THE UNIVERSITY OF CHICAGO

Fiscal Decentralization and Regional Growth: Evidence from China

By

Harlly Hongyi Zhou

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Faculty Advisor: Kanit Kuevibulvanich

Preceptor: Kanit Kuevibulvanich

Abstract

This paper investigates the relationship between city-level fiscal decentralization and economic growth of cities within China, incorporating the new perspective of spatial analysis. Utilizing data on fiscal decentralization alongside other economic metrics from the period 2010 to 2019, the research aims to delineate the influence of fiscal decentralization on urban economic expansion. Notably, this analysis integrates an assessment of the spatial spillover effects to enhance the depiction of growth patterns of cities. The empirical results suggest that fiscal decentralization is positively correlated with economic growth at the city level. Meanwhile, the efficacy of fiscal decentralization in stimulating economic growth is found to be weaker in cities that serve as provincial capitals. As an additional result, the study also uncovers that spillover effects from adjacent cities predominantly serve as a deterrent to economic growth in neighboring municipalities.

Keywords: Fiscal Decentralization; Regional Growth; Spatial Correlation; China Economy

1 Introduction

In effect, decentralization, which generally takes the form of transferring power from the central government to sub-level governments or non-government organizations, can result in more efficient growth and, on the other hand, higher organizational and administrative costs (Rondinelli et al., 1983; Rondinelli & Nellis, 1986).

In economic analyses of developmental trajectories, the Chinese economy is often regarded as an exceptional case, characterized as a 'miracle' due to its sustained high growth rates over several decades. There is a broad consensus among scholars that the 'Reform and Opening Up' policy, initiated by Xiaoping Deng in 1978 and subsequently pursued by later Chinese governments, has been a main contributor to this prolonged economic expansion. This policy fundamentally aims to institute internal reforms and foster connection with the global market, thereby transitioning away from the centralized and relatively insular economic system prevalent prior to 1978. While the overall efficacy of this policy is well-acknowledged, the specific impact of its various components remains a subject for rigorous scholarly examination.

Economic development in China exhibits heterogeneity across different regions, influenced by a combination of distinct policies, cultural diversity, and various socio-political and socio-economic factors. This diversity notably affects the degree and efficacy of fiscal decentralization policies. Such heterogeneity is crucial as it offers valuable insights for public finance policymaking, enabling the formulation of strategies that not only support intra-regional economic development but also aim to mitigate growth disparities inter-regionally.

Empirically, this study investigates the impact of fiscal decentralization at the city level on municipal economic growth within China. Furthermore, this paper explores the effects of fiscal decentralization from a political perspective, examining whether cities with higher political ranking gain more substantial benefits from fiscal decentralization. The remainder of the paper is structured as follows: Section 2 provides a review of the relevant literature. Section 3 describes the data used in this study and elaborates on the construction of the spillover effect measurement. Section 4 discusses the empirical methodologies employed and presents the findings. Section 5 offers an analysis of several robustness tests, and Section 6 concludes the study.

2 Literature Review

The study of fiscal decentralization in China demands an international perspective. Martinez-Vazquez et al. (2014) provide a comprehensive overview of China's public finance system, setting a foundational context for further studies. Based on this, Bloom et al. (2012) analyze decentralization from a microeconomic perspective, proposing that while trust facilitates decentralization and increases firm size, it has potential drawbacks. Specifically, they argue that in contexts where decentralization costs are high, welfare may decline as efficient firms face increased growth impediments. Helmut & Theilen (2017) employ a fixed-effect model and an error-correction framework to demonstrate a negative correlation between fiscal decentralization and public spending. Echoing with the implementation of the opening up policy, Li et al. (2003) contend that fiscal decentralization may intensify regional protectionism and exacerbate competitive pressures among regions. In recent years, with the central government's increased emphasis on sustainable development, new research avenues have opened. For example, Hao et al. (2020) investigate the impact of fiscal decentralization on environmental quality, finding that it does not significantly influence environmental pollution.

Theoretical frameworks typically focus on the provision and distribution of public goods like infrastructure and fiscal systems, but China presents a unique case where the government also significantly controls private goods, such as vehicles and medicine, challenging the applicability of models based on public goods. Notable works, such as Alesina & Spolaore (2003) and Davoodi & Zou (1998), contributed to understanding the optimization problem of fiscal decentralization and the concept of "equilibrium" within this context.

Empirical research aligns broadly with theoretical propositions. For instance, Huang et al. (2017) validated Hayek's hypotheses on decentralization using data from China, which states that governments further from the SOE should decentralize the contro l rights to a lower-lever government closer to the

SOE. This paper indicates that an optimal level of fiscal decentralization is based on certain spatial characteristics. Despite the variety of empirical methodologies, there's no consensus on the effect of fiscal decentralization on China's economic growth due to differing analytical strategies and results. Studies such as Zhang & Zou (1998), Lin & Liu (2000), Jin & Zou (2002), and Thushyanthan & Feld (2013) demonstrate varying results, often conflicting at different levels. A critical consensus on defining fiscal decentralization—typically using ratios of government finance between local and superior governments—provides a unified foundation for research, avoiding the pitfalls of inconsistent measurement standards.

In particular, Zhang & Zou (1998) and Davoodi & Zou (1998) showed that at a provincial level, the effect of fiscal decentralization is negative, while Lin & Liu (2000) and Thushyanthan & Feld (2013) exhibit positive results at provincial level in China and national level within OECD countries, respectively. These literature provide insightful empirical design, but some aspects are often ignored. First, economic interactions across regions have an impact on growth, which were overlooked by previous literature. Second, there were many concurrent reforms in China. For example, the "opening up" policy, the urbanization process, and the "rejuvenating the country through science and education" strategy (initiated in 1988, focusing on changing the driver of growth from labour to technology and human capital) were generally not considered, which is likely to cause an identification problem for the effect of fiscal decentralization. Moreover, the absence of fixed effect in previous literature ignored the importance of the unobserved heterogeneity across cities, which will be considered in the empirical strategy of this paper.

3 Data and Measurement

3.1 Overview of Data

The dataset utilized in this research is sourced from the China Statistical Yearbook and Gaode, a publicly available mapping application in China. It consists of city-level data including government expenditures and revenues, GDP per capita, among other economic indicators, as well as distance measurements. The dataset is a balanced panel dataset.

Several provinces have been excluded from our dataset due to issues related to measurement errors and the availability of data. These provinces include Inner Mongolia, Ningxia, Gansu, Xinjiang, Tibet, Yunnan, Guizhou, Sichuan, Qinghai, and Hainan. [1] Additionally, the provincial-level municipalities of Chongqing, Beijing, Tianjin, and Shanghai are omitted as they do not align with the classification of "cities" in this paper.

3.2 Growth Data

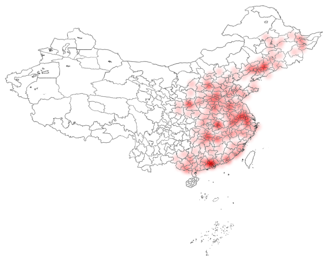
Table 1 provides a quantitative summary of the annual growth rates, highlighting the mean growth rates across selected cities within four sample provinces: Liaoning, Shaanxi, Guangdong, and Jiangsu. Notably, the table reflects a general slowdown in growth rates, with a temporary rebound in 2017. Additionally, comparing across the provinces, the table shows that economic growth in China has been highly uneven, with higher growth rate observed in areas adjacent to Shanghai and the Greater Bay Area.

Table 1: Summary of Growth Data

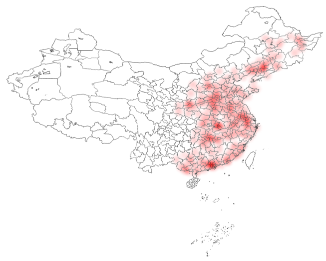
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Mean	16.01	13.31	8.45	6.43	3.68	2.96	2.56	6.61	4.03	0.94
St.Dev.	5.29	6.35	6.35	4.79	5.72	5.49	5.49	5.49	5.02	13.41

In Figure 1, heat maps are utilized to illustrate the dynamics of regional growth across China, with varying shades indicating the intensity of growth rates. The darker the red colour is, the higher the growth rate is in that city. Areas without color represent regions excluded from the dataset. This visual representation echoes the uneven growth as well as the trend of slowdown shown in Table 1.

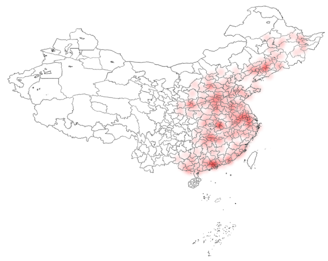
[1] In China, the administrative structure comprises three tiers: province, city, and county. Among the provinces, Inner Mogolia, Ningxia, Xinjiang, Tibet, and Guangxi are autonomous regions for the minority nationalities. Hereby, this dataset excludes all the cities within the above-mentioned provinces or regions.



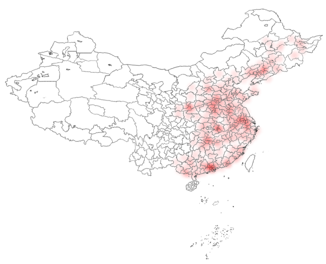
(a) Subfigure 1: Year 2010



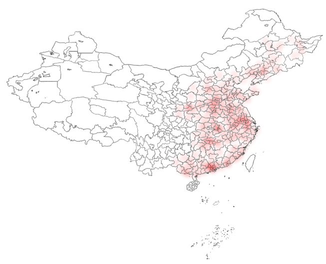
(b) Subfigure 2: Year 2011



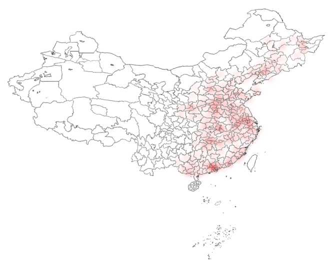
(c) Subfigure 3: Year 2012



(d) Subfigure 4: Year 2013



(e) Subfigure 5: Year 2014

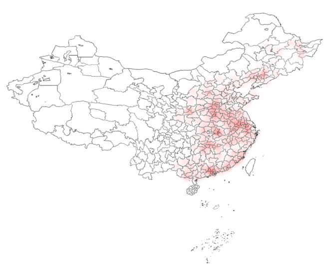


(f) Subfigure 6: Year 2015

(g) Subfigure 7: Year 2016

(h) Subfigure 8: Year 2017

(i) Subfigure 9: Year 2018



(j) Subfigure 10: Year 2019

Figure 1: Figure 1: Dynamics of per Capita GDP Growth Rate from 2010 to 2019

Note: The growth is defined as the per Capita real GDP growth rate.

3.3 Measurement of Fiscal Decentralization

This paper uses two distinct methodologies to quantify the level of fiscal decentralization within a city, specifically adopting the revenue approach (DC_{rev}) and the expenditure approach (DC_{exp}), as proposed by Zhang & Zou (1998). Within the framework of China's fiscal system, city-level government revenue contributes to the broader provincial government revenue pool, while expenditure allocations are influenced by provincial directives to varying extents. A higher degree of fiscal decentralization implies that city governments retain a greater proportion of their generated revenue and exercise increased autonomy over their expenditures, independent of provincial oversight. The formulas used to calculate these measures are as follows:

$$DC_{rev} = \frac{\text{City Fiscal Revenue in per capita}}{\text{Provincial Fiscal Revenue in per capita}} \quad DC_{exp} = \frac{\text{City Fiscal Spending in per capita}}{\text{Provincial Fiscal Spending in per capita}}.$$

Table 2: Summary of Fiscal Decentralization Level

	Decentralization (Expenditure) (%)		Decentralization (Revenue) (%)	
Year	Mean	St.Dev.	Mean	St.Dev.
2010	6.37	4.83	6.50	6.49
2011	6.17	4.24	6.41	6.54
2012	6.33	4.20	6.52	6.54
2013	6.39	4.32	6.76	7.81
2014	6.47	4.36	6.66	6.65
2015	6.48	4.36	6.68	6.89
2016	6.62	4.64	6.68	7.06
2017	6.61	4.70	6.58	7.09
2018	6.63	4.69	6.52	7.24
2019	6.66	4.68	6.57	7.23

Table 2 shows a summary of the two ratios. The revenue approach ratios are in general higher than the expenditure ratios, suggesting that while city governments have some leeway in retaining their revenue, the discretion in expenditure remains relatively constrained.

3.4 Measurement of Spillover Effect

Note that this paper tries to find the effect of fiscal decentralization on city economic growth. In particular, this paper discusses the issue about economic growth in a certain region. Recognizing the significance of interregional economic activities, it is imperative to consider the spillover effect, which has been notably overlooked in prior analyses as discussed in Section 2. Such omission may affect the interpretability of the results. Therefore, it is essential to develop a measurement of spillover effect to be incorporated in the empirical model.

Based on Moran (1950), Getis & Ord (1992), Ord & Getis (1995), Anselin (1995), and Long (1999), this paper uses the criterion called Moran's I. This measurement was used to measure spatila autocorrelation, which is closely related to spillover effect. This paper, based on the conventional Moran's I, proposes a modified version to better suit the analysis of economic spillovers, a concept of paramount relevance to this investigation. This paper first introduces the conventional Moran's I, and then progresses to explain the newly proposed measurement.

3.4.1 Conventional Moran's I

Moran's I has two forms, the local I (often referred to as I_i to indicate a local region i) and the global I. The local statistic assesses the spillover effect on an individual city basis, revealing localized patterns of growth interdependence. On the other hand, the global version measures the aggregate effect within a region, offering insights into broader economic interconnections. Generally speaking, the statistic is derived as a normalized weighted average of correlation.

Consider a study analyzing spatial correlation of a variable of interest x across m regions indexed by i. By fixing a distance d, all the regions can be classified into two categories relative to region i, call the centered region: the "adjacent" ones that are located within a radius d, and others that are located outside the radius d. An adjacency index γ_{ij} is assigned such that

$$\gamma_{ij} = \begin{cases} 1 & \text{if } j \in B(i,d) \setminus \{i\} \\ 0 & \text{otherwise} \end{cases}$$

This indicates that if a region is classified as "adjacent", then assign 1 to the region, 0 otherwise. The reason why the index is indexed by both i and j is that when changing the centered region from i to i', the index for other regions will change.

With this index, one can define the number of adjacent regions to region i to be $n_i = \sum_{j=1}^{m} \gamma_{ij}$.

Now consider the weighted average. Moran (1950) proposes a weighting matrix $\Omega = [\omega_{ij}]$ such that

$$\omega_{ij} = \frac{\gamma_{ij}}{n_i} = \begin{cases} \frac{1}{n_i} & \text{if } j \in B(i,d) \setminus \{i\} \\ 0 & \text{otherwise} \end{cases}$$

Furthermore, define $z = x - \bar{x}$ to be the demeaned variable of interest, where $\bar{x}$ is the mean of the variable of interest x. The variable z is indexed by ij to reflect its definition relative to both a centered region i and one of its adjacent regions j. From this point, j is used to index the **adjacent regions** only, thus $j = 1, 2, \cdots, n_i$ for a centered region i. The explicit formulae are given as follows:

$$\text{Local Moran's } I : I_i = \frac{z_{ii} \sum_{j \neq i}^{n_i} \omega_{ij} z_{ij}}{\sum_{j \neq i}^{n_i} z_{ij}^2}$$

$$\text{Global Moran's } I : I = \frac{\sum_{i=1}^{m} z_{ii} \sum_{j \neq i}^{n_i} \omega_{ij} z_{ij}}{\sum_{i=1}^{m} \sum_{j \neq i}^{n_i} z_{ij}^2}.$$

3.4.2 Measurement of Economic Spillover: A Definition

This paper critiques the conventional dummy weighting matrix of calculating Moran's I in Moran (1950) and its subsequent literature, in the context of economic analysis. The conventional matrix, designed merely to identify spatial contiguity without regard to economic indicators, may lead to misspecifications in models aiming to analyze economic spillovers. This is particularly crucial when studying city economic growth, where the spillover effect is an important consideration.

In response, this research introduces an alternative weighting matrix that incorporates both the exact distances from a centered city to its adjacent cities and their economic capacities, that is, the real GDP. This weighting matrix provides a more nuanced measure of economic interdependence. In essence, this matrix is not merely a tool for averaging but serves as a penalizing mechanism where:

- Cities with higher GDP (indicating a greater economic capacity) have a larger spillover effect on their neighboring cities.
- Cities located farther from the centered city have a diminishing spillover effect.

In view of this penalty method, define the $(i,j)-th$ entry of the weight matrix to be as follows:

$$\omega_{ij} = \begin{cases} \frac{Y_{ij}/d_{ij}}{\sum_{j \neq i}^{n_i} (Y_{ij}/d_{ij})} & \text{if } j \in B(i,d) \setminus \{i\} \\ 0 & \text{otherwise} \end{cases}$$

where Y_{ij} is the real aggregate GDP of region j; and d_{ij} is the distance between region i and region j.

3.4.3 Determining an Appropriate Distance

A critical parameter in the spatial analysis using Moran's I is the choice of the distance radius, d. The optimal selection of d should maximize the detection of the total spillover effect within the area, reflecting significant spatial interactions with high probability. According to Long (1999), the optimal radius d will produce the global I with the smallest $p-$ value under its distribution, which is assumed to be a normal distribution by Getis & Ord (1992), Ord & Getis (1995), and Anselin (1995). When the sample size is small, the normality assumption may fail, but asymptotically the assumption holds well.

To find the parameters of the normal distribution given different distance radii, it is necessary to compute the first two moments. By a modification of the proof in Moran (1950), the first two moments of the modified I with the newly proposed matrix are

$$\mathbb{E}[I] = -\frac{m}{N-1}$$
$$\mathbb{E}[I^2] = \frac{\sum_i W_i^2 A + (m - \sum_i W_i^2)B + m(m-1)C}{(N-1)(N+1)}$$

where $W_i^2 = \sum_{j\neq i} \omega_{ij}^2$; $A = (1+2\rho^2)\sigma^4$; $B = (\rho + 2\rho^2)\sigma^4$; $C = 3\rho^2\sigma^4$; $\rho = \frac{1}{N-1}$; and $\sigma^2 = \frac{N-1}{N}$. The proof is shown in the appendix.

Table 3 shows the $p-$values using Liaoning and Guangdong as examples. The $p-$value can be interpreted as the probability that the true global I is more extreme than the sample value under the normality assumption. It is observed that 200km radius provides the smallest $p-$value. Therefore, the following empirical study will adapt this 200km modified Moran's I as the measurement of spillover effect.

While the tendency might be to select even smaller radii based on $p-$value optimization, it is crucial to consider the trade-off involved: smaller radii may exclude economically significant adjacent cities, thus underestimating the broader spillover effects. Consequently, this study will employ a 200 km radius for the calculation of modified Moran's I to ensure a balanced approach between statistical significance and economic relevance.

Table 3: Diagnostics for spatial dependence based on China's city GDP growth rates

	Liaoning		Guangdong	
Distance Radius (km)	Global I	$p-$values	Global I	$p-$values
200	0.3940	0.3931	0.7135	0.3353
300	0.1290	0.4490	0.4167	0.3884
400	0.0431	0.4731	0.2688	0.4215
500	0.0272	0.4790	0.1949	0.4405
600	0.0131	0.4847	0.1378	0.4554
700	0.0049	0.4887	0.1047	0.4647
800	0.0053	0.4896	0.0847	0.4706
900	0.0049	0.4906	0.0673	0.4756
1000	0.0041	0.4917	0.0570	0.4788

4 Empirical Strategy

4.1 Construction of Empirical Strategy

Given a production function in the form of

$$Y_t = A_t K_t^{\alpha} N_t^{\beta}$$

where Y is output, A is the endogenous factors, K is capital, N is labor and α and β are coefficients. Then it can be shown that

$$g_t = \dot{A}_t + \alpha k_t + \beta n_t$$

where g is regional real GDP growth rate, $\dot{A}_t$ is the growth rate of the endogenous factors, k is regional capital accumulation rate, and n is regional employment growth rate.

It is worth noting that $\dot{A}_t$ does not only incorporate technology, but also takes the reforms and development into account, for example, the urbanization process, and the international trade. Therefore, in the empirical model, we control the above-mentioned variables.

To address potential autocorrelation and endogeneity issues within our data, the model adds a lagged term of growth. This term accounts for the possibility that economic outcomes in one period could influence fiscal decentralization level in subsequent periods, potentially due to administrative reasons or the delayed effects of such policies.

Moreover, given the significance of inter-city interactions and economic spillovers, it is imperative to include a measure of the spillover effect in the model. Ignoring such interactions can lead to biased estimates of the impact of fiscal decentralization on city-level economic growth.

Therefore, the empirical model can be specified as

$$g_{i,t} = \beta_1 DC_{i,t} + \beta_2 I_{i,t} + \beta_3 k_{i,t} + \beta_4 n_{i,t} + \beta_5 u_{i,t} + \beta_6 o_{i,t} + \beta_7 a_{i,t} + \gamma g_{i,t-1} + \alpha_i + \delta_t + \epsilon_{i,t}$$

where i is subscript for city and t is subscript for time; g is the growth of per capita real GDP; DC is the fiscal decentralization measurement (either approach); I is the local Moran's I; k is the capital growth rate; n is the employment growth rate; u is the urbanization rate; o is the growth rate of international trade from and to city i; a is the technology investment growth. $g_{i,t-1}$ is the growth rate in the previous year $t-1$; α_i is the fixed effect for city; δ is the fixed effect for time; and ϵ is the error term.

4.2 Results

Table 4 shows the basic results. It reveals that decentralization, when measured through the revenue approach, exerts a significantly positive impact on growth. This outcome suggests that empowering city governments with greater fiscal autonomy enhances efficiency. The rationale behind this is that local governments, being closer to the pertinent economic activities and needs, have access to more precise information, which enables them to allocate resources more efficiently than higher-level authorities.

Conversely, the results from the expenditure approach do not demonstrate a statistically significant impact. This discrepancy between the revenue and expenditure approaches might be indicative of the varying dynamics and challenges associated with spending decisions, compared to revenue collection, in achieving fiscal decentralization goals.

A particularly notable finding is the statistically significant negative coefficients associated with the spillover effect. This paper interprets such negativity as a "crowding out" effect rather than a beneficial spillover. In essence, rather than contributing positively to the economic conditions of neighboring cities, the dominant cities appear to be absorbing resources from their vicinity. This phenomenon can be particularly observed in major urban aggregations, where large cities draw both physical and human capital resources away from smaller, surrounding cities.

Table 4: Basic Regression Results

	Dependent variable:	
	Growth Rate	
	Revenue Approach	Expenditure Approach
Decentralization	0.311**	0.104
(Revenue/Expenditure)	(0.125)	(0.144)
Spillover	−0.068***	−0.068***
(Modified I, 200km)	(0.017)	(0.017)
Lag	0.047*	0.052**
	(0.025)	(0.025)
Capital	0.140***	0.140***
	(0.011)	(0.011)
Labour	0.001	0.001
	(0.005)	(0.005)
Urbanization	−0.214***	−0.218***
	(0.067)	(0.068)
Trade	0.940***	0.944***
	(0.198)	(0.199)
Technology	0.869***	0.880***
	(0.272)	(0.272)
Observations	2,179	2,179
R^2	0.682	0.681
Adjusted R^2	0.644	0.643
F Statistic (df = 235; 1944)	17.753***	17.678***
Note:		*p<0.1; **p<0.05; ***p<0.01

Empirical evidence supports this analysis. For instance, Chengdu, as the capital of Sichuan province and one of the largest cities in China, accounts for approximately 40% of the province's GDP, despite the presence of 21 other cities within the same province. Similarly, the area surrounding Beijing and Tianjin, contrasted to the economic prominence of these municipalities, is often described as a "poverty belt around Beijing and Tianjin." This describes the resource drain experienced by adjacent areas, where poverty remains as a result of the resource consolidation within these megacities.

Investments, either physical or technological (human resource) contribute positively to economic growth which resonates with the infrastructure development in China and the strategy of "rejuvenating the country through science and education". Labour growth does not contribute to productivity significantly. This may be attributed to the diminishing marginal returns of labour. Urbanization is deteriorating growth since the resources become more scarce as more population centering in the urban areas. International trade is contributing to economic growth significantly due to the "opening up" policy.

4.3 A Heterogeneity Analysis: Political Ranking of Cities

As was discussed in Section 1, it is important to compare the effects of fiscal decentralization on different cities in China. This paper focuses on one aspect that cities differ from each other – political ranking. Different cities have different political ranks in China. One of the classification is whether a city is a provincial capital city. [2] This paper uses a dummy variable $c_i 1$ to classify whether a city is a provincial capital city: $c_i = 1$ if yes, otherwise zero. Hence an interaction term is added to examine the second-order result, that is, whether being a provincial city enhances the beneficial effect of fiscal decentralization on the city or not. The empirical specification is now

$$g_{i,t} = \beta_1 DC_{i,t} + \beta X_{i,t} + \gamma_1 g_{i,t-1} + \gamma_2 c_i + \gamma_3 DC_{i,t} \times c_i + \alpha_i + \delta_t + \epsilon_{i,t}$$

where $X_{i,t}$ is the matrix of the control variables and β is a vector of the coefficients.

Table 5 shows the heterogeneity of the impacts of fiscal decentralization on economic growth between provincial capital cities and non-capital cities within provinces. The analysis reveals a statistically significant negative coefficient for the interaction term between fiscal decentralization and capital city status. This finding suggests that, holding the level of decentralization constant, provincial capitals exhibit lower growth rates compared to their non-capital counterparts.

Typically, provincial capital cities hold a higher political status and, as such, are often the recipients of more substantial policy support and fiscal transfers from higher-level governments. This direct support contributes to their economic activities and infrastructural development.

In the context of this paper, if fiscal decentralization is emphasized, then the direct financial inflows from higher government levels should diminish as more freedom is granted to local governments to generate and manage their revenues. Consequently, while decentralization generally aims to enhance

[2] In the data employed by this paper, provincial capital cities include Shijiazhuang, Taiyuan, Shenyang, Changchun, Harbin, Nanjing, Hangzhou, Hefei, Fuzhou, Jinan, Nanchang, Zhengzhou, Wuhan, Changsha, Guangzhou, Nanning, and Xi'an.

efficiency and local governance responsiveness, in the case of provincial capitals, it might reduce the financial resources to support the economic growth. Thus, a more decentralized fiscal system could lead to a relative decline in growth rates for these cities, as they potentially lose the fiscal support they should have enjoyed.

Table 5: Regression Results: Provincial Capital Cities

	Dependent variable:	
	Growth Rate	
	Revenue Approach	Expenditure Approach
Decentralization	0.736***	0.060
(Revenue/Expenditure)	(0.206)	(0.152)
Spillover	−0.069***	−0.068***
(Modified I, 200km)	(0.017)	(0.017)
Lag	0.042*	0.052**
	(0.025)	(0.025)
Capital	0.138***	0.140***
	(0.011)	(0.011)
Labour	0.001	0.001
	(0.005)	(0.005)
Urbanization	−0.209***	−0.219***
	(0.067)	(0.068)
Trade	0.915***	0.939***
	(0.198)	(0.199)
Technology	0.862***	0.877***
	(0.271)	(0.272)
Capital City	3.629	−3.400
	(9.132)	(11.242)
Dec × Cap	−0.673***	0.389
	(0.259)	(0.439)
Observations	2,179	2,179
R^2	0.683	0.681
Adjusted R^2	0.645	0.643
F Statistic (df = 236; 1943)	17.759***	17.604***
Note:		*p<0.1; **p<0.05; ***p<0.01

While fiscal decentralization has presented heterogeneous effects on different cities, it also sheds light on the regional disparity in economic growth within China. The preferential financial support provided to politically superior cities, such as provincial capitals, often results in a concentration of resources. This concentration may increase growth inequalities across different cities. It not only privileges already well-endowed cities but also drives investments away from less-developed cities. As a result, these poorer cities face a chronic shortage of financial resources, which hampers their ability to develop infrastructure and other essential services. Hence, the transfer deteriorates the potential of growth.

This uneven allocation of resources reinforces the existing disparities by centralized fiscal policies that favor politically stronger cities. The lack of inputs and infrastructural support in underprivileged areas leads to a cycle of underdevelopment, where limits local revenues and investment capacities.

To address these deepening disparities, there is a critical need to broaden the scope of fiscal decentralization. Such a policy shift would emphasize decentralization and equality, ensuring that less-developed cities gain direct access to financial resources necessary for their growth and development. Broadening fiscal decentralization would not only enable these cities to adjust development strategies according to their unique needs but also mitigate the concentration of wealth and opportunities in provincial capitals. This serves as a counterbalance to the current system's propensity to aggregate resources in politically dominant urban centers.

5 Robustness Tests

5.1 Choice of Model

5.1.1 Optimal Lagging

Due to the time series property of growth, it is worth examining the optimal number of lagging terms to be included. Since the data only contains 10 years of data, this paper compares the regression model with one and two lagging terms. The results for one lagging terms are shown in Table 4, and Table 6 shows that result with two lagging terms.

First, including an additional lagged term in the regression model leads to a reduction in the number of observations. This reduction occurs since each added lag necessitates an additional prior period of data, thus shortening the effective sample size. As the sample size decreases, so does the power of the statistical tests, which can be a limitation in the analysis. Second, the degree of freedom is less due to the additional variable. This reduction impacts the statistical inference, as fewer degrees of freedom can increase the standard errors of the estimated coefficients, lead to wider confidence intervals, and deteriorate the estimation precision. Moreover, the performance of the model is no better than the model with only one lag in view of the adjusted R^2 statistic, as well as the F statistic. Therefore, this paper prefers the model with only one lag.

Table 6: Test Results of Optimal Lagging

	Dependent variable:	
	Growth Rate	
	Revenue Approach	Expenditure Approach
Decentralization	0.230*	0.153
(Revenue/Expenditure)	(0.138)	(0.262)
Spillover	−0.074***	−0.074***
(Modified I, 200km)	(0.018)	(0.018)
Lag1	0.027	0.031
	(0.027)	(0.027)
Lag2	−0.015	0.014
	(0.027)	(0.027)
Capital	0.142***	0.142***
	(0.012)	(0.012)
Labour	0.001	0.0004
	(0.006)	(0.006)
Urbanization	−0.164**	−0.164**
	(0.078)	(0.078)
Trade	0.986***	0.981***
	(0.212)	(0.213)
Technology	0.883***	0.894***
	(0.290)	(0.290)
Observations	1,961	1,961
R^2	0.613	0.612
Adjusted R^2	0.560	0.559
F Statistic (df = 235; 1726)	11.624***	11.598***
Note:		*p<0.1; **p<0.05; ***p<0.01

5.1.2 Model Stability: Change of Control Variable

It is worth examining whether the empirical model provides a stable result. To check this, different sets of control variables will be used, that is, changing the inclusion of urbanization, technology, and trade variables to check whether the results are consistent with the original strategy.

Table 7 shows the results of dropping one of the control variables in the revenue approach regression. This design has two main reasons. First, the regression is based on the Cobb-Douglas production function, which means that capital growth and employment must be kept in the regression model, while, besides fiscal decentralization, the urbanization, openness, and technology growth are subjectively chosen as relevant. Therefore, the latter three variables are the ones that can be alternatively deleted, while other variables are not. Second, the measurement of interregional economic correlation is incorporated all the way in the sense that without this inclusion will there be identification problem from the perspective of spatial inference and regional growth as was illustrated in previous sections. The results seem plausible since the magnitude and the significance level are similar to the results in 4. Therefore, the empirical strategy provides a stable result and causality analysis.

Table 7: Robustness Test: Change of Control Variable

	Dependent variable:		
	Growth Rate		
	No UB	No OP	No TG
DCrev	0.316**	0.326***	0.317**
	(0.125)	(0.126)	(0.125)
Spillover	−0.068***	−0.066***	−0.068***
(Modified I, 200km)	(0.017)	(0.017)	(0.017)
EGL	0.050**	0.062**	0.047*
	(0.025)	(0.025)	(0.025)
KG	0.139***	0.146***	0.140***
	(0.011)	(0.011)	(0.011)
EM	0.001	0.002	0.001
	(0.005)	(0.006)	(0.005)
OP	1.114***		0.953***
	(0.191)		(0.199)
UB		−0.305***	−0.234***
		(0.065)	(0.067)
TG	0.948***	0.919***	
	(0.271)	(0.273)	
Observations	2,179	2,179	
R^2	0.681	0.678	0.680
Adjusted R^2	0.642	0.639	0.642
F Statistic (df = 234; 1945)	17.704***	17.518***	17.701***
Note:			*p<0.1; **p<0.05; ***p<0.01

5.2 Robustness of the Spillover Effect Measurement

5.2.1 Test of the New Matrix

Since a new approach is proposed to measure the spillover effect to avoid identification problem, testing whether this new measurement provides a consistent and better performance is required. This test requires to calculate the measurement using the original design by, for example, Moran (1950) and Long (1999), and compare the estimates, especially the sign, the statistics, for example, $p-$value of the coefficients and the adjusted R^2, and the interpretability of the model, that is, whether the empirical strategy can be interpreted in a better way in economic sense, which, in this case, becomes the question of whether the identification problem has actually been solved.

Table 8: Robustness Test for the Modified Matrix: 200km

	Dependent variable:	
	Growth Rate	
	Modified matrix	Dummy matrix
Decentralization	0.311**	0.294**
	(0.125)	(0.124)
Spillover	−0.068***	−0.144***
(200km)	(0.017)	(0.021)
EGL	0.047*	0.045*
	(0.025)	(0.025)
KG	0.140***	0.140***
	(0.011)	(0.011)
EM	0.001	0.001
	(0.005)	(0.005)
UB	−0.214***	−0.204***
	(0.067)	(0.067)
OP	0.940***	0.919***
	(0.198)	(0.197)
TG	0.869***	0.890***
	(0.272)	(0.270)
Observations	2,179	2,179
R^2	0.682	0.687
Adjusted R^2	0.644	0.649
Residual Std. Error (df = 1944)	6.392	6.342
F Statistic (df = 235; 1944)	17.753***	18.165***
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 8 shows that robustness test results. The new approach results are shown in the left column entitled "modified matrix" while the approach adapted by previous spatial literature is the right column "dummy matrix". First, the new approach does not deteriorate the explanability of the model, that is , the (adjusted) R^2's are almost the same. In order to get a more desirable R^2, it is feasible to adjust the penalty function so that the R^2 does not exhibit overfitting evidence while the weight is still increasing in Y and decreasing in d, and this may be conducted in the future by trial and error.

More importantly, the modified matrix is more desirable since it increases the interpretability of the empirical model. First, the penalty makes more sense than considering all the "adjacent" cities as homogeneous except for growth. Second, the new approach tries to consider the aggregate level (Y in the modified matrix). Last but not the least, the new measurement has a smaller-in-magnitude coefficient, indicating that it penalizes less for the "sucking blood" effect from large citie while it keeps the fact that cities tend to "compete" instead of "collaborating" which is shown by the negative signs of both coefficients.

5.3 Choice of Distance Radius

In the choice of distance radius, normality assumption was imposed according to previous literature. However, there are two possible concerns. First, previous literature assumed normal distribution for their measurement, while this paper uses a modified version, when using normality assumption may make the significance testing more problematic. The second concern, which resonates to the first one, is the $p-$values in Table 3. The p-values are actually far from a "confident" level to reject zero correlation, while in reality there is always spillover effect, which in turn indicates that the normality assumption may have brought in imprecise distribution assumption. Therefore, this robustness test aims at testing the performance of the empirical model using the Moran'I with different radius, and examine the consistency across different radii and evaluate the previous application of 200km radius.

Table 9: Robustness Test: Distance Radii

	Dependent variable:				
	Growth Rate				
	200km (Base)	400km	600km	800km	1000km
Decentralization	0.311**	0.265**	0.189*	0.214*	0.217*
(Revenue)	(0.125)	(0.121)	(0.113)	(0.113)	(0.114)
Spillover	−0.068***	−1.616***	−8.685***	−10.12***	−10.54***
(Modified)	(0.017)	(0.134)	(0.403)	(0.468)	(0.523)
Observations	2179	2179	2179	2179	2179
R^2	0.682	0.702	0.741	0.742	0.735
Adjusted R^2	0.644	0.666	0.701	0.710	0.703
F Statistic	17.753***	19.47***	23.69***	23.73***	22.93***
Note:	*p<0.1; **p<0.05; ***p<0.01				

Table 9 show that results for 200km, 400km, 800km, and 1000km, respectively. First, all the choices of distance radius result in the statistically significant negative spillover coefficients. The great change in magnitude is due to the change of magnitude in raw modified Moran's I index. Second, it is worth noticing that the (adjusted) R^2 at 800km level is the largest, as well as the F statistic, which may indicate that 800km is preferred in terms of this empirical model.

6 Conclusion

China, as a large economy, has shown unbalanced development across different regions. This unbalance can be attributed to various aspects, in particular, the development level of the local economy, the government efficiency, and the political rank of the cities. This paper has a glimpse of the political ranking issue. It is also important to analyze the interaction between fiscal decentralization and other economic metrics. Basically, research can fundamentally adapt the interaction term to have an overview of the second-order effect. Then other strategy may be utilized to extend the research to a deeper level.

Due to the time limit and data limitation, some designed works were not yet done. First, relative to the stable economic condition in the studied areas in this paper, border areas and minority areas seem more interesting and necessary to be studied. However, these areas seem not to have complete city level data published by National Statistics Department of China, and this calls for further investigation of data source. Second, though the measurement of spillover effect has made an progress in incorporating economic indicator, there is still a lack of interaction between cities, for example, the measurement of labour mobility, or resource allocation. Considering this, it is worth reconstructing the penalty function of the weighting matrix with some interregional economic activity. Nevertheless, this again requires cities level trade or micro labour data, which is also difficult to get. It is considered that one can use the train and flight data to mitigate. In the future study, it may work to use the number of trains and flights to indicate the economic relation between cities.

Appendices

A Proof of the Moments of the Spillover Measurement

Let I be the spillover measurement proposed by this paper. Then

$$\mathbb{E}[I] = -\frac{m}{N-1}$$
$$\mathbb{E}[I^2] = \frac{\sum_i W_i^2 A + (m - \sum_i W_i^2)B + m(m-1)C}{(N-1)(N+1)}$$

where

$$W_i^2 = \sum_{j \neq i} \omega_{ij}^2;$$

$$A = (1 + 2\rho^2)\sigma^4;$$

$$B = (\rho + 2\rho^2)\sigma^4;$$

$$C = 3\rho^2\sigma^4;$$

$$\rho = \frac{1}{N-1}; \text{ and}$$
$$\sigma^2 = \frac{N-1}{N}.$$

Proof. Note that

$$\mathbb{E}[I] = \frac{\sum\sum_{i\neq j}\omega_{ij}\mathbb{E}[z_{ii}z||ij]}{\sum\sum_{i\neq j} z_{ij}^2}.$$

Inheriting the independence assumption from Ord & Getis (1992), we may write

$$\mathbb{E}[z_{ii}z_{ij}] = \frac{\sum\sum_{i\neq j} z_{ii}z_{ij}}{N-1}.$$

Note that

$$\left(\sum_l \sum_m z_{lm}\right)^2 = \sum_i \sum_j z_{ij}^2 + \sum_i \sum_{i\neq j} z_{ii}z_{ij} = 0$$

since $\sum_m z_{lm} = 0$ for the demeaned z for any l.

Therefore, $\sum_i \sum_j z_{ij}^2 = -\sum_i \sum_{i\neq j} z_{ii}z_{ij}$. Hence, $\mathbb{E}[I] = -\frac{m}{N-1}$.

By Moran (1950), it follows from the standard normality assumption of z_{ij} that

$$\mathbb{E}[I^2] = \frac{\mathbb{E}\left[\left(\sum\sum_{i\neq j}\omega_{ij} z_{ii} z_{ij}\right)^2\right]}{\mathbb{E}\left[\left(\sum\sum_{i\neq j} z_{ij}^2\right)^2\right]}.$$

Note that $\sum\sum_{i\neq j} z_{ij}^2$ has χ^2 distribution. It follows from the property of χ^2 distribution that

$$\mathbb{E}\left[\left(\sum\sum_{i\neq j} z_{ij}^2\right)^2\right] = (N-1)(N+1).$$

The numerator has three components (inside the expectation):

$$\left(\sum\sum_{i\neq j} \omega_{ij} z_{ii} z_{ij}\right)^2 = WZ_1 + WZ_2 + WZ_3,$$

where

$$WZ_1 = \sum\sum_{i\neq j} \omega_{ij}^2 z_{ii}^2 z_{ij}^2;$$

$$WZ_2 = \sum\sum\sum_{i\neq j\neq k} \omega_{ij}\omega_{ik} z_{ii}^2 z_{ij} z_{ik};$$

$$WZ_3 = \sum\sum\sum\sum_{i\neq i', i\neq j, i'\neq k} \omega_{ij}\omega_{i'k} z_{ii} z_{i'i'} z_{ij} z_{i'k}.$$

By Moran (1950),

$$\mathbb{E}[WZ_1] = \sum\sum_{i\neq j} \omega_{ij}^2 (1+2\rho^2)\sigma^4$$

$$\mathbb{E}[WZ_2] = \sum\sum\sum_{i\neq j\neq k} \omega_{ij}\omega_{ik} (\rho+2\rho^2)\sigma^4$$

$$\mathbb{E}[WZ_3] = \sum\sum\sum\sum_{i\neq i', i\neq j, i'\neq k} \omega_{ij}\omega_{i'k} 3\rho^2\sigma^4,$$

where $\rho = \dfrac{1}{N-1}$ and $\sigma^2 = \dfrac{N-1}{N}$. Note that

$$\begin{aligned}\sum\sum\sum_{i\neq j\neq k} \omega_{ij}\omega_{ik} &= \sum\sum_{i\neq j} \omega_{ij} \sum_{k\neq j} \omega_{ik} \\ &= \sum\sum_{i\neq j} \omega_{ij}(1-\omega_{ij}) \\ &= m - \sum\sum_{i\neq j} \omega_{ij}^2,\end{aligned}$$

and

$$\begin{aligned}\sum\sum\sum\sum_{i\neq i', i\neq j, i'\neq k} \omega_{ij}\omega_{i'k} &= \sum\sum\sum_{i\neq i', i\neq j} \omega_{ij} \sum_{i'\neq k} \omega_{i'k} \\ &= \sum\sum_{i\neq j} \omega_{ij} \sum_{i'\neq i} 1 \\ &= m(m-1).\end{aligned}$$

Denote $W_i^2 = \sum_{j\neq i} \omega_{ij}^2$. Then

$$\mathbb{E}[I^2] = \frac{\sum_i W_i^2 A + (m - \sum_i W_i^2) B + m(m-1) C}{(N-1)(N+1)},$$

where A, B, C are defined above. It follows that the variance can be deduced from the following formula of moments:

$$Var[I] = \mathbb{E}[I^2] - (\mathbb{E}[I])^2 .$$

□

References

[1] Alesina, Alberto, and Enrico Spolaore. *The Size of Nations.* Cambridge, Mass: MIT Press, 2003.

[2] Anselin Luc. "Local Indicators of Spatial Association—LISA." *Geographical Analysis* 27, no.2 (1995): 93-115.

[3] Arthur Getis, J. K. Ord. "The Analysis of Spatial Association by Use of Distance Statistics." *Geographical Analysis* 24, no.3 (1992): 189-206.

[4] Baskaran, Thushyanthan, and Lars P. Feld. "Fiscal decentralization and economic growth in OECD countries: is there a relationship?." *Public finance review* 41, no. 4 (2013): 421-445.

[5] Bloom, Nicholas, Raffaella Sadun, and John Van Reenen. "The Organization of Firms Across Countries." *The Quarterly journal of economics* 127, no. 4 (2012): 1663–1705.

[6] *China Statistical Yearbook.* Beijing: China Statistical Information & Consultancy Service Centre, 2009-2019.

[7] Davoodi, Hamid, and Heng-fu Zou. "Fiscal Decentralization and Economic Growth: A Cross-Country Study." *Journal of urban economics* 43, no. 2 (1998): 244–257.

[8] Gen Ying, Kong. "Measuring the spillover effects: Some Chinese evidence." *Papers in Regional Science* 79 (1999): 75-89.

[9] Hao, Yu, Yu-Fu Chen, Hua Liao, and Yi-Ming Wei. "China's Fiscal Decentralization and Environmental Quality: Theory and an Empirical Study." *Environment and development economics* 25, no. 2 (2020): 159–181.

[10] Herwartz, Helmut, and Bernd Theilen. "Fiscal Decentralization and Public Spending: Evidence from Heteroscedasticity-Based Identification." *The B.E. journal of economic analysis & policy 17*, no. 2 (2017).

[11] Huang, Zhangkai, Lixing Li, Guangrong Ma, and Lixin Colin Xu. “Hayek, Local Information, and Commanding Heights: Decentralizing State-Owned Enterprises in China.” *The American economic review* 107, no. 8 (2017): 2455–2478.

[12] J. K. Ord, Arthur Getis. ”Local Spatial Autocorrelation Statistics: Distributional Issues and an Application.” *Geographical Analysis* 27, no.4 (1995): 286-306.

[13] Jie, Li, D. QIU Larry, and Sun Qunyan. ”Interregional protection: Implications of fiscal decentralization and trade liberalization.” *China Economic Review* 14, no. 3 (2003): 227-245.

[14] Jin, Jing, and Heng-fu Zou. “How Does Fiscal Decentralization Affect Aggregate, National, and Subnational Government Size?” *Journal of urban economics* 52, no. 2 (2002): 270–293.

[15] Lin, Justin Yifu, and Liu, Zhiqiang. “Fiscal Decentralization and Economic Growth in China.” *Economic development and cultural change* 49, no. 1 (2000): 1–21.

[16] Martinez-Vazquez, Jorge, Baoyun Qiao, Shuilin Wang, and Heng-Fu Zou. ”An essay on public finance in China.” *Annals of Economics and Finance* 15, no. 1 (2014): 413-519.

[17] Moran, P. ”A Test for the Serial Independence of Residuals.” *Biometrika* 37, (1950): 178-181.

[18] Rondinelli, Dennis A. and John R. Nellis. ”Assessing Decentralization Policies in Developing Countries: A Case for Cautious Optimism”, *Development Policy Review* 4, no.1 (1986): 3-23.

[19] Rondinelli, Dennis A., John R. Nellis, and G. Shabbir. Cheema. *Decentralization in Developing Countries: a Review of Recent Experience.* Washington, D.C., U.S.A: World Bank, 1983.

[20] Zhang, Tao, and Heng-fu Zou. “Fiscal Decentralization, Public Spending, and Economic Growth in China.” *Journal of public economics* 67, no. 2 (1998): 221–240.