

Regional Heterogeneity Analysis of Macroprudential Policy Responses

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ABSTRACT

The global financial crisis in 2008 made people realize that the role of monetary policy in maintaining financial system stability is limited. In that case, macro-prudential policy came into being. At present, there is a lack of related research on the evaluation of this policy effect. Given this, this paper constructs a macro-prudential policy response index, which scales the policy responses from 31 provincial-level administrative regions for 45 quarters from 2010 to 2021. Besides, a fixed-effect model was used to attribute the differences of performance results. The results show four: (1) The macro-prudential policy responses of China regions can be divided into four: the response invalid region, the typical response region, the excellent response region, and the excessive response region. (2) The provincial macro-prudential policy response is related to financial development: The higher the financial development, the stronger the macro-prudential policy response. (3) The macro-prudential policy response of provincial-level administrative regions is also related to the advanced industrial structure. The higher the provincial administrative region, the stronger the macro-prudential policy response. (4) The difference in the macro-prudential policy response is also affected by the rationality of the regional industrial structure. The lower the need for intervention, the more likely the market's self-regulatory effects are offsetting each other.

Keywords: *macro-prudential policy, regional effect, industrial structure, financial development index, counter-cyclical regulation.*

1. INTRODUCTION

Since macro-prudential policy focuses on systemic financial risks, it is more precise than monetary policy in reducing the pro-cyclicality of the financial system [1]. Improving the mechanism of macro-prudential policies has tremendous significance in resolving systemic risks of finance. The central government has set the upper limit of various financial indicators for macro-prudential policies. Then, each local administrative unit forms a policy response based on the economic situation. The difference in policy impact is closely related to the intermediary-local financial system. The development scale and quality of the financial system have an indispensable impact on the transmission of macro-prudential policies, generally measured by the FCI index. The rationalization and upgrading of the industrial structure are considered proxy variables for the quality of financial development. At this point, will the scale and quality of the financial system influence the impact of

macro-prudential policies? If so, is the effect substitutional or complementary? Furthermore, what are the differences in the macro-prudential policy responses among provincial administrative regions?

The indexing monetary policy measurement originated in OECD countries at the earliest, anchoring inflation as the policy objective. Methods include constructing an index of impulse response functions. However, the Dutch central bank uses standardized data to set the index range to reflect the fluctuation of monetary policy in different periods (Jan Willem Van Den, 2006) [2]. There are also studies on the effects of macro-prudential policies in China, mainly focusing on the interaction between macro-prudential policies and monetary impact (Fang Yi, 2016) [3].

Early research was limited to changes in credit supply and real estate prices, and late found that effectiveness varies with variables. Suh H pointed out policies are only effective when the monitoring objects have the same or

no direction [4]. Fagiolo shows that when the economy is in a non-expansion period, macro-prudential policies significantly restrain external fluctuations, especially the tools — loan-to-value ratio, and other mechanisms play a preventive role [5].

The marginal contributions of this paper include the following: 1. Most previous studies focused on the national [6], but this paper expands the research on macro-prudential policy to the provincial field. 2. The description of macro-prudential policy in previous studies is relatively scattered [7]. This paper summarizes the instrumental variables of macro-prudential policy and builds a more comprehensive index. 3. Through formula calculation, we completed some data from 2010 to 2014 and obtained balanced panel data. 4. Systematically divide China's 31 provinces into four response areas, providing practical evidence for policy regulation.

2. THEORETICAL MECHANISM AND RESEARCH HYPOTHESIS

According to the optimal currency theory, when the production factors are freely flowing, the industrial structure is similar and there will be no regional effect of the central policy. However, there are apparent differences in the fixed-asset investment between different provinces, and the industrial structure is not completely similar. As the transmission inter-mediacy of the central policy, the financial system also has inconsistencies in the degree of development in each province, mainly reflected in the scale of financial development and the quality of financial growth. The quality of finance evolution is primarily reflected in the relative cost of production factors, which has led to the optimization of industrial investment, resulting in industrial structure differentiation (Zhang Lin, 2016) [8].

This paper proposes Hypothesis 1: There are obvious differences in the response of regional macro-prudential policies in China.

The macro-prudential policy's primary purpose was to smooth the pro-cyclicality and reduce the risk amplification (Zhou Xiaochuan, 2011) [9], to achieve a counter-cyclical effect. The transmission needs two main channels: the credit channel (Song Wang, 2006) and the bank risk-taking channel [10]. Specifically, the credit channel depends on the loan-to-value ratio and debt-to-income ratio. The bank's risk-taking channel relies on the market's expectations, forward-looking on the direction of policy regulation, and counter-market situation. In contrast, the authorities limit the financial system's highest risk-taking by restricting leverage, capital adequacy, and bank provision coverage ratios. The level of regional financial development shows apparent differences, and there is a differentiation trend in the level of economic growth in various places. As the main of central policy transmission, differences in the

development of the financial system make the same policy have different responses.

Based on the above, this paper proposes Hypothesis 2: The regional level of financial development supports the transmission of regional macro-prudential policies, and provincial-level administrative regions with high levels of economic development respond better to macro-prudential policies.

Whether banks or non-banks play the leading role is affected by the industrial structure. Differences in industrial structure jeopardize the effectiveness of the banking and non-bank system. Countries with labour-intensive sectors are more suitable for banks to realize financial allocation. While the government with technology and product innovation as the leading industries is the ideal choice to rely on the financial market (Silvia J, 2011) [11]. Differences in industrial structure determine the positions of wealth effect constraints and competition effect constraints in policy transmission.

Based on this, this paper proposes Hypothesis 3: Regional macro-prudential policy response is related to local industrial structure.

The local industrial structure includes the Theil index, also called the industrial structure advanced index, and industrial structure rationalization (Fu Linghui, China National Bureau of Statistics). On the one hand, the advanced industrial structure measures the transformation from 1st or 2nd industries into the 3rd industry structure. The higher the parameter value of the flow of factors in the area, the more efficacious the allocation of resources will be.

On the other hand, when the economy is balanced, the productivity levels of various departments are theoretically very close, and the Theil index is closer to 0). Besides the credit and the bank's risk-taking channel, the wealth effect constraint and the competition effect constraint are also effective. The industrial structure determines the proportion of wealth effect constraints and competition effect constraints in the transmission process of macro-prudential policy.

Therefore, Hypothesis 3 can be sub-divided into:

Hypothesis 3.1 Rationalization of industrial structure harms the macro-prudential policy response.

Hypothesis 3.2 The advanced industrial structure positively affects the response of regional macro-prudential policies.

3. DATA SOURCES AND MODEL SETTINGS

3.1. Data source and variable definition

The research samples are 45 quarterly data from 2010 to 2021 among 31 provinces and 1395 quarterly balanced panel data. It includes three types of tools to describe macro-prudential policies, variables to describe the level of regional financial development, and variables used to calculate the advanced and rationalized industrial structure. The relevant indicators of macro-prudential policies are derived from the industry economic database, the National Bureau of Statistics, the statistics of local units, the Chinese Academy of Social Sciences, the People's Bank of China and the China Banking Regulatory Commission.

After obtaining the data list, the variables of each part also involve specific calculation methods, and the formula is now given.

$$MA = \frac{\sum_{j=1}^3 I_{aj}}{3} \quad (1)$$

$$MC = \frac{\sum_{j=1}^4 I_{cj}}{4} \quad (2)$$

$$ML = \frac{\sum_{j=1}^4 I_{lj}}{4} \quad (3)$$

The formula for calculating the composite index is as follows.

$$MP = \frac{3}{11}MA + \frac{4}{11}MC + \frac{4}{11}ML \quad (4)$$

The construction of the financial development level draws on the FCI index method commonly used in academia.

$$FD = \frac{1}{6}state_{owed} + \frac{1}{6}financing + \frac{1}{3}investment + \frac{1}{6}enterprise_{ratio} \quad (5)$$

This paper draws on the Theil index constructed by Qian Chunhui (2011) to describe the rationalization degree of regional industrial structure.

$$IR = \sum_{i=1}^n \left(\frac{Y_i}{Y}\right) \ln \left(\frac{Y_i}{L_i} / \frac{Y}{L}\right) = \sum_{i=1}^n \left(\frac{Y_i}{Y}\right) \ln \left(\frac{Y_i}{Y} / \frac{L_i}{L}\right) \quad (6)$$

This paper applies the "space vector angle method" constructed by Fu Linghui of the National Bureau of Statistics to describe the advanced regional industrial structure.

According to the proportion of the 1st, 2nd and 3rd industries in GDP at the initial moment, three components can be obtained respectively, so as to construct a 3-dimensional vector, and then calculate the vector $x_1 = (1, 0, 0)$, $x_2 = (0, 1, 0)$, $x_3 = (0, 0, 1)$ angle $\theta_1, \theta_2, \theta_3$.

$$IA = \sum_{k=1}^3 \sum_{j=1}^k \theta_j \quad (7)$$

$$\theta_j = \arccos \frac{x_{1,j} * x_{1,0} + x_{2,j} * x_{2,0} + x_{3,j} * x_{3,0}}{\sqrt{x_{1,j}^2 + x_{2,j}^2 + x_{3,j}^2} \sqrt{x_{1,0}^2 + x_{2,0}^2 + x_{3,0}^2}} \quad (8)$$

3.2. Data Descriptive Statistics

The explained variable is the regional response of macro-prudential policy (MP). The explanatory is the financial development index (FD), industrial structure rationalization (IR), industrial structure advanced (IA), and control variables. According to statistics, the average of the MP is 0.427, which is far from the optimal criterion of 0.5, indicating that the current effect of macro-prudential policy is not good enough. The reason may be that the development of the financial system is not perfect enough, or the industrial structure has not reached the optimal allocation. The minimum value is 0.115 indicates that the response of some provinces is weak, and the max value of 0.953 tells that the reaction of particular regions is excessive. The average value of the financial development index is 0.485, indicating significant room for improvement. The min value of the IR is 0.0175, which is close to the equilibrium state. At this time, the Theil index is 0. It shows that some provinces' industrial structures are reasonable in a certain period. According to mathematical derivation, the industrial structure advanced index IA is at most 3π , and the max value for local units is 5.234, indicating that China's current 3rd industry conversion rate is not high.

After accounting for the response of provinces, according to Table2, divided the country into four regions: provinces below the 1/4 quantile—named Policies failure area(Z1), sections near the median named Normal response area(Z2), and provinces near the optimal criterion: Optimal response area(Z3), exceeding the optimal criterion area called Over-response space(Z4).

Table 2. Differences in macro-prudential policy responses of 31 provincial-level administrative regions from 2010 to 2021

zone	province	response	zone	province	response
Z2	Shaanxi	0.37	Z3	Chongqing	0.41
	Yunnan	0.38		Fujian	0.41
	Guizhou	0.39		Jiangsu	0.41
	Hainan	0.39		Zhejiang	0.45
	Henan	0.40		Guangdong	0.47
	Hebei	0.40		Shanghai	0.47
	Hunan	0.39		Sichuan	0.49
	Hubei	0.39		Beijing	0.52
	Guangxi	0.40		Tibet	0.27
	Anhui	0.40		Qinghai	0.29
	Jiangxi	0.40		Gansu	0.29
	Z4	Heilongjiang		0.80	Z1
Shanxi		0.60	Xinjiang	0.33	
Shandong		0.60	Tianjin	0.33	
Liaoning		0.63	Inner Mongolia	0.34	
Jilin		0.66			

Macro-prudential policy responses are divided into four groups. The average value of each group is

significantly different. The average value is 0.3036, 0.3876, 0.4491, 0.6512, respectively. The analysis of variance results in the lower part $\chi^2(3) = 552.1182$, $\text{Prob} > \chi^2 = 0.000$, indicating rejection of the equal variance assumption. In other words, there are differences between groups, and the macro-prudential policy responses of different groups are also significantly different.

3.3. Correlation test

The paper has done Pearson correlation and Kendall correlation. According to the correlation test, the Pearson coefficient between MP and FD was 0.1636, while Kendall's was 0.1977. And the Pearson between MP and IA was -0.3358, and the Kendall was -0.3158. Besides, the coefficient between MP and IR was 0.0692 and 0.0316, respectively. All were significantly correlated at the significance level of = 5%, and the sign direction was consistent with the hypothesis, preliminary verification of Hypotheses 1, 2, and 3 proposed in the article. The maximum correlation coefficient between other independent variables does not exceed 0.5. We can consider there is no multicollinearity among the independent variables.

3.4. Econometric models and estimation methods

The test model is

$$\widehat{MP}_{i,t} = \gamma \widehat{FD}_{i,t} + \tau \widehat{IR}_{i,t} + \rho \widehat{IA}_{i,t} + \beta_k \text{control} + \varepsilon_{i,t} \quad (9)$$

γ represents the marginal effect of FD on MP. According to assumption 2, γ should be a positive number. τ is the marginal impact of IR on the dependent variable, and it is estimated from assumption 3.1 that it τ should be a negative value; ρ is the IA on the response is expected to be positive according to assumption 3.2.

Based on balanced panel data, it is necessary to judge whether fixed effects or random effects are more suitable. Since the Hausman test is not suitable for heteroscedasticity, the article chooses the robust Sargan-Hansen test. Got Sargan-Hansen statistic = 70.857, P-value = 0.0000, rejecting H_0 , a fixed-effect model should be used, not a random effect model.

4. MEASUREMENT RESULTS AND ANALYSIS

4.1. Regression analysis and robustness test of regional effects of macro-prudential policies

Based on the Gaussian Markov assumption, the common standard error may not suit panel data. Therefore, this paper adopts the robust error of clustering standard, taking province as the clustering standard. Observations in the same cluster are correlated, while obs

in different groups are not associated, thus ensuring that the coefficient estimates are reliable.

This paper estimates the fixed-effect model and the robust fixed-effect model. The following table shows the calculated results. From this, financial development is significant at the 1% significance level. The response to macro-prudential policies will increase by about 7.7 percentage for every doubling of financial development. It is not significant in the robust fixed-effect model, and in the fixed-effect model, the rationalization of the industrial structure is significant at 1 % significance level. Every time the rationalization of the industrial structure increases, the response of macro-prudential policies decreases by ten percentage points. The significance level of 1 % in the FE model is significant and significant at the 10 % significance level in the robust fixed-effects model. Every doubling of the advanced industrial structure brings a marginal positive benefit of 0.019.

The reasons may be in the following aspects. The more reasonable the industrial structure is, the more the rationalization index tends to 0, and the numerical influence changes in the opposite direction. The more in place the constraints of wealth and competition, the better the response to macro-prudential policies. The advanced industrial structure reflects the conversion rate to the 3rd industry. The more perfect the economic system, the more perfect the financial system is, the wider the channels for macro-prudential policies to exert wealth effect constraints and competition effect constraints through non-bank capital, and the better the response of macro-prudential policies.

The results consistently show that financial development positively affects the macro-prudential policy response, so Hypothesis 2 is confirmed. Rationalization of industrial structure has a pronounced negative impact on the macro-prudential policy response. That is, Hypothesis 3.1 is proved. The advanced industrial structure has a particularly positive effect on the reaction of macro-prudential policies. So far, Hypothesis 3.2 has been confirmed.

Table 3. Regression Analysis of Influencing Factors of Regional Effects of Macroprudential Policies

	(1)	(2)	(3)	(4)	(5)
FD	0.114 *** (0.007)	0.088 *** (0.008)	0.083 *** (0.011)	0.077 *** (0.011)	0.077 *** (0.021)
IR		-0.095 ***	-0.095 ***	-0.103 ***	-0.103 (0.058)

	(1)	(2)	(3)	(4)	(5)
		(0.015)	(0.015)	(0.014)	
IA			0.003 *** (0.005)	0.020 *** (0.005)	0.020 * (0.008)
C1				0.084 *** (0.007)	0.084 *** (0.010)
C2				-0.002 *** (0.000)	-0.002 *** (0.000)
				-0.014 *** (0.004)	-0.014 *** (0.003)
C3					
Intercept	0.372 *** (0.003)	0.407 *** (0.007)	0.405 *** (0.007)	0.363 *** (0.008)	0.363 *** (0.021)
N	1395	1395	1395	1395	1395
R ²	0.1668	0.1905	0.1908	0.2804	0.2804
P	0.0000	0.0000	0.0000	0.0000	0.0000

*, **, and *** indicate significant levels at 10%, 5%, and 1%, respectively

4.2. Robustness test of empirical analysis of macroprudential policies

Due to space limitations, the robustness test results are not all listed. To ensure the estimated effects are valid, we did several robustness tests. Firstly, the least-squares and the two-stage least squares are used for estimation. The over-identification test is carried out to obtain Sargan-Hansen statistic= 7.266, P-value = 0.2969, indicating that the coefficient of the two-stage least

square method is not significant, meaning that the variable endogeneity is not apparent.

Table 4. Robustness test results

	OLS	2SLS	Ln form FE	IR (2) FE	LSDV
FD	0.0724* (0.028)	0.0500* (0.028)	0.0638*** (0.011)	0.0744*** (0.010)	0.077 *** (0.021)
IR	-0.249 *** (0.023)	-0.231 *** (0.019)			-0.103 * (0.059)
IA	0.0045 (0.005)	0.0026 (0.003)		0.0306 *** (0.0049)	0.020 (0.008)
IR2				-0.002 *** (0.000)	
LIR				-0.0348 *** (0.004)	
LIA				0.0228 ** (0.007)	

Besides, taking the Ln function for some variables and using the industrial structure upgrading degree (Xu De Yun) to replace the original IR. The marginal effects of the main explanatory variables changed little after changing the data form and the data measurement method, and the signs were all not changed. At last, add provinces dummy variables into the LSDV model. Financial development is significant at the 1 % significance level, the rationalization of the industrial structure is significant at the 10% significance level, and the advanced industrial system fails the significance test. In addition, other explanatory variables are influenced unchanged. The R² of the LSDV model reaches 0.94, indicating that the model has explained 94 % of the probability, so the problem of missing variables can be approximately regarded as solved.

4.3. Heterogeneity analysis of macroprudential policy response

The heterogeneity of the four regions was verified by grouped regression. The financial development index is significant in the two groups. Its numerical value shows increasing characteristics, indicating that finance development may positively impact the response to macro-prudential policies. The coefficients of IR among the four groups are -0.134, -0.0265, -0.108, -0.280, which are all significantly different from zero at the 10% level. Showing the characteristics are reduction, indicating that the IR may affect the productivity of specific industrial construction sectors in various regions and affect

macroprudential policies. The advanced industrial system is only significant in the optimal response area. It is significantly positive, indicating that it positively impacts the response of macro-prudential policies.

5. CONCLUSIONS

5.1. Analysis conclusion

This paper studies the response of macroprudential policies in different provinces. Then, it explores the impact of the scale and quality of financial system development. This paper firstly constructs an index named MP to describe the macro-prudential policy response of each province. Then, it constructs a financial development index to measure the scale of regional financial development. Besides, two proxy variables, rationalization of industrial structure and advancement of industrial structure, are used to measure the quality of financial development, and the fixed effect model of stepwise regression and grouping regression is adopted. Analytical heterogeneity and the LSDV model explored the individual heterogeneity of each local unit.

The results show:

(1) There is apparent regional differentiation in China's macro-prudential policy response, which can be divided into policy failure areas, Normal response areas, Optimal response areas, and Over-response areas.

(2) The level of financial development positively affects the transmission of macro-prudential policies. Still, there is a lack of financial supervision in areas where the financial system is not systematic.

(3) The rationalization of industrial structure (IR) has a significant effect on the response of macro-prudential policies. The more reasonable the industrial system, the smaller the Theil index, and the more suitable the response of macro-prudential policies. The role of advanced industrial structure is most significant in the optimal response area. The higher the IA, the more reasonable the allocation of resources will lead to a positive spill over effect.

5.2. Policy Implications

(1) According to the differentiation trend of macro-prudential policy response, provinces in different clusters need to be regulated separately. Most of the over-response areas are old industrial areas, and the transmission mechanism has a good foundation. However, financial development lacks monitoring and has high risks. On the contrary, most policy failure areas are western provinces with a backward economy, which should develop finance levels, and build transmission intermediaries.

(2) Since the financial development level has a positive impact on the response to macro-prudential policies, it is necessary to promote the rational development of the financial system. On the one hand, improve the supervision mechanism, so that the finance system can develop healthily. On the other hand, encourage high-level regions to carry out cross-regional cooperation and guide backward areas to develop finance through the establishment of branches.

(3) Promoting the rationalization and upgrading of the industrial structure will help enhance the quality of the development of the financial system, thereby making policy transmission smoother. Encourage developed regions to transfer industrial structures, realize a one-help-one mechanism, ensure soft cross-regional production factors, and achieve a more reasonable large-scale industrial structure and a more developed tertiary industry.

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