, L. and Fan, G. (2021). *Marketization index of China's provinces: NERI report 2021*, Social Sciences Academic Press, Beijing.
- Wang, X., Sun, Y. and Peng, B. (2023). Industrial linkage and clustered regional business cycles in China, *International Review of Economics & Finance* **85**: 59–72.
- Xie, P. and Luo, X. (2002). Taylor rule and its empirical test for China's monetary policy, *Economic Research Journal* **3**: 3–12.
- Yu, H. and Huang, Y. (2016). Regional heterogeneity and the trans-regional interaction of housing prices and inflation: Evidence from China's 35 major cities, *Urban Studies* **53**(16): 3472–3492.
- Zheng, T., Wang, X. and Guo, H. (2012). Estimating forward-looking rules for China's Monetary Policy: A regime-switching perspective, *China Economic Review* **23**(1): 47–59.