Inter-regional risk sharing and the effectiveness of monetary policy in China

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Abstract

Risk sharing and monetary policy play a key role in dealing with different types of shocks affecting personal consumption in the presence of regional heterogeneity. This paper explores the impact of various degrees and channels of risk sharing on monetary policy transmission for two separate regional divisions in China over the period 2001-2019. We first estimate the amount of risk sharing among prefecture-level cities and between provinces, and then interact it with a monetary policy shock to investigate the joint effect on output and prices. Our results show that the fiscal and factor market channel smooths a large part of personal consumption among prefecture-level cities within a province as well as between provinces, while the credit market plays a relatively minor role. We find that high risk sharing constraints the impact of monetary shocks on GDP, while amplifying their impact on prices mostly between provinces. A significant regional divide is observed where high risk sharing hampers monetary transmission in coastal provinces, while facilitating it in interior provinces. These patterns appear to be driven by differences in the institutional development across regions, especially with respect to factor market flexibility.

Keywords: risk sharing, consumption smoothing, monetary policy, regional heterogeneity, China
JEL: E21; E52;

1 Introduction

The market transition in China has been marked not only by rapid economic growth but also by the rise in income uncertainty and volatility, caused, among others, by dramatic structural changes and reforms of the social safety system (Yang, 2023; Yu and Zhu, 2013). Moreover, income risk is spread unevenly across urban and rural areas, coastal and interior provinces, wealthy and poor districts. Chinese households have employed various channels to smooth their consumption in response to rising income risks, taking advantage of the regional heterogeneity and asynchronous business cycles across the country. Rural dwellers migrated to urban areas and coastal regions in search of better employment opportunities. Precautionary savings surged in the face of underdeveloped credit and insurance markets (Chamon et al., 2013; Yang, 2023). The Chinese government reformed its existing social security system and introduced new pension and health insurance schemes, some of them targeted specifically at the rural population (Chen, Xiao, Zang and Liu, 2018; Yang and Zhao, 2024). Furthermore, the central government implemented a new fiscal transfer system that cushioned idiosyncratic shocks to provincial government revenue (Tochkov, 2007).

Regional heterogeneity provides opportunities for risk sharing but it also creates challenges to unitary monetary policy, making it more difficult for monetary authorities to achieve their policy objectives. The focus of this paper is on the interaction between inter-regional risk sharing and unitary monetary policy in the presence of regional diversity in China. While risk sharing responds to asymmetric shocks across regions, monetary policy aims at smoothing aggregate shocks shared by all regions in the country. However, a national monetary shock in China exerts a regionally heterogeneous effect on regional output, consumer prices, and loans (Guo and Masron, 2017; El-Shagi and Tochkov, 2024), which, in turn, could be driven by different levels of risk sharing across provinces. In fact, it has been shown that risk sharing, for instance, is correlated with industrial agglomeration across Chinese regions (Du et al., 2022).

We investigate the effect of different degrees and channels of inter-regional risk sharing on monetary transmission in China using annual data over the period 2001-2019. First, we estimate the extent of two types of risk sharing: among prefecture-level cities (within a given province) and between provinces, which are then decomposed into a joint fiscal and factor market channel and a credit market channel. Next, we obtain the monetary policy shocks from an asymmetric McCallum rule specification. In the main part of our analysis, we estimate the effect of the monetary policy shock conditional on inter- and intra-provincial risk sharing on provincial per-capita output and consumer prices in a local projection framework. This conditional effect is further explored in a comparative context for coastal and interior provinces. Lastly, we employ the NERI Marketization Index to determine the role of institutional factors in the interaction between risk sharing and monetary transmission.

There is a large literature measuring the extent of consumption smoothing and its various channels, especially in developed countries (Asdrubali et al.,

1996, 2023; Ferrari and Rogantini Picco, 2023). Another strand focuses on the connection between risk sharing and other factors, such as economic sentiments (Clancy and Ricci, 2022), development aid (Balli et al., 2019), financial inclusion (Cavoli and Gopalan, 2023), and financial integration (Donadelli and Gufler, 2021). For China, risk sharing has been explored in the context of inter-regional fiscal transfers and provincial government expenditure (Tochkov, 2007), comparisons of regional consumption risk sharing in China, US, and Canada (Xu, 2008), channels of consumption smoothing across provinces (Du et al., 2011), and the link between risk sharing and industrial specialization at the subprovincial level (Du et al., 2022).

The other relevant strand of the literature examines the regional effects of monetary policy, predominantly in developed countries (for a survey, see Dominguez-Torres and Hierro, 2019). Recent studies on emerging economies (e.g. Aginta and Someya, 2022; Torres-Preciado, 2021) report a heterogeneous response of regional macroeconomic variables to monetary policy shocks and try to identify its determinants. Studies on China detect differences between coastal and inland provinces (Cortes and Kong, 2007), highlight the role of spillover effects across provinces (Guo and Masron, 2017), and reveal heterogeneous responses for output and property prices but not for consumer prices and loans (El-Shagi and Tochkov, 2024). These papers find that the share of state-owned enterprises, the size of the private sector, and institutional factors are responsible for the diverse regional effect of monetary policy in China but they do not consider risk sharing as a contributing factor.

We add to the existing literature by investigating the impact of risk sharing on monetary transmission in a large emerging economy. To the best of our knowledge, the only prior study on this topic is Hauptmeier et al. (2022), which interacts consumption smoothing within each member state of the Euro Area with a monetary shock. By comparison, we conduct the analysis both within and across provinces in China. While existing research typically estimates a single coefficent for risk sharing across all provinces, we obtain separate coefficients for each province by employing a mean group estimator, which allows us to juxtapose the extent of intra- and inter-regional risk sharing.

The rest of the paper is structured as follows. First, we measure the extent and channels of risk sharing in the next section and estimate the monetary policy shock in Section 3. The effect of risk sharing on monetary transmission is explored in Section 4. Section 5 provides some conclusions and policy recommendations.

2 Risk sharing

Risk is typically defined as the variance of macroeconomic aggregates over time. To some degree output risk (i.e., the variation of GDP) translates to a corresponding consumption risk (i.e., variation of consumption). Yet, modern economies have various instruments to insure against the idiosyncratic components of this variations through risk sharing. In line with the seminal paper

by Asdrubali et al. (1996), it is possible to attribute risk sharing to its various channels by decomposing the relationship of GDP and consumption as follows:

$$GRP_i = \frac{GRP_i}{PI_i}\frac{PI_i}{PDI_i}\frac{PDI_i}{C_i}C_i \tag{1}$$

where GRP_i is the per-capita gross regional product, PI_i is the per-capita personal income, PDI_i is the per-capita personal disposable income, and C_i is the per-capita personal consumption of region i. The equation shows how the comovements between output and consumption can be decomposed into the comovements of the individual aggregates (which are implied by the three ratios on the right hand side of the equation). Risk sharing, i.e. the lack of a correlation between output and consumption, can correspondingly be split into those components. Risk sharing through a specific channel occurs, if the denominator in this fraction varies less than the numerator. In the case when all risks are absorbed, consumption does not react to changes in GRP.

The first channel deals with the effects of inter-regional flows as the difference between GRP and PI consists of the net income received from other regions. This mechanism takes into account that people can smooth their consumption by earning income outside of their home region due to, for instance, employment or ownership of financial assets in other regions. The second avenue for risk sharing is based on the difference between PI and PDI, which results from transfer income net of direct taxes and social insurance deductions. The fiscal system can achieve consumption smoothing by redistributing income across regions. The last mechanism relies on the credit market to mitigate the propagation of income shocks with net savings (or net lending) accounting for the difference between disposable income and consumption.

Since personal income is not available at the subnational level in China, for the remainder of the paper, we consider a simplified version of the decomposition given by:

$$GRP_i = \frac{GRP_i}{PDI_i}\frac{PDI_i}{C_i}C_i \tag{2}$$

In other words, we are unable to separate the factor market and fiscal channels from each other and instead merely decompose into a joint factor market and fiscal channel on the one hand, and the credit market channel on the other hand.

We estimate two different models based on the log form of Eq. (2) to quantify the amount of risk sharing provided by each channel at the regional level in China.

2.1 Inter-provincial risk sharing

In the first specification, regions correspond to the provinces of China and the estimation measures risk sharing between these provinces as follows:

$$\Delta y_{it} - \Delta d_{it} = \beta_{F,i}\Delta y_{it} + v_{F,t} + u_{F,i} + \varepsilon_{F,it} \qquad \text{(Factor market+Fiscal)} \tag{3}$$

$$\Delta d_{it} - \Delta c_{it} = \beta_{C,i}\Delta y_{it} + v_{C,t} + u_{C,i} + \varepsilon_{C,it} \qquad \text{(Credit market)} \quad (4)$$

$$\Delta c_{it} = \beta_{U,i}\Delta y_{U,it} + v_{U,t} + u_{U,i} + \varepsilon_{U,it} \qquad \text{(Unsmoothed)} \quad (5)$$

where y_{it} is the GRP, d_{it} is the disposable personal income, and c_{it} is the personal consumption of province i in year t. All variables are in per-capita terms and expressed as natural logs. Province fixed effects (u_i) account for provincial heterogeneity, while time fixed effects (v_t) control for common shocks at the national level in China. The coefficient β_F denotes the fraction of inter-provincial risk sharing provided jointly by the factor market and the fiscal system. Risk sharing via the credit market is represented by β_C, while β_U is the remaining share that has not been smoothed. The three coefficients sum to one.

Equations (2)-(4) are estimated using a mean group (MG) estimator developed by Pesaran and Shin (1995), which allows the slope coefficients to vary across provinces in contrast to the fixed effects estimator that constrains them to be the same. While the main purpose of the MG estimator is to generate an estimate of the mean of all parameters, we are more interested in the individual estimates of β_F, β_C, and β_U for each province i.

2.2 Intra-provincial risk sharing

The second specification of the model relies on data from subprovincial regions called prefecture-level cities to measure risk sharing within each Chinese province as follows:

$$\Delta y_{it} - \Delta d_{it} = \beta_F\Delta y_{it} + v_{F,t} + u_{F,i} + \varepsilon_{F,it} \qquad \text{(Factor market+Fiscal)} \quad (6)$$

$$\Delta d_{it} - \Delta c_{it} = \beta_C\Delta y_{it} + v_{C,t} + u_{C,i} + \varepsilon_{C,it} \qquad \text{(Credit market)} \quad (7)$$

$$\Delta c_{it} = \beta_U\Delta y_{U,it} + v_{U,t} + u_{U,i} + \varepsilon_{U,it} \qquad \text{(Unsmoothed)} \quad (8)$$

where the notation is the same as for Eqs. (2)-(4) except that region i is now defined as the prefecture-level city. Accordingly, the time fixed effects in this case account for common shocks across a given province. In contrast to the model with provincial data, Eqs. (5)-(7) are estimated separately for each province in a panel setting with fixed effects where intercepts are allowed to vary but the β coefficients are constrained to be the same for all prefecture-level cities in a given province.

Note that the key difference betweeen the models given in Subsections 2.1 and 2.2 lies in the datasets they are applied to. In Subsection 2.1, we estimate at the national level using provinces as observations. That means that the time

fixed effects absorb national comovements, leaving province-level idiosyncratic components of output, income, and consumption to be the subject of potential inter-provincial risk sharing. In Subsection 2.2, we estimate separate models for each province using prefectures as panel dimension. Therefore, the time fixed effects capture the macroeconomic dynamics at the provincial level (which are the focus of the previous subsection). This leaves prefecture-level idiosyncratic movements, which are then subject to intra-provincial risk sharing.

2.3 Data

Our analysis focuses on the sub-national level in China, employing both provincial and prefectural-city data at annual frequency over the period 2001-2019.[1] The sample covers all 31 administrative units at the province level and 318 out of 333 prefecture-level cities.[2] It is important to note that the so-called prefecture-level cities are actually regions that typically include a major city along with a number of smaller cities and rural counties. As an example, the prefectural city of Nanyang in Henan Province has a population of around 10 million spread across an area of 27,000 km^2 (almost the size of Belgium). The administrative unit consists of the city of Nanyang itself, as well as a county-level city and 10 counties.[3] The metropolitan areas with provincial status (Beijing, Shanghai, Tianjin, and Chongqing) are not subdivided into prefecture-level cities and are thus included only in the provincial estimation. In summary, the subprovincial analysis employs data from 27 provinces with an average of 12 prefecture-level cities per province.

The main variables of interest are per-capita gross regional product, personal disposable income, and personal consumption. The gross regional product is reported at the provincial and prefecture-city level as part of national accounting. Personal disposable income and consumption are obtained from the annual household survey conducted by China's National Bureau of Statistics (NBS). The survey is administered in all provinces and prefecture-level cities in China and the results are reported separately for urban and rural households. We collect the main body of the relevant data from various issues of the *China Yearbook of Household Survey*. In addition, we verify and complement the dataset using a variety of supplemental provincial and local statistical publications, such as statistical yearbooks of individual prefecture-level cities or household survey yearbooks for individual provinces.

The raw data presents a number of challenges. First, we need to combine the urban and rural series from the survey into a single regional series which is

[1] Data is available until 2022. However, the COVID pandemic did not only create a huge and hetergeneous shock to income (in an order of magnitude that the entire results would be driven by that single shock), but the travel restrictions in response to COVID also were a major impediment to migrant labor, one of the key risk sharing channels in China.

[2] We exclude 15 prefectural cities due to lack of data, including two from each of the provinces Heilongjiang, Hainan, and Yunnan, as well as 9 from Xinjiang.

[3] For convenience, we use the general term "prefecture-level city" throughout the paper, although 12% of these are officially labeled as prefectures, autonomous prefectures, or leagues, depending on their share of ethnic minorities and location.

typically done by simple averaging in previous studies on risk sharing in China. The problem with this approach is that the share of urbanization varies greatly across regions.[4] Instead, we employ a weighted average with the shares of urban and rural population in the region serving as weights. Obtaining urban and rural population data at the prefectural-city level for our sample period is challenging because of various inconsistencies in the definition (e.g., *hukou* registration vs. permanent residency) and missing observations. We establish an uniform standard by relying on three data points for each prefecture-level city collected from the national population census in 2000, 2010, and 2020. The missing observations between these years are interpolated using cubic splines as the exact dynamics of the urban/rural population series are less important in the context of their role as weights.

A second issue is missing data at the prefectural-city level, despite our best attempts to fill in gaps through various sources. For the majority of provinces (85%), we have either complete data for all variables or a few missing observations for some regions, while the rest of the sample exhibits larger gaps, especially with regard to rural consumption. Since we are looking at the correlation of log differences of gross regional product, income, and consumption, simple linear or cubic interpolation that essentially removes the dynamics is not helpful. Instead, we use the data for prefecture-level cities with complete time series to estimate the missing growth rates. For prefecture-level cities where some data is missing, we identify the two regions in the same province where the variable of interest shows the highest bilateral correlation. The missing data points are then replaced by out-of-sample predictions based on a simple regression model, where the (available) data of the region with missing observations is regressed on the corresponding variable for the two chosen regions with complete data.[5] The median R^2 for our regression used for this interpolation is around 60%, with almost 80% reaching an R^2 of 0.35 and higher. The vast majority of missing observations are for rural consumption and since those values are lower than their urban counterpart and the corresponding population share used for weighting is decreasing over time (due to China's urbanization), the impact of the interpolation on dynamics is minimal at best.

The last problem refers to a change in the definition of rural income in the household survey during the sample period. Initially, the survey reported disposable income for urban households and net income for rural households. In 2013, NBS harmonized the urban and rural survey, mandating the use of disposable income for both groups from 2014 onwards. According to the definition by NBS, rural net income is converted to disposable income by subtracting social-insurance contributions and interest payments on consumer loans.[6] This differ-

[4] The metropolis of Shenzhen in Guangdong province is an extreme example of a prefecture-level city that has recorded only urban population since the 2010 census.

[5] In the case of Jilin and Tibet, data for urban and rural consumption is missing completely across all prefecture-level cities for several years, preventing us from applying our interpolation procedure. Accordingly, the estimation is conducted only over the period for which data is available.

[6] See National Bureau of Statistics (2011), p.393, and NBS website: `https://www.stats.`

ence is relatively small and affects only prefectural-level cities as the provincial series have been adjusted according to the new definition for the years before the change was implemented.[7] The time fixed effects in our model control for the change in 2013 given that it affected all prefectural-level cities. Additionally, we run a robustness test estimating the model only with urban data.

2.4 Estimation of risk sharing

The results for the sample of prefecture-level cities in the first three columns of Table 1 indicate that the coefficients for the joint factor market and fiscal channel are positive and significant across all provinces. The magnitude is relatively high with an average share of risk sharing for this channel of 94%. For the credit market channel, only a third of the coefficients are significant and about half of these exhibit a negative sign. This means that the credit channel in some provinces (e.g., Jiangsu, Hubei) amplifies the volatility of consumption among prefecture-level cities instead of smoothing it. As for the remaining unsmoothed part of consumption, a third of the coefficients are significantly different from zero and range between 6% and 44%.

As an example, for prefecture-level cities within Henan province the joint factor market and fiscal channel smooths 73% of shocks to consumption, while the credit channel takes care of an additional 9%, leaving around 18% unsmoothed. Another example is Guangdong province where the joint factor market and fiscal channel absorbs 87% of shocks but the negative effect of the credit market channel cuts this share down by 10%, leaving 23% unsmoothed.

The results for inter-provincial risk sharing in the last three columns of Table 1 present a similar pattern with high values for the joint effect of the factor market and the fiscal mechanism. The corresponding coefficients for all provinces (including the four metropolitan areas excluded from the subprovincial analysis) are positive and significant with two exceptions. The average of 82% across the significant values is lower than for intraprovincial risk sharing, which is to be expected. The credit market channel does not seem to play a substantial role in risk sharing between Chinese provinces, resulting in a relatively high share of unsmoothed shocks to consumption ranging from 22% in Shanxi to 75% in Yunnan.

The predominance of the factor market in providing risk sharing in China can be explained by the large-scale migration of labor across regional borders within and between provinces, which allows households (especially rural ones) to smooth their consumption in the face of a negative local income shock by finding employment in other regions and sending remittances to their home locality. The per-capita GDP captures the contributions of migrants from other areas, while survey data on income and consumption is collected from permanent residents in conventional dwellings, which typically excludes migrant workers living in

gov.cn/zs/tjws/cjwtjd/202302/t20230217_1912787.html.

[7] Limited evidence from an overlap of the old and new series in 2013 suggests that the difference across all prefecture-level cities in Jiangsu province in 2013 was on average only 2.7% of disposable income.

factory dormitories or on construction sites. Furthermore, the system of taxes and transfers has also been shown to contribute to risk sharing (Tochkov, 2007; Xu, 2008), although the data does not allow us to measure its contribution separately. The relatively minor role of the capital market in risk sharing in China is explained in the literature by the fact that financial intermediation tends to be locally oriented (Du et al., 2011).

We test the robustness of our results with regards to the change in the definition of rural income in 2013 by conducting the estimation only for the urban part of the sample. The results (available from the authors upon request) produce a very similar picture with the joint factor market and fiscal channel accounting for an average of 96% of shocks in the prefecture-level analysis and 84% in inter-provincial risk sharing. At the same time, the average share of unsmoothed shocks is somewhat lower in both groups compared to the combined urban and rural samples.

3 Monetary policy

3.1 Institutional background and Data

For the vast majority of our sample period, there is a clear consensus in the literature that the People's Bank of China (PBoC) was targeting money supply, in particular $M2$. Much more than its Western counterparts, the PBoC is tasked with supporting the government's general policy objectives, especially its growth target that is outlined in the five-year plans and then specified annually in the government work reports. As argued by Chen, Ren and Zha (2018), the PBoC's reaction function is, therefore, not a standard McCallum-type rule (the typically estimated rule for countries targeting money) but an inherently asymmetric one. When growth is below target, the PBoC leans strongly against this development, while it remains relatively passive to a quickly expanding economy, unless inflation is imminent.

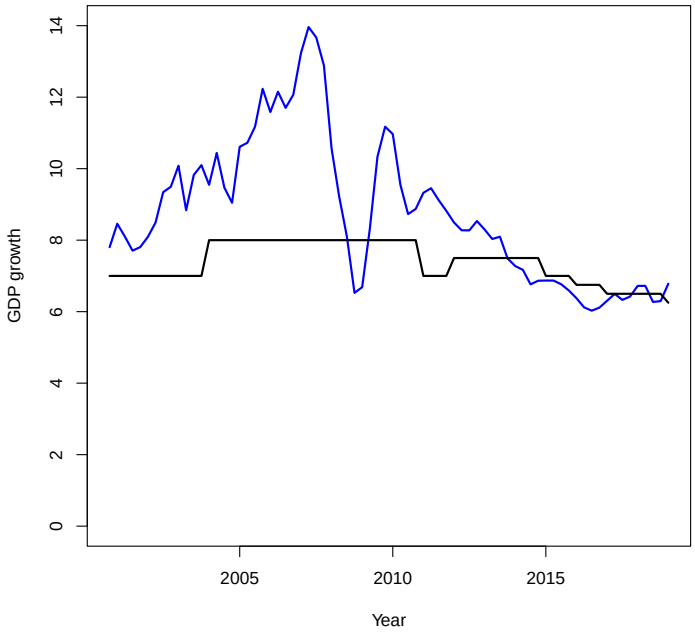


Figure 1: China's real GDP growth (blue) relative to target (black)

Figure 1 shows year-over-year real GDP growth, compared to the annual targets. Before the Global Financial Crisis, the Chinese economy usually massively outperformed the official targets. In other words, the central bank was largely in charge of controlling inflation, while accommodating GDP growth.

After the recovery from the crisis, as China gradually shifted to a slightly lower growth path often dubbed the "new normal", GDP growth was typically closer and occasionally below target.

All of our data except the growth targets are taken from the Federal Reserve Bank of Atlanta's "China's Macroeconomy: Time Series Data", originally introduced by Chang et al. (2016). The targets are collected directly from the annual government work report. Our sample makes use of quarterly data starting in 2000Q1 (or 2001Q1 after accounting for the computation of year-over-year growth rates) and ending in 2019Q4, just before the COVID pandemic.

3.2 Estimation of monetary shocks

We identify monetary policy shocks as deviation from the PBoC's monetary policy rule. Following the work by Chen, Ren and Zha (2018), our baseline specification is an asymmetric McCallum rule, where $M2$ growth is determined by deviations of inflation and growth from their respective targets. Unlike the inflation target, the growth target set by the State Council is typically understood as a lower bound, creating an asymmetric reaction to GDP growth being above or below target. Following the literature we assume a constant inflation target, implying it can be omitted from the estimation, yielding a policy rule in the form:

$$m_t = \gamma_0 + \gamma_1 m_{t-1} + \gamma_2 \pi_t + \gamma_3 \mathbb{1}_{y>y^*} y_t - y_t^* \gamma_3 \mathbb{1}_{y \leq y^*} y_t - y_t^* + \varepsilon_t, \qquad (9)$$

where m, y, and π denote the year-over-year growth of $M2$, real GDP, and the CPI, approximated as fourth-order log differences (times 100), while y^* is the growth target. Like the original paper, we allow for heteroscedasticity in the form of different variance regimes when GDP growth is above and below target. However, rather than using maximum likelihood estimation, we employ an iterative feasible generalized least squares approach, modeling two different variance regimes.

Our coefficient estimates in Table 2 by and large match the order of magnitude of the coefficients found in the literature. The shocks themselves (i.e., the residuals of the regression in Eq.(9) are shown in Figure 2.

4 Monetary policy transmission and risk sharing

4.1 Local projections

Our main objective in this paper is to investigate the changes in monetary policy transmission, depending on different degrees and forms of risk sharing. To this end, we estimate the difference in the response of two key provincial macroeconomic indicators (per-capita GDP and consumer price index) to the

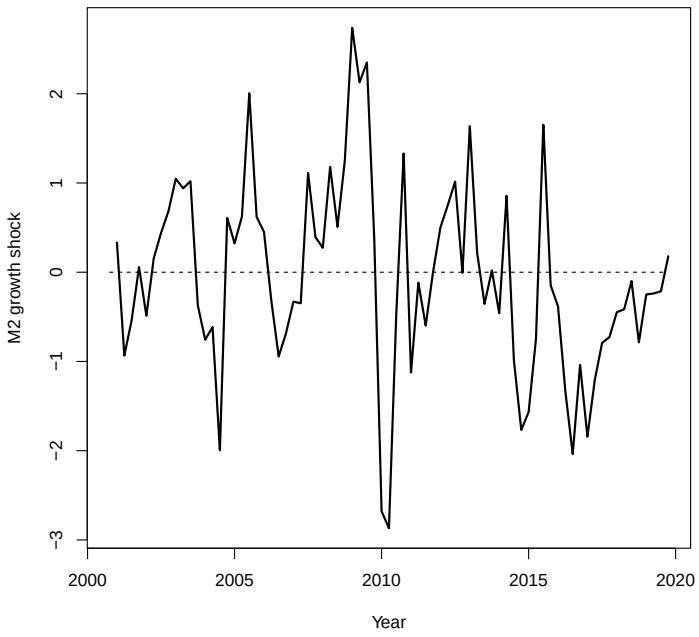


Figure 2: Estimated monetary policy shock (2001Q1-2019Q4)

shock identified in Section 3, conditional on the risk sharing parameters obtained in Section 2. The conditional impulse responses are estimated using local projections following the seminal paper by Jordà (2005).[8] While a vector of province-level controls is included, we mostly account for heterogeneity using time and province fixed effects. This means that we cannot include the monetary policy shock itself into our model, but only the interaction between the shock (that varies over time) and the estimated risk sharing coefficients (which vary across provinces).

Our model is given by:

$$x_{i,t+h} = \phi_1(\hat{\varepsilon}_t \times \hat{\beta}_{S,i}) + \phi_2 x_{i,t-1} + \Phi Z_{i,t} + v_t + u_i, \tag{10}$$

where x_i is the macroeconomic indicator of interest (per-capita GDP or the price level) for province i, $\hat{\varepsilon}$ is the monetary policy shock from Eq.(9), and $\hat{\beta}_{S,i}$ is the estimated provincial risk sharing parameter defined as $\beta_S = \beta_F + \beta_C = 1 - \beta_U$. We further include province and time fixed effects (u_i and v_t, respectively) as well as a vector of controls ($Z_{i,t}$), containing the first two lags of the dependent variable x_i. We consider horizons from $h = 0$ (the contemporaneous effect of a

[8] For a guide to applications, see Jordà (2023).

shock) to $h = 3$ (three years ahead). Following the literature, we normalize the estimated βs and the policy shocks to simplify the interpretation.

In addition, we estimate a second specification where risk sharing is decomposed as follows:

$$x_{i,t+h} = \psi_1(\hat{\varepsilon}_t \times \hat{\beta}_{F,i}) + \psi_2(\hat{\varepsilon}_t \times \hat{\beta}_{C,i}) + \phi_3 x_{i,t-1} + \Psi Z_{i,t} + v_t + u_i, \qquad (11)$$

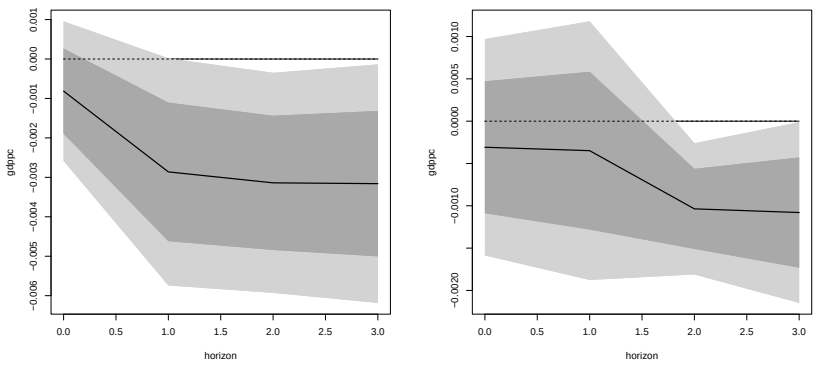
where $\hat{\beta}_F$ and $\hat{\beta}_C$ represent the shares of risk sharing provided by the joint factor market plus fiscal channel and the credit market channel, respectively.

4.2 Results

As discussed in the previous subsection, the necessity to include time fixed effects (to avoid hugely overstating significance) means that we cannot include the response to monetary policy itself. Rather, we only look at the difference of the response to a monetary policy shock between a province where the risk-sharing parameter β is high (one standard deviation above the level for the average province) and low (more precisely "normal", i.e. matching the average across provinces). For our interpretation, we assume that the standard effects of monetary policy hold. There is a huge literature on the effects of monetary policy in China, and while details differ, the general consensus that expansionary policy increases production and dampens inflation is completely uncontroversial. Since we estimate a money-based policy rule, as is standard for China, a positive shock corresponds to expansionary policy. All our results will therefore be interpreted relative to this (assumed) increase in GDP growth and reduction in inflation.

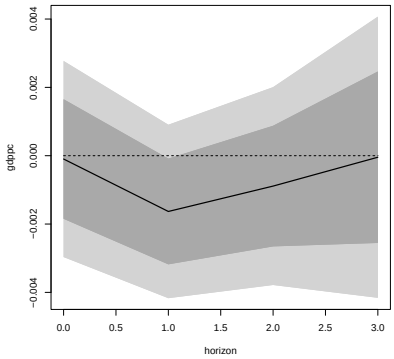
For both the intra- and inter-provincial analysis, we find that increased risk sharing through the combined fiscal and factor market channels dampens the impact of monetary policy on GDP (see Fig. 3, top panel), i.e. the effect of the interactions is negative, offsetting the effect of expansionary policy to some (albeit quantitatively small) degree. In other words, the negative sign of the β coefficient suggests that the stimulating effect of the monetary policy shock on GDP is lower for high levels of risk sharing. In the intra-provincial sample, the dampening effect becomes significant about a year after the shock and remains relatively persistent, while risk sharing across provinces reacts with a certain delay.

There is little to no impact of risk sharing through the credit market on monetary policy transmission (see Fig. 3, middle panel). At first glance, this might seem counterintuitive, given the role that financial markets plays in monetary policy transmission. However, our estimates in Section 2 and the existing literature (e.g., (Du et al., 2011) show that the credit market plays a relatively small role in China's inter- and intra-provincial risk sharing. In light of these findings, the lack of significant results with regard to monetary policy transmission is to be expected. At the same time, the different patterns for the intra- and inter-provincial samples are worth noting. Risk sharing across provinces

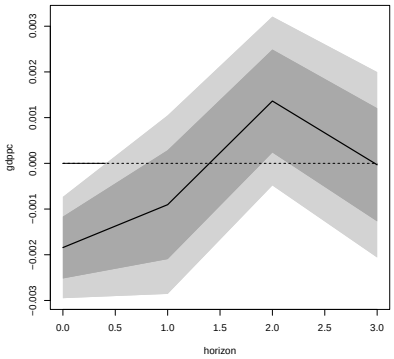


(a) Factor market + Fiscal (intra)

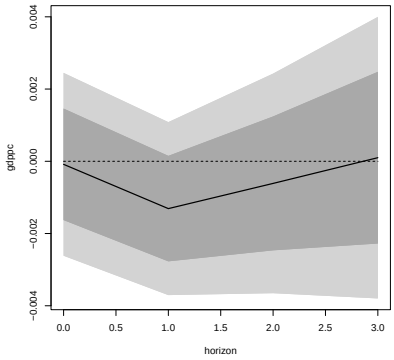
(b) Factor market + Fiscal (inter)



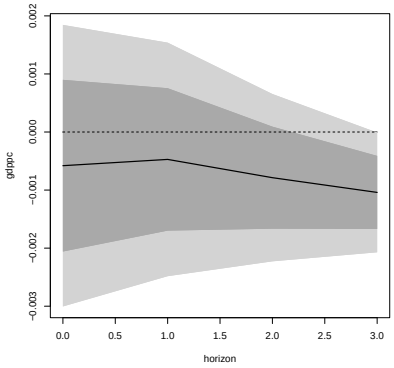
(c) Credit market (intra)



(d) Credit market (inter)



(e) Total risk sharing (intra)



(f) Total risk sharing (inter)

Figure 3: Relative response of regional per-capita GDP to an expansionary monetary policy shock conditional on risk sharing

Note: IRF differences conditional on intra-provincial (left panel) and inter-provincial (right panel) risk sharing with one standard deviation (dark grey) and 90% (light grey) confidence bounds.

via the credit market initially displays the dampening effect that is statistically significant even right after the shock. However, a reversal two years later indicates that more consumption smoothing across provinces via the credit market channel now facilitates monetary transmission but the resulting effect is rather short-lived.

Total risk sharing does not appear to affect the impact of monetary policy on GDP both within and across provinces (see Fig. 3, bottom panel). The same is true for prices (see Figure 4, bottom panel) but a decomposition by channel offers some additional insights. In the case of the fiscal and factor market channel across provinces, higher risk sharing significantly complements monetary policy transmission two years after the shock (see Fig. 4, top panel). By contrast, the credit market exhibits a significantly dampening effect of risk sharing across provinces that dies out by the end of the horizon (see Fig. 4, middle panel).[9]

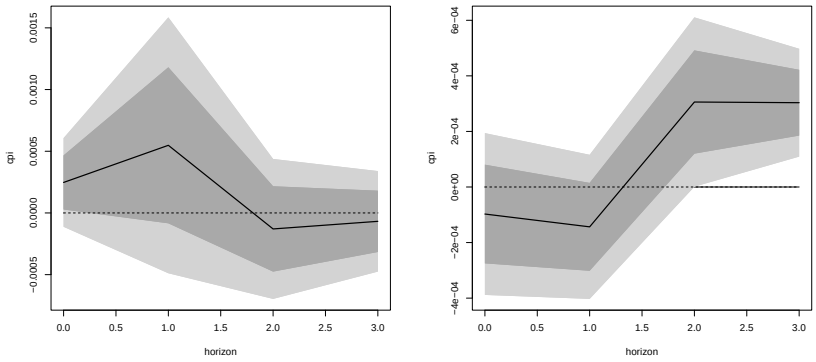
The opposite direction of the effects for GDP and prices, especially across provinces, is in line with the finding that risk sharing is primarily driven by fiscal policy and the factor market rather than the credit market. In other words, the dampening impact of monetary policy on GDP in high risk sharing areas is not due to a lesser direct effect of monetary transmission, i.e. that less liquidity is channeled to those areas through the credit market, but rather the effect of monetary policy is compensated through other means. Lower GDP growth in the face of increasing liquidity translates into a (relatively) larger increase in prices.

4.3 Coastal vs interior provinces

Next, we split the sample into coastal and interior provinces given their different developmental paths that saw the former experience rapid growth and wealth accummulation, which deepened regional income disparities.[10] The results reveal major differences between the two subsamples regarding the interaction effect of risk sharing with monetary policy transmission. In the case of inter-provincial smoothing, the coefficient in the GDP model is significant for both groups but carries a positive sign for interior provinces and a negative one for coastal provinces (see Fig. 5, right column). The negative effect seems stronger and more persistent in the fiscal and factor market channel, while for the credit market a significant reaction in either direction emerges with a delay of one year after the shock. Overall, this means that higher inter-regional risk sharing amplifies monetary transmission within the group of poor provinces while con-

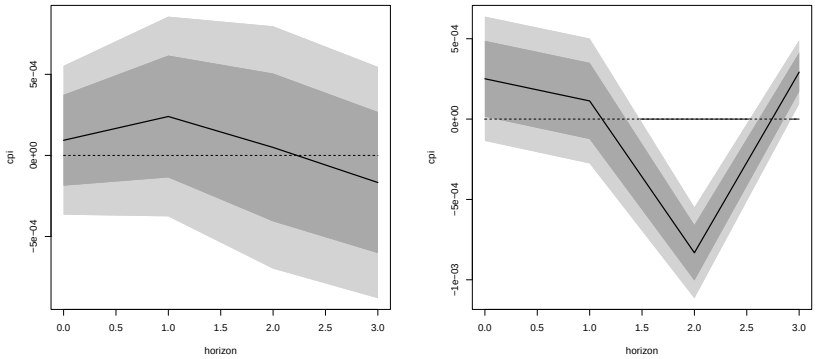
[9] As a robustness test, we repeated the analysis for the inter-provincial risk sharing using a reduced sample of provinces that excludes the four metropolitan areas with provincial status (Beijing, Chongqing, Shanghai, and Tianjin). The results, which are available upon request from the authors, do not differ much from the ones presented in the right columns of Figs. 3 and 4.

[10] Coastal provinces include Beijing, Fujian, Guangdong, Hainan, Hebei, Jiangsu, Liaoning, Shandong, Shanghai, Tianjin, and Zhejiang. The group of interior provinces consists of Anhui, Chongqing, Gansu, Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Inner Mongolia, Jiangxi, Jilin, Ningxia, Qinghai, Shanxi, Shaanxi, Sichuan, Tibet, Xinjiang, and Yunnan.



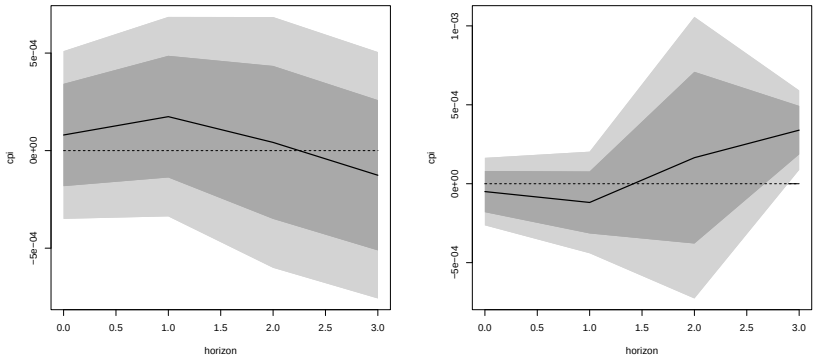
(a) Factor market + Fiscal (intra)

(b) Factor market + Fiscal (inter)



(c) Credit market (intra)

(d) Credit market (inter)



(e) Total risk sharing (intra)

(f) Total risk sharing (inter)

Figure 4: Relative response of regional CPI to an expansionary monetary policy shock conditional on risk sharing

Note: IRF differences conditional on intra-provincial (left panel) and inter-provincial (right panel) risk sharing with one standard deviation (dark grey) and 90% (light grey) confidence bounds.

straining it among wealthier ones. The smoothing across prefecture-level cities within provinces presents a different picture where the credit market channel produces a positive and significant (albeit short-lived) effect for both groups immediately following the shock, whereas the fiscal and factor market channel lead to a dampening and persistent effect but only among interior provinces (see Fig. 5, left column).

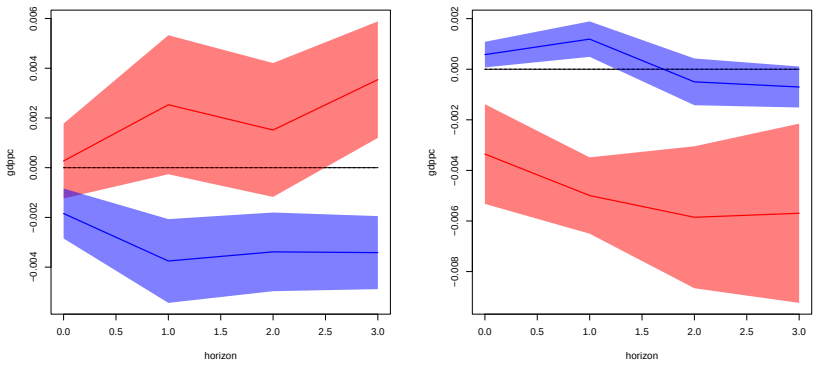
Given the minor role that the credit market plays in risk sharing, we focus our interpretation of the results on the fiscal and factor market channel. Interior provinces with high inter-regional risk sharing see a relatively large share of their working-age population (especially from rural areas) move to the wealthier regions along the coast in order to smooth their consumption. They typically travel long distances and return only once per year to their home towns or villages. A positive monetary shock affects both their home province and their new workplace; however, they are unlikely to react swiftly by moving back to their home region in China's interior as travel is costly and the additional rewards uncertain (given that wages for migrants increase in the coastal areas as well). Accordingly, the continuing inflows of remittances in the interior provinces coupled with fiscal transfers from the central government amplify the effect of the positive monetary shock on GDP.

Risk sharing across prefecture-level cities within an interior province is subject to different dynamics. The migrants in this context are typically either commuters who work in the nearby big city or workers who can easily return home on a short notice without incurring high costs. Under these circumstances, prefecture-level cities with high risk sharing are likely to face smaller net migrant outflows in response to a positive monetary shock, which in turn constraints the effects of monetary policy transmission.

Rich provinces with high inter-regional risk sharing attract migrant workers from interior provinces and the demand for cheaper labor is likely to surge in response to a positive monetary shock. This trend might be further magnified by the possibility that locals decrease their labor supply in the face of rising incomes or stop commuting to adjacent provinces, which is easier because rich regions are clustered along the coast and travel costs are low.[11] The larger net inflows of migrants combined with the stabilizing role of the fiscal system produce the dampening effect on monetary policy transmission for coastal provinces.

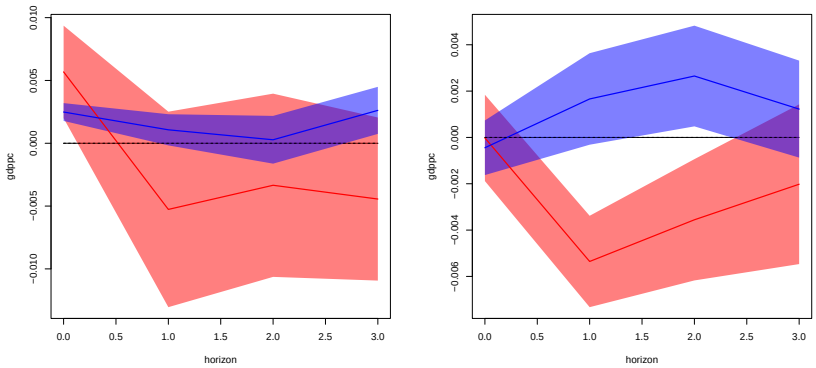
With regard to prices, we observe a lack of a significant difference between coastal and interior provinces for the intra-provincial risk sharing (see Fig. 6, left column). By comparison, both groups reveal significant but opposite patterns in the context of cross-provincial smoothing (see Fig. 6, right column). For coastal provinces, the fiscal and factor market channel complements monetary policy one year after the shock before reversing the effect a year later. Interior provinces, on the other hand, experience a restraining effect at one year and a magnifying effect after two years following the shock. These patterns are largely mirror images of the dynamics observed for GDP. The dampening effect on GDP

[11] For instance, Jiangsu, Shanghai, and Zhejiang form a large cluster of metropolitan areas in the Yangtze Delta. Its counterpart in North China is the Jing-Jin-Ji agglomeration between Beijing, Tianjin, and Hebei.



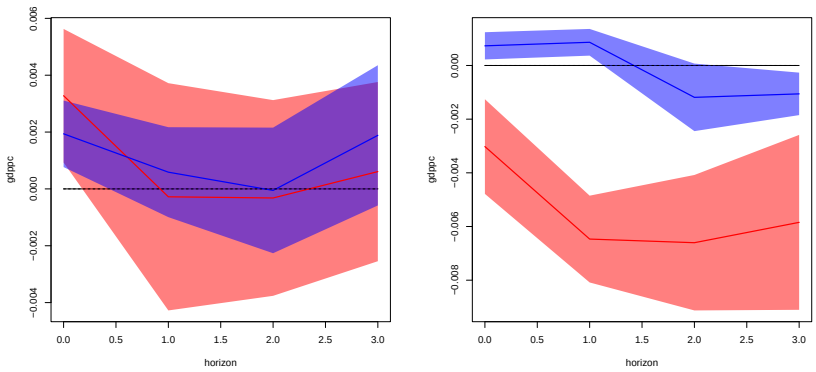
(a) Factor market + Fiscal (intra)

(b) Factor market + Fiscal (inter)



(c) Credit market (intra)

(d) Credit market (inter)

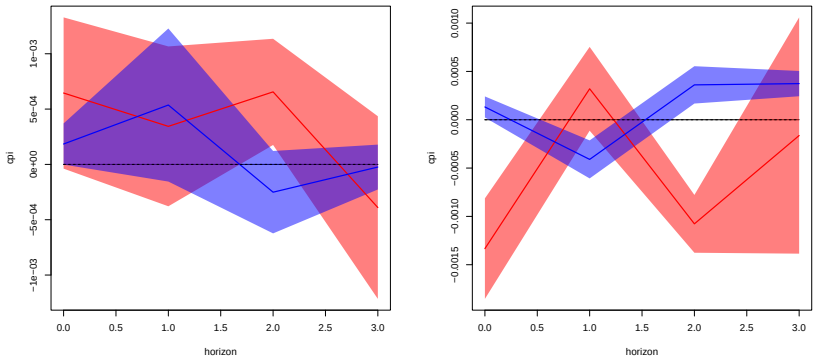


(e) Total risk sharing (intra)

(f) Total risk sharing (inter)

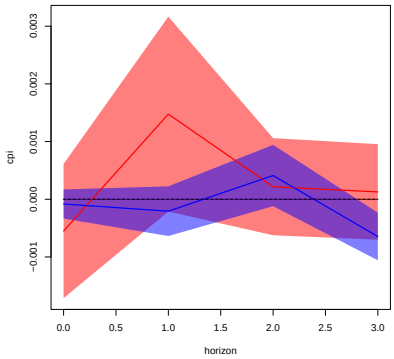
Figure 5: Relative response of regional per-capita GDP to an expansionary monetary policy shock conditional on risk sharing (coastal vs interior provinces)

Note: IRF differences conditional on intra-provincial (left panel) and inter-provincial (right panel) risk sharing with one standard deviation confidence bounds for coastal (red) and interior (blue) provinces.

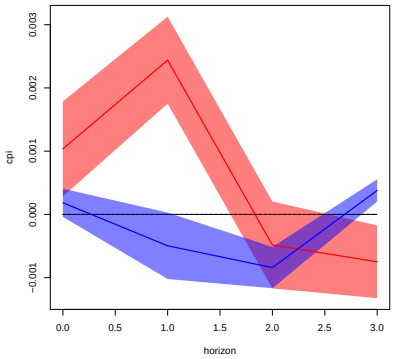


(a) Factor market + Fiscal (intra)

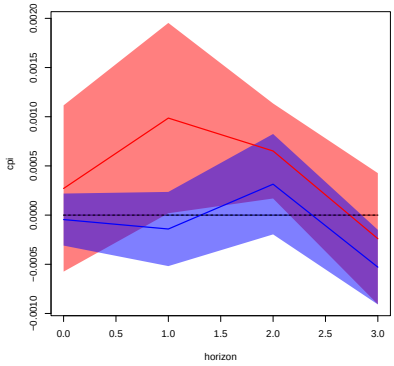
(b) Factor market + Fiscal (inter)



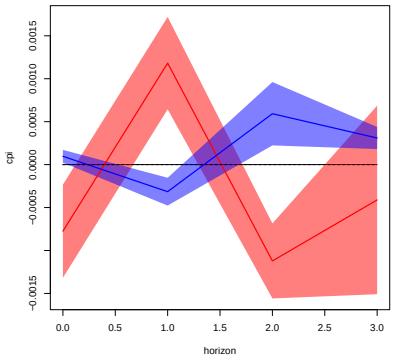
(c) Credit market (intra)



(d) Credit market (inter)



(e) Total risk sharing (intra)



(f) Total risk sharing (inter)

Figure 6: Relative response of regional CPI to an expansionary monetary policy shock conditional on risk sharing (coastal vs interior provinces)

Note: IRF differences conditional on intra-provincial (left panel) and inter-provincial (right panel) risk sharing with one standard deviation confidence bounds for coastal (red) and interior (blue) provinces.

magnifies the impact of the monetary shock on prices, and vice versa.

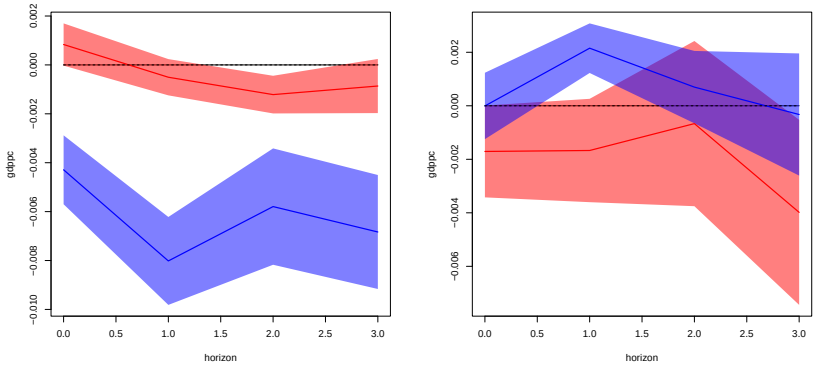
4.4 The role of institutional factors

Institutional heterogeneity across regions potentially contributes to the differences in the effect of risk sharing on monetary policy between the coast and the interior. Existing research highlights the role of market institutions, competition, and regulation in the asymmetric effects of monetary policy (Aghion et al., 2019; Liao and Wang, 2021). To explore this aspect further, we use the NERI (National Economic Research Institute) Marketization Index, which gauges the institutional advancement of the market economy in each province on an annual basis. The data are collected from the annual NERI reports over the period 2001–2019 (Fan and Wang, 2001; Wang et al., 2021).[12] The overall marketization index is averaged across four sub-indices that focus on (1) the extent of market expansion relative to state intervention, and the development of the (2) private sector, (3) factor markets, and (4) product markets. We average the index for each province across the 2001-2019 period and then split the sample at the median.

The results in Fig. 7 reveal significant differences between provinces depending on their institutional development. Among advanced provinces, high risk sharing has a significantly adverse impact on monetary policy transmission with regard to GDP across all channels both within and between provinces. The effect seems relatively persistent over the horizon but comparatively small in magnitude, especially for the fiscal and factor market channel. Institutionally underdeveloped provinces behave very similarly to the subsample of interior provinces, which is not surprising given that the poor provinces in Central and Western China rank at the bottom of the marketization index; however, the interaction effect here is much stronger. As for prices (Fig.8), institutional heterogeneity does not appear to cause significant differences with the exception of the amplifying effect of high intra-regional risk sharing among underdeveloped provinces, which mirrors (and is likely triggered by) the dampening effect on GDP.

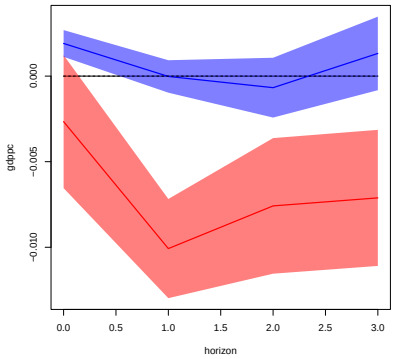
Lastly, we focus on a specific aspect of the institutional development by analyzing the marketization subindex measuring advances in the factor markets. The components of the subindex dealing with the competitiveness in the banking sector, credit allocation to private enterprises, and the mobility of labor (assessed via the ratio of migrant labor to total employment) are highly relevant in the context of the factor market and credit market channels' contributions to risk sharing. The results for GDP and prices (Figs. 9 and 10, respectively) are broadly in line with those for the overall marketization index, which is to be expected. A key difference can be detected in the inter-provincial risk sharing for provinces with more advanced factor markets where the dampening effect of higher smoothing on GDP experiences a significant increase in magnitude over

[12] We exclude Tibet and Chongqing from the sample in this part of the analysis due to missing data.

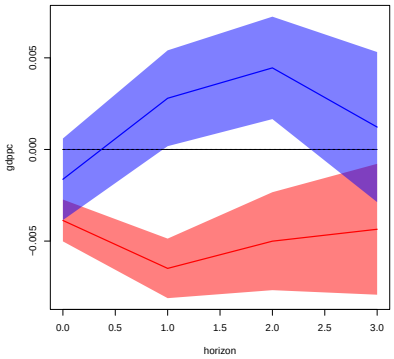


(a) Factor market + Fiscal (intra)

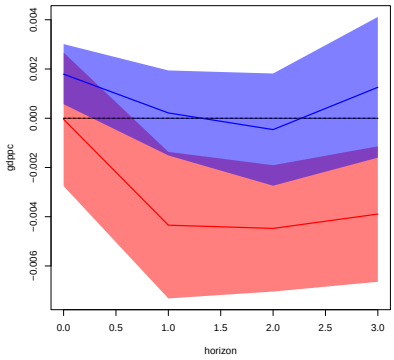
(b) Factor market + Fiscal (inter)



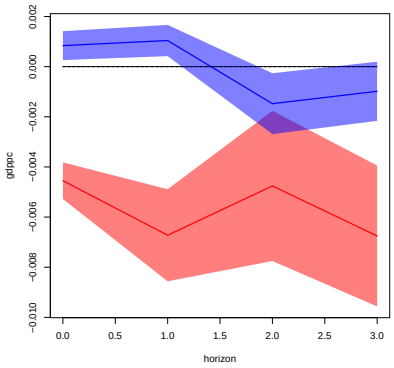
(c) Credit market (intra)



(d) Credit market (inter)



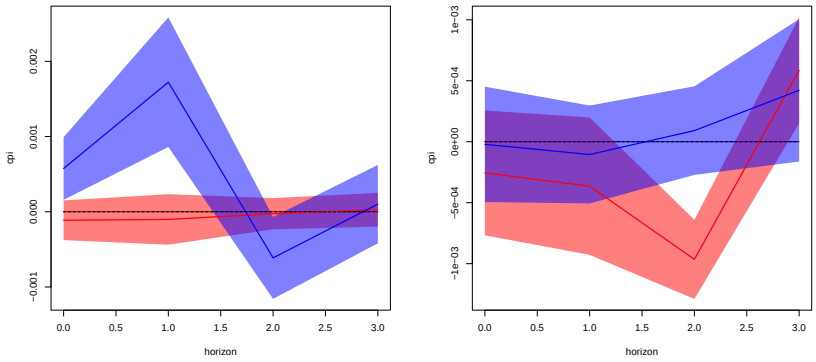
(e) Total risk sharing (intra)



(f) Total risk sharing (inter)

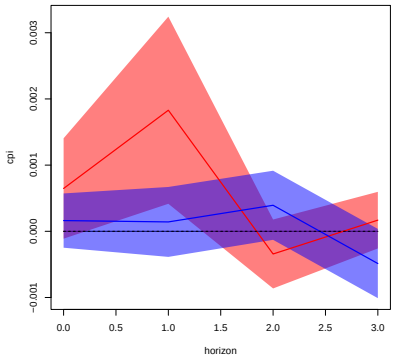
Figure 7: Relative response of regional per-capita GDP to an expansionary monetary policy shock conditional on risk sharing (high vs low institutional development)

Note: IRF differences conditional on intra-provincial (left panel) and inter-provincial (right panel) risk sharing with one standard deviation confidence bounds for provinces with a high (red) and low (blue) institutional development as measured by the NERI marketization index.

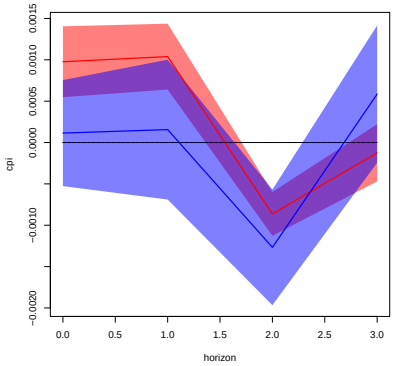


(a) Factor market + Fiscal (intra)

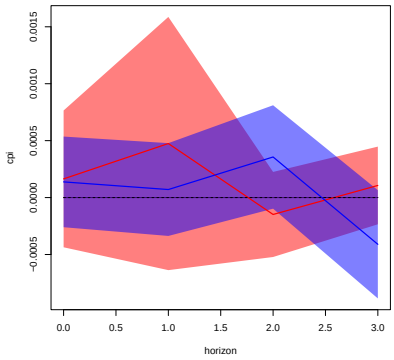
(b) Factor market + Fiscal (inter)



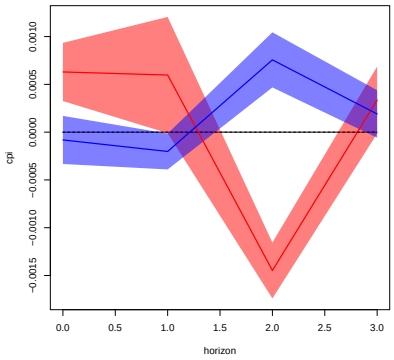
(c) Credit market (intra)



(d) Credit market (inter)



(e) Total risk sharing (intra)



(f) Total risk sharing (inter)

Figure 8: Relative response of regional CPI to an expansionary monetary policy shock conditional on risk sharing for subsamples based on the marketization index

Note: IRF differences conditional on intra-provincial (left panel) and inter-provincial (right panel) risk sharing with one standard deviation confidence bounds for provinces with a high (red) and low (blue) institutional development as measured by the NERI marketization index.

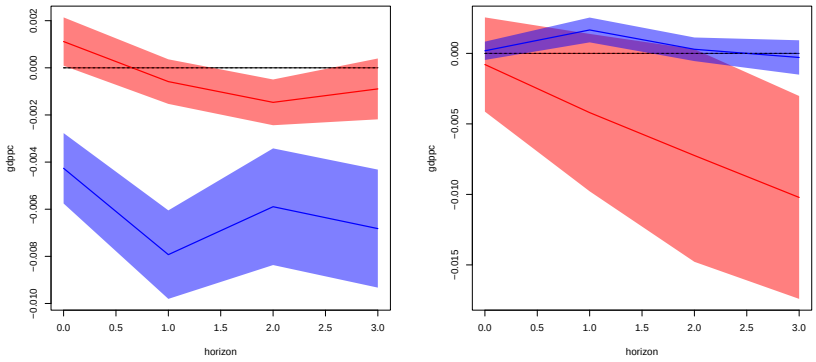
the entire horizon. This supports our earlier interpretation that a larger share of migrant workers (and the outflow of their remittances in particular) counteracts the effects of the positive monetary shock.

5 Conclusions

Risk sharing mechanisms help households to smooth consumption in the face of income shocks that can have a different impact across countries with high levels of regional heterogeneity. The main objective of this paper is to explore the impact of various degrees and channels of risk sharing on monetary policy transmission for two separate layers of subnational administrative divisions in China. Our results show that the joint fiscal and factor market channel smooths a large part of personal consumption across prefecture-level cities as well as between provinces, while the credit market plays a relatively minor role within provinces. We find that high risk sharing through the fiscal and factor market channel limits the impact of a positive monetary shock on GDP, while amplifying the impact on prices, especially between provinces.

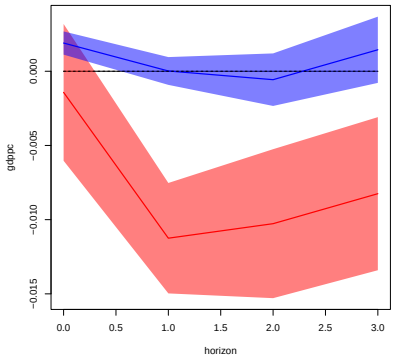
Major differences emerge once we split the sample based on geographical location and institutional development. High levels of smoothing through the fiscal and factor market exhibit a dampening effect on the stimulation of GDP by monetary policy for rich coastal provinces. This effect is even more prominent for risk sharing both within and between provinces that have more advanced market institutions. By contrast, poor regions in China's interior, which are also mostly institutionally underdeveloped, display a positive, amplifying effect in the inter-provincial setting. We interpret this mainly as the result of labor migration from poor to rich provinces, which while helpful in smoothing personal consumption, mitigates the effectiveness of unitary monetary policy across China.

China will continue to be in great need of effective mechanisms for smoothing income shocks as its economy transitions to a new growth model based primarily on domestic consumption. The ageing of the labor force and the gradual decline in migration from interior to coastal provinces are likely to weaken the factor market channel of risk sharing, meaning that the fiscal and credit market channels will have to be expanded and strengthened so as to be able to absorb a larger share of income shocks. The added benefit of the continuing development and liberalization of credit markets and their expansion across regional borders is that this would also likely improve the effectiveness of monetary policy in the face of regional heterogeneity.

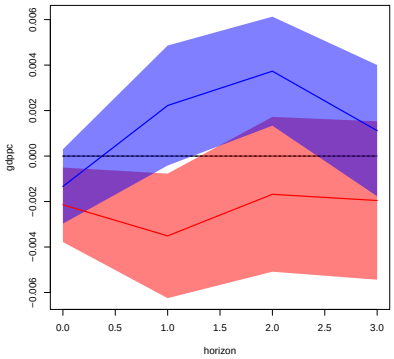


(a) Factor market + Fiscal (intra)

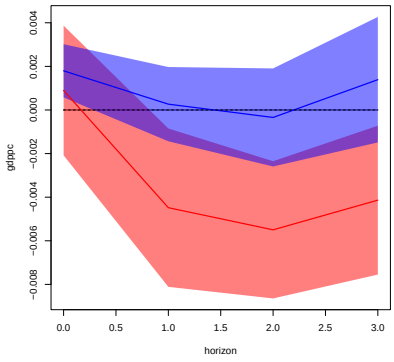
(b) Factor market + Fiscal (inter)



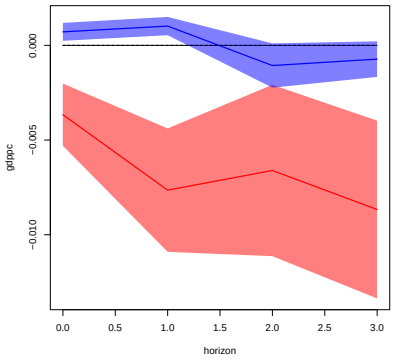
(c) Credit market (intra)



(d) Credit market (inter)



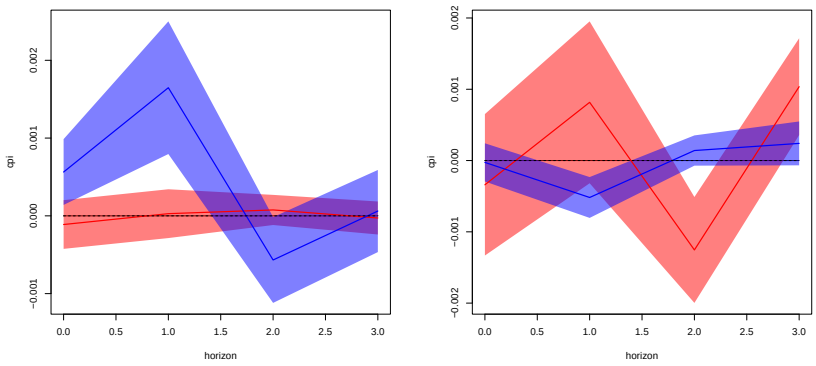
(e) Total risk sharing (intra)



(f) Total risk sharing (inter)

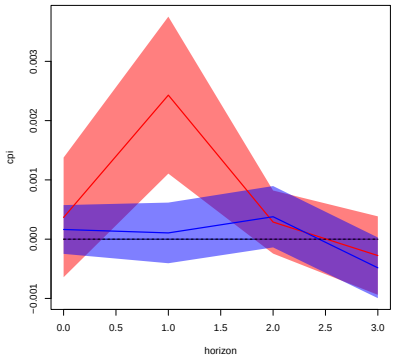
Figure 9: Relative response of regional per-capita GDP to an expansionary monetary policy shock conditional on risk sharing (advanced vs underdeveloped factor markets)

Note: IRF differences conditional on intra-provincial (left panel) and inter-provincial (right panel) risk sharing with one standard deviation confidence bounds for provinces with advanced (red) and underdeveloped (blue) factor markets.

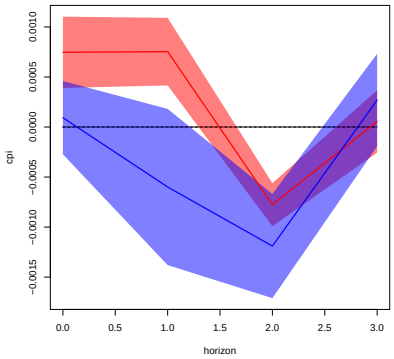


(a) Factor market + Fiscal (intra)

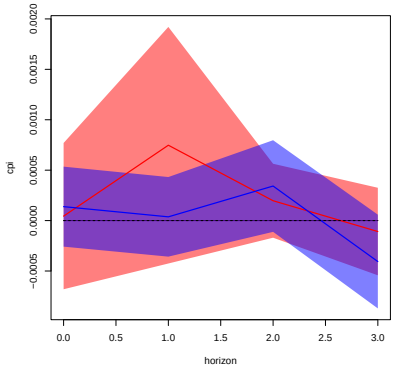
(b) Factor market + Fiscal (inter)



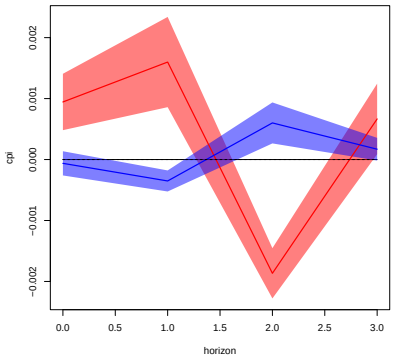
(c) Credit market (intra)



(d) Credit market (inter)



(e) Total risk sharing (intra)



(f) Total risk sharing (inter)

Figure 10: Relative response of regional CPI to an expansionary monetary policy shock conditional on risk sharing (advanced vs underdeveloped factor markets)

Note: IRF differences conditional on intra-provincial (left panel) and inter-provincial (right panel) risk sharing with one standard deviation confidence bounds for provinces with advanced (red) and underdeveloped (blue) factor markets.

Table 1: Intra- and inter-provincial risk sharing in China

	Intra-provincial risk sharing			Inter-provincial risk sharing		
	factor/fiscal	credit	unsmoothed	factor/fiscal	credit	unsmoothed
Anhui	0.94***	0.01	0.04	0.91***	0.19	-0.1
	(36.67)	(0.26)	(0.97)	(6.28)	(0.84)	(-0.38)
Fujian	0.95***	-0.08	0.13**	0.89***	0.14	-0.04
	(21.36)	(-1.22)	(1.98)	(6.76)	(0.83)	(-0.19)
Gansu	0.95***	0	0.06	0.89***	0.12	-0.01
	(54.46)	(-0.02)	(0.6)	(4.1)	(0.57)	(-0.05)
Guangdong	0.87***	-0.1**	0.23***	0.62***	-0.17	0.55***
	(19.13)	(-1.72)	(3.8)	(2.95)	(-0.88)	(3.02)
Guangxi	0.96***	0.16**	-0.12	-2.27	0.49	2.78**
	(31.33)	(1.76)	(-1.37)	(-1.3)	(1.06)	(1.78)
Guizhou	0.96***	-0.09	0.13	0.87***	-0.22	0.35
	(33.77)	(-0.7)	(1)	(6.4)	(-1.32)	(1.55)
Hainan	0.87***	-0.09	0.23	1.38***	0.03	-0.4
	(14.13)	(-0.31)	(0.78)	(3.23)	(0.08)	(-0.66)
Hebei	0.94***	-0.06	0.13	0.92***	-0.15	0.23
	(14.47)	(-0.61)	(1.36)	(7.66)	(-0.78)	(1.01)
Heilongjiang	0.89***	0.14**	-0.03	0.91***	0.01	0.08
	(24.15)	(1.95)	(-0.46)	(7.9)	(0.04)	(0.33)
Henan	0.73***	0.09**	0.18***	0.92***	0	0.08
	(20.8)	(2.01)	(3.75)	(5.69)	(0)	(0.33)
Hubei	0.99***	-0.06**	0.06**	0.9***	0.18	-0.09
	(66.58)	(-1.78)	(1.94)	(5.14)	(0.7)	(-0.27)
Hunan	0.87***	0.04	0.09	0.91***	0.24	-0.15
	(16.44)	(0.38)	(0.9)	(4.19)	(1.15)	(-0.46)
In. Mongolia	0.89***	0.08	0.04	0.53***	-0.02	0.5**
	(22.67)	(0.85)	(0.4)	(4.41)	(-0.14)	(2.31)
Jiangsu	0.95***	-0.08**	0.14**	0.51***	0.02	0.47**
	(24.6)	(-1.7)	(2.48)	(3.44)	(0.14)	(1.81)
Jiangxi	0.93***	0.08	-0.01	1.55***	0.15	-0.7**
	(38.52)	(0.9)	(-0.09)	(8.02)	(0.5)	(-2.05)
Jilin	0.81***	0.43**	-0.25	1.2***	-0.18	-0.02
	(5.75)	(2)	(-1.04)	(8.03)	(-1.15)	(-0.13)
Liaoning	0.95***	0.09**	-0.04	0.79**	0.08	0.13
	(39.8)	(1.7)	(-0.81)	(2.74)	(0.26)	(0.3)
Ningxia	0.99***	-0.05	0.06	0.81***	-0.11	0.31
	(36.28)	(-0.63)	(0.78)	(9.85)	(-0.54)	(1.31)
Qinghai	1.05***	0.01	-0.07	0.88***	-0.11	0.23
	(16)	(0.11)	(-0.78)	(5.92)	(-0.56)	(1.03)
Shaanxi	0.91***	0.06	0.03	0.78***	-0.2	0.42**
	(27.26)	(0.64)	(0.29)	(4.81)	(-1.4)	(1.8)
Shandong	0.93***	0.03	0.03	0.61**	0	0.38
	(16.82)	(0.54)	(0.44)	(2.28)	(0.03)	(1.46)
Shanxi	0.94***	0	0.06	0.84***	-0.06	0.22**
	(27.28)	(0)	(0.83)	(8.86)	(-0.67)	(2)
Sichuan	0.93***	-0.03	0.1**	0.71***	0.32	-0.03
	(58.7)	(-0.59)	(2.07)	(3.21)	(0.76)	(-0.06)
Tibet	1.08***	-0.54	0.46	-0.8	-0.62	2.42***
	(35.16)	(-1.38)	(1.15)	(-1.45)	(-1.55)	(3.4)
Xinjiang	0.97***	-0.42***	0.44***	0.87***	0.07	0.06
	(17.14)	(-2.89)	(2.91)	(5.84)	(0.38)	(0.33)
Yunnan	1.01***	0.23	-0.24**	0.44**	-0.18	0.75**
	(26.44)	(1.55)	(-1.68)	(2.61)	(-0.65)	(2.93)
Zhejiang	1.01***	-0.02	0.01	0.43***	0.04	0.53**
	(26.72)	(-0.2)	(0.07)	(3.76)	(0.31)	(2.25)
Beijing				0.8***	-0.1	0.3
				(5.03)	(-0.55)	(1.41)
Chongqing				0.82***	-0.12	0.3
				(5.3)	(-0.86)	(1.22)
Shanghai				0.78***	0	0.22
				(4.74)	(0)	(1.1)
Tianjin				0.44**	0.07	0.49**
				(2.15)	(0.5)	(2.02)

Note: Estimates of the β coefficients from Eqs.(2)-(4) for inter- and Eqs. (5)-(7) for intra-provincial risk sharing. t-values in parenthesis. *** $p < .01$; ** $p < .05$; * $p < .10$.

Table 2: Asymmetric monetary policy reaction function for China (2000Q1 to 2019Q4)

	Asymmetric McCallum Rule
m_{t-1}	0.90^{***}
	(0.04)
π_{t-1}	-0.22^{***}
	(0.06)
y_{t-1} (high growth)	0.18^{*}
	(0.10)
y_{t-1} (low growth)	-1.73^{***}
	(0.59)
$\sigma_{y>y^*}$	0.94
$\sigma_{y\leq y^*}$	1.76
R^2	0.92
Adj. R^2	0.92
Num. obs.	76

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

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