

Heterogeneity Analysis of Metropolitan Area Policies Affecting Regional Economic Growth and Examination of the Mechanism --Evidence from Municipal Panel Data from 2012-2021

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Abstract. As urbanization deepens, metropolitan areas have gradually become an important vehicle for regional economy development. To study how metropolitan area planning will affect regional economic growth, this paper considers metropolitan area planning as a regional economic policy and examines the effect of metropolitan area policy on regional economic growth based on panel data of metropolitan areas within the Yangtze River Delta city cluster and Chengdu-Chongqing city cluster from 2012 to 2021, using a multi-period difference-in-difference model. It is found that: (1) the policy of metropolitan area generally promotes regional economic growth and enhances the regional economic growth rate; (2) there is some heterogeneity in the policy effects of metropolitan area, specifically: the positive promotion effect of the policy on Shanghai metropolitan area and Hangzhou metropolitan area is obvious, while Nanjing metropolitan area and Chengdu-Chongqing twin-city economic circle do not benefit from it; (3) the economic benefits brought by the policy of the metropolitan area are jointly determined by the spillover effect of the central city and the siphon effect, and the larger the economic scale of the central city, the more significant the positive impact on the economy of the surrounding areas; (4) the policy effectiveness of the metropolitan area decays with the expansion of the radius of action.

Keywords: metropolitan area; regional economy; spillover effect; difference-in-difference.

1. Introduction

Metropolitan area is a product of advanced urbanization. The construction of modernized metropolitan areas is an important measure to achieve coordinated regional development. In 2019, the National Development and Reform Commission clearly pointed out in the "Guidance on Fostering the Development of Modernized Metropolitan Areas" that the construction of modernized metropolitan areas is an important means to promote urbanization, which is conducive to optimizing the spatial structure of population and economy, activating effective investment and potential consumption demand, and enhancing endogenous development momentum. As a representative region with a mature economic development model in China, the Yangtze River Delta region has a high level of urbanization and can provide a typical demonstration for other regions. The Chengdu-Chongqing region, as the key target of China's regional economic development in recent years, has huge development potential. From "Chengdu-Chongqing Economic Zone" to "Chengdu-Chongqing City Cluster" and then to "Chengdu-Chongqing Twin-City Economic Circle", the development of Chengdu-Chongqing region has risen to the height of national strategy.

Therefore, it is of practical significance to analyze the effects and mechanisms of urban economic growth in metropolitan areas to improve the urban spatial structure and regional coordinated development in China.

2. Review of Literature

The structure of "central city-metropolitan area-city cluster" will be the main carrier of regional economic development in China for a long period of time. At the early stage of urbanization, production factors are concentrated in the central cities, and the polarization effect is greater than the radiation effect, which makes the central cities become the economic growth poles. When

urbanization reaches a certain stage, the core area starts to produce economic spillover to the surrounding areas, and this kind of multiple cities with economic linkage under the role of radiation and radiated relationship forms the prototype of metropolitan area in a certain range.

It is generally believed that the concept of metropolitan area originated from the Megalopolis proposed by Gottman in 1957[1]. In 1992, Yao proposed the concept of Urban Agglomeration and summarized it as a considerable number of cities of different nature, type and scale within a specific geographical area, with one or two mega or large cities as the core of the regional economy. With the help of the comprehensive transportation network, the interconnectedness of cities occurs and develops. The interconnectedness of individual cities constitutes a relatively complete urban "aggregate"[2].

Hu et al. (2022) measured and decomposed the economic disparity of cities within metropolitan areas, finding that China's mature and developing metropolitan areas are in the process of "nucleation". The siphoning effect of central cities is relatively obvious, but the diffusion effect has increased at the same time. The siphoning effect of the central city is not yet significant[3]. By conducting a panoramic scan of China's metropolitan areas, Lu et al. (2021) found that the correlation between the spatial expansion and the intensity of metropolitan areas indicated an inverted "U"-shape. And it corresponded to the three stages of metropolitan area development[4].

Xiao and Li (2020) suggested that the radiation effect of central cities is important for regional economic development. Besides, the radiation-driven effect depends on the strength of both central cities' radiation capacity and adjacent areas' ability to accept industrial transfer[5]. Meng et al. (2021) argued that core cities and regional central cities determine the extent of modernization. The capacity of neighboring area absorbing factor-spillovers has an important impact on the sustainability of modernization[6]. Zhang et al. (2021) found that with the synergistic effect of spatial networks, central cities can drive the surrounding areas to better withstand external shocks and thus enhance regional economic resilience[7].

As cities expand in size, the costs arising from the negative externalities of agglomeration will gradually outweigh the benefits brought by economies of scale, eventually leading to the transformation of the spatial structure from monocentric to polycentric. Therefore, the polycentric structure will become the main form of large cities in China in the future. But in the actual implementation process, the effect of polycentric structure is not obvious[8]. Yang (2021) argues that the imperfect rationality of market players and information asymmetry lead to a time lag in the formation of polycentric structure[9]. Wang and Liu (2021) found that polycentric structure inhibits regional innovation, but the negative effects of polycentricity can be mitigated to some extent by the increase of city size[10]. The polycentric structure and dynamic industrial agglomeration are conducive to urban productivity synergy, but more conducive to the efficiency of large-scale cities, the development of small cities is limited, and the phenomenon of "one city alone" in some areas will inhibit the development of neighboring cities and reduce the overall economic efficiency of the region[11][12]. Chen et al. (2021) argued that the impact of polycentric structure on economic efficiency is an inverted "U" type of non-linear relationship. Cities with similar level of development are not conducive to market integration and economic efficiency improvement[13].

3. Theoretical mechanisms and research hypotheses

The spatial clustering of cities strengthens the economic spillover to the surrounding areas. The metropolitan area policy brings positive externalities to the regional economy through two main paths. Firstly, the implementation of metropolitan area policy can help reduce intra-regional transportation costs. As the main medium for knowledge and innovation spillovers, the reduction of transportation costs, especially high-speed railway, promote the technology spillovers from the central cities. Secondly, the implementation of metropolitan area policies can promote the free flow of production factors, which helps industries with a high degree of interconnectedness to gather and form industrial clusters, thus reducing production costs and market search costs. Such a process further expands

economies of scale. Thus, the positive externalities of agglomeration are transformed into centrifugal forces that drive the economic benefits from point to point, which in turn drives the overall economic growth of the region.

Hypothesis 1: The metropolitan area policy promotes regional economic growth.

In the process of metropolitan area formation and development, the status of central cities and other parts is often unequal. Central cities often have better economic foundation in the initial stage and hold most economic resources, especially high-quality production factors. With further expansion of the economic scale of the central city, the core area may exert a siphon effect on adjacent regions. Moreover, the reduction of transportation costs accelerate the concentration of production factors to the central city, hindering the development of the peripheral areas and widening the gap in the region.

Based on the analysis above, whether the metropolitan area can drive urban economic growth lies in the comparison of the power between the spillover effect and the siphon effect. When the centrifugal force caused by the spillover effect is greater than the centripetal force caused by the siphon effect, the spillover effect will dominate and the metropolitan area policy will promote regional economic growth. Conversely, when the centripetal force is greater than the centrifugal force, the siphon effect will offset the economic benefits of the spillover effect, and the development of the metropolitan area will widen the economic gap between cities and hinder the overall development of regional economy.

Hypothesis 2: The effect of metropolitan area policy varies. When the spillover effect dominates, such a policy boosts economic growth. When the siphon effect dominates, it hinders economic growth.

The economic radiation range of the central city is proportional to its economic scale. On the one hand, spillover effect is positively related to the economic level of the central city. On the other hand, the agglomeration shadow area caused by the siphon effect also expands with the strengthening of the economic strength of the central city. And these cities are more likely to become subordinate to the core area.

Hypothesis 3: The effectiveness of metropolitan area policies is related to the central city. When the spillover effect dominates, metropolitan area policies promote economic growth; when the siphon effect dominates, metropolitan area policies hinder economic growth.

Tobler's first law of geography holds that the degree of mutual influence of regions is negatively related to distance, so the spillover effect of the central city will also be affected by the spatial distribution of cities. Generally, cities closer to the central area gain more benefits from economic spillover[14].

Hypothesis 4: The effect of metropolitan area policy decreases as the distance increases.

4. Model construction

4.1 Sample selection and data sources

This paper takes the five major metropolitan areas within the Yangtze River Delta city cluster and Chengdu-Chongqing city cluster as the research objects, namely Shanghai metropolitan area, Nanjing metropolitan area, Hangzhou metropolitan area, Chengdu metropolitan area, and Chongqing metropolitan area. Samples are based on the data of each city within those five metropolitan areas during the time span of 2012-2021. Since the main metropolitan area of Chongqing was expanded in 2020, previous economic plans corresponded to Chengdu-Chongqing city cluster, so this paper will still use the Chengdu-Chongqing cluster in the subsequent empirical process. The data involved are from “Chinese City Statistical Yearbook”, “local statistical yearbooks” and “local government statistical bulletins on national economic and social development”. Several missing statistics are interpolated and extrapolated to form a balanced panel.

Table 1 Time and main contents of relevant policies

Metropolitan area	Time	Important documents and decisions	Main contents
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Shanghai Metropolitan Area	2016	Shanghai Urban Master Plan (2016-2040) (Draft) ("Shanghai 2040")	Actively promoting the co-location of Shanghai metropolitan area
Nanjing Metropolitan Area	2015	Implementation Plan for the Reform of the Mechanism for Sound Synergistic Development of Nanjing Metropolitan Area	
Hangzhou Metropolitan Area	2014		The Development and Reform Commission approved the comprehensive reform for upgrading Hangzhou metropolitan area
Chengdu Metropolitan Area (Chongqing Metropolitan Area)	2016	Development Plan of Chengdu-Chongqing City Cluster	Promote the construction of twin-city economic circles in Chengdu and Chongqing

4.2 Model Establishment

In order to avoid the endogeneity problem caused by the ordinary panel regression, the metropolitan area is considered as a regional economic policy. Considering the different enactment and implementation times of the policies concerning each area, this paper applies a multi-period difference-in-difference model for empirical analysis. The model is established referring to Beck(2010) [15] and Ding et al. (2021) [16].

$$rgdp_{it} = \alpha_0 + \theta Did_{it} + \beta_0 X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Where

$rgdp_{it}$ refers to the economic growth rate of the i th city in year t ;

μ_i , λ_t , and ε_{it} respectively refers to individual fixed effects, time fixed effects and the random disturbance term.

Did_{it} is a binary dummy variable indicating political intervention, which is composed by $treat_i \times time_t$. The individual dummy variable $treat_i$ takes the value of 1 if the city is part of a metropolitan area, otherwise it remains 0. The time dummy variable $time_t$ takes the value of 1 after year t when the policy has been enforced, and 0 otherwise. Therefore, the binary dummy variable Did_{it} means that the i th city joined the metropolitan area as a treatment group in the year t . The coefficient θ reflects the strength of the metropolitan area policy effect.

X_{it} is a vector of control variables including: investment scale (INV), industrialization degree (IND), government expenditure (GOV), and innovation level (PAT). β_0 is the coefficient.

5. Analysis of Empirical Results

5.1 Regression Results

The results of the multi-period difference-in-difference benchmark regressions are shown in Table 2. Column (1) shows the correlation between the explained variable urban economic growth rate and the core explanatory variable metropolitan area policy post, controlling individual fixed effects and time fixed effects. The regression coefficient holds at a 5% significance level. Column (2) introduces the control variables based on (1), indicating that the metropolitan area policy has a positive effect on regional economic growth. And the implementation of such policy increases the overall urban economic growth rate by 3.97%. To further analyze whether there is regional heterogeneity in the

effect of the policy, regressions are conducted in columns (3), (4), (5), and (6) respectively for the Shanghai metropolitan area, Nanjing metropolitan area, Hangzhou metropolitan area, and Chengdu-Chongqing economic circles. The coefficients of Shanghai metropolitan area and Hangzhou metropolitan area are positive and hold at the 10% significance level, indicating that the policy promotes economic growth. However, the coefficients of Nanjing metropolitan area and Chengdu-Chongqing economic circles are negative, indicating that the policy effect hinders regional economic growth. The results confirm the heterogeneity regarding the effect of metropolitan area policies in different regions.

Table 2 Regression results of the multi-period difference-in-difference model

Variables	<i>rgdp</i>					
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Did</i>	0.241** (2.10)	3.973** (1.97)	1.212* (1.71)	-0.099*** (-4.06)	0.585* (1.85)	-3.973* (-1.97)
<i>ind</i>		0.012 (0.16)	0.054 (0.57)	0.022 (0.28)	-0.120 (-1.59)	0.012 (0.16)
<i>inv</i>		0.047** (1.99)	0.059** (2.11)	0.054** (2.13)	0.070** (2.42)	0.047** (1.99)
<i>gov</i>		0.284** (2.14)	0.276* (1.75)	0.251* (1.62)	0.195 (1.41)	0.284** (2.14)
<i>pat</i>		0.000 (-0.65)	0.000 (-1.54)	0.000 (-0.94)	0.000 (-0.22)	0.000 (-0.65)
<i>_cons</i>	0.111*** (13.55)	5.326 (1.30)	-0.918 (-0.16)	1.358 (0.29)	10.181** (2.26)	1.255 (0.28)
Individual fixed effects	Control	Control	Control	Control	Control	Control
Time fixed effects	Control	Control	Control	Control	Control	Control
<i>R – squared</i>	0.47	0.45	0.36	0.29	0.56	0.32
<i>Obs</i>	740	740	240	210	120	170

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, t-values in parentheses.

5.2 Parallel trend test

To exclude the effect of the differences between the treatment and control groups on estimating the actual policy effect, the paper undertakes a parallel trend test. It changes the year and repeats the regression to see if the coefficients are still significant. *pre_i* represents the *i*th year before the policy post; *post_j* represents the *j*th year after implementation. The coefficients are all insignificant in the year before the policy post. So the sample passes the parallel trend test.

Table 3 Parallel trend test regression results

Variables	(1)	(2)	(3)	(4)	(5)
<i>pre_i</i>	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
<i>post_j</i>	Control	Control	Control	Control	Control

5.3 Robustness test

This paper changes the time point of the policy post to exclude the effect of unknown factors and tests the robustness of the regression results. The time point of the policy shock is adjusted forward. If the coefficient is not significantly positive after adjusting the time, it indicates that the regional economic growth is resulted from the policy rather than random factors. Column (1), (2), and (3) in Table 4 respectively show the results of the full-sample benchmark regressions adjusted forward by 1, 2, and 3 years. Column (4) and (5) show the results of the benchmark regressions for the Shanghai

metropolitan area adjusted forward by 1 and 2 years. Column (6) and (7) show the results of the benchmark regressions for the Hangzhou metropolitan area adjusted forward by 1 and 2 years. The coefficients are negative after advancing the time point. Therefore, the regression results are robust enough.

Table 6 Robustness test regression results

Variables	<i>rgdp</i>						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
<i>Did</i>	- 1.445** (-2.66)	- 2.011*** (-3.93)	- 2.196*** (-4.19)	- 1.302** (-2.60)	-1.329* (- 1.64) (-1.64)	- 1.543** (-2.74)	-1.136* (- 1.75) (-1.75)
<i>_cons</i>	7.150 (1.35)	7.702* (1.53)	6.459 (1.42)	4.673 (1.02)	3.552 (0.76)	3.770 (0.86)	3.437 (0.81)

*** p<0.01, ** p<0.05, * p<0.1, t-values in parentheses.

6. Mechanism examination

As mentioned earlier in the paper, the impact of metropolitan area policy on regional economic growth is mainly the result of the combined effect of both the economic spillover and the siphon effect. Since the economic spillover is closely related to the radiation capacity of the central city and the distance, this paper further analyzes the mechanism of metropolitan area policy from two aspects: the radiation capacity of the central city and the radius of the policy.

6.1 Radiation capacity of the central city

Generally, the radiation capacity of the central city is positively related to the economic size. Therefore, on the basis of the baseline regression model, the economic scale of the central city (*cgdp_{it}*) is introduced:

$$rgdp_{it} = \alpha_0 + \theta Did_{it} + \theta_i Did_{it} \times cgdp_{it} + \beta_0 X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Column (1) in Table 7 is a full-sample regression, and columns (2) to (5) are sub-regional sample regressions corresponding to the Shanghai metropolitan area, Nanjing metropolitan area, Hangzhou metropolitan area, and Chengdu-Chongqing twin-city economic circles. The regression results show that most coefficients of the interaction variable (θ_i) pass the 10% significance level test, indicating that central cities do have a positive impact on regional economic growth through economic spillovers.

Table 7 Regression results of introducing the economic scale of central cities

Variables	<i>rgdp</i>				
	(1)	(2)	(3)	(4)	(5)
<i>Did</i>	2.598 (1.17)	-3.496 (-0.63)	- 5.750*** (-1.35)	3.522* (1.60)	- 5.286*** (-2.83)
<i>Did × cgdp</i>	0.112* (1.69)	0.000 (0.86)	0.031* (1.39)	0.040* (1.70)	0.073* (1.79)
<i>_cons</i>	4.321 (0.96)	-1.001 (-0.17)	0.332 (0.06)	8.926** (2.00)	0.132 (0.27)
<i>R</i> <i>-squared</i>	0.48	0.37	0.32	0.60	0.45

*** p<0.01, ** p<0.05, * p<0.1, t-values in parentheses.

6.2 Radius of the policy effect

To verify how the radius influence the policy effect, the geographical distance from each city to the central city (*dis_i*) is introduced in the regression model as below:

$$rgdp_{it} = \alpha_0 + \theta Did_{it} + \theta_i Did_{it} \times dis_i + \beta_0 X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

The coefficients θ_i of the interaction term are all negative, indicating that the policy effect of metropolitan area decreases as the distance increases.

Table 8 Regression results of the introduced distance

Variables	<i>rgdp</i>				
	(1)	(2)	(3)	(4)	(5)
<i>Did</i>	3.847* (1.79)	2.468* (1.65)	0.829 (0.32)	0.714 (0.78)	-1.011 (-0.55)
<i>Did × dis</i>	-0.001 (-0.14)	-0.008 (-0.78)	-0.009 (-0.48)	-0.001 (-0.19)	-0.047 (-0.95)
<i>_cons</i>	5.199 (1.25)	-0.838 (-0.14)	1.248 (0.26)	10.208** (2.25)	1.077 (0.24)
<i>R – squared</i>	0.45	0.37	0.29	0.56	0.48

*** p<0.01, ** p<0.05, * p<0.1, t-values in parentheses.

7. Conclusions

Based on the multi-period difference-in-difference model, this paper finds that metropolitan area policies have an overall positive effect on economic growth within Yangtze River Delta city cluster and Chengyu city cluster. The heterogeneity test of metropolitan areas proves a promotion effect of metropolitan area policy on Shanghai metropolitan area and Hangzhou metropolitan area, while Nanjing metropolitan area and Chengdu-Chongqing economic circle are more affected by the siphoning effect and the economic growth is limited. Further analysis of the mechanism reveals that economic benefits of the metropolitan area are determined by both the spillover effect of the central city and the siphon effect, and the larger the economic scale of the central city, the more significant the positive impact on the economy of the surrounding areas. Finally, the policy effect of the metropolitan area weakens with the expansion of the radius of action, and the intensity of the policy effect is negatively related to the distance.

Based on the findings, the following suggestions are proposed regarding the development of metropolitan areas in China: First, the spatial layout of metropolitan areas should be reasonably planned. Metropolitan areas do have a positive effect on regional economic growth, but the effect varies depending on many factors. Therefore, when planning the metropolitan area, we should consider the radiation capacity of the central city, industrial copolymerization, agglomeration shadow and other aspects. Second, given that the economic hinterland of the central city is often affected by the siphon effect and the shadow of agglomeration can lead to negative externalities, it is necessary to put forward market-oriented reforms and smooth the flow of production factors to make full use of the economic spillover from the central city. Besides, the government should assist peripheral areas to take in industrial transfers from the core area, thus promoting the transformation and upgrading of industrial structures. In addition, it is necessary to further strengthen the regional specialization division of labor, so that small and medium-sized cities can get rid of their over-dependence on the central cities, take advantage of function-borrowing and scale-borrowing, and promote the the rational development of the metropolitan area system. Third, the spatial scope of the metropolitan area should be reasonably planned. The metropolitan area is by no means the bigger the better. There is an optimal scale. Geographical distance will not only prevent the policy effect from benefiting the peripheral areas, but also cause higher coordination cost. Therefore, in the process of developing metropolitan areas, we should be wary of the disorderly expansion of the metropolitan area.

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