

The Impact of Inter-city Cooperation on Local Economy and Environment: Evidence from the Greater Bay Area

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Abstract: Regional cooperation between cities is of great importance to economic development and environmental protection. However, there appear to be fewer papers in the economic literature on the actual result of cooperation between cities quantitatively. Therefore, this paper, theoretically, studies how local governments strategically interact with each other in improving environmental quality and local economy. To this end, we, specifically, collect data before building a fixed effects model and adopting instrumental variables. Empirical evidence shows that inter-city cooperation in the Greater Bay Area has a positive impact on local economy and environment. This paper provides insightful comments on the economic and environmental effects of cooperation between cities, which is of great relevance to government, enterprises, and residents. We substantially advance the understanding of the impact of inter-city cooperation, which benefits the regional cooperation in China further.

Keywords: Inter-city cooperation, GDP, Environment, IV approach, China.

1. Introduction

The Greater Bay Area (Guangdong-Hong Kong-Macao Greater Bay Area (hereinafter called GBA) consists of two special administrative regions, Hong Kong and Macao, and nine cities in Guangdong province: Dongguan, Foshan, Guangzhou, Huizhou, Jiangmen, Shenzhen, Zhaoqing, Zhongshan and Zhuhai) enjoys obvious regional advantages, strong economic strength, aggregation of innovation factors, leading internationalization level, and a sound cooperation foundation. As one of the most open and dynamic regions in China, GBA plays an important strategic role in the overall development of the country. The development of it has been included in the development plan (In 2005, the Guangdong provincial government designed “Guangdong-Hong Kong-Macao Cross-boundary Cooperation and Development Area” in the 《urban agglomeration coordinated development plan of pearl river delta》. Subsequently, the concept of “Bay Area”

has been written into several local development documents) of Guangdong since 2005, when the Guangdong government clearly designed the “Guangdong-Hong Kong-Macao Cross-boundary Cooperation and Development Area”. Over the next dozen years, GBA has become a national development strategy and has gradually developed into an international first-class bay area. According to “Outline Development Plan for the GBA” released by The State Council in 2019, GBA as one pole of China’s economic growth will become a world-class city cluster. The 11 cities in GBA have a population of more than 80 million, with around 12.6 trillion yuan economic aggregate, making it one of the most open and dynamic regions in China. Therefore, as a landmark regional development in the world, it is necessary to research its inter-city cooperation effect. Fig. 1 (The data comes from <https://thinktank.phbs.pku.edu.cn/> and www.stats.gov.cn/.) displays the total annual GDP of GBA and its proportion to the national annual GDP, showing the rapid economic development of GBA in the past decade.

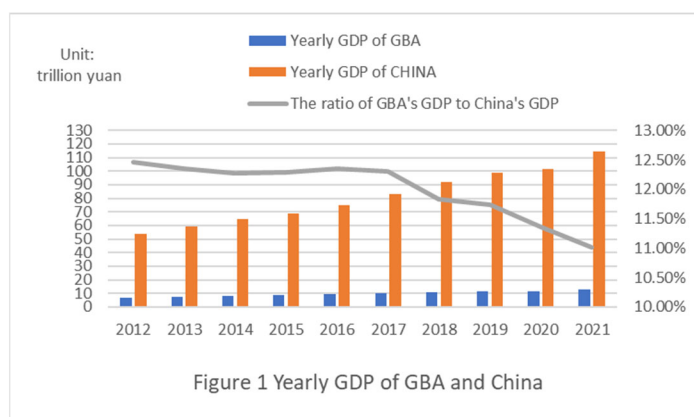


Figure 1. Yearly GDP of GBA and China

Regional cooperation is not just indispensable access to realize the coordinated development of urban agglomerations (Coordinated urban development refers to the division of labor and cooperation, complementary functions, close connections among cities. Cooperation between cities create

mutual benefits with lower costs and higher efficiency. Besides, it can improve the overall competitiveness of urban agglomeration.), but also an important measure to promote the high-quality development of cities in urban agglomerations. As a representative urban agglomeration

cooperation region, GBA has established three free trade zones--Nansha, Qinhai and Hengqin--to jointly build a hub for opening-up. Apart from regional economic cooperation construction, it accelerates infrastructure connectivity, building a modern and integrated transport system, improving the information infrastructure, to strengthen cooperation among the 11 cities. Surprisingly, we find that there are not lot of papers that provide a comprehensive review with empirical evidence in exploring the impact of inter-city cooperation on the local economy and environment quantitatively. Thus, it is noteworthy to study the inter-city cooperation in GBA and explore a potentially optimal pathway to strategically collaborate with other cities.

This paper seeks to fill that gap in the context of China's most dynamic inter-city cooperation area, GBA. To this end, we, firstly, collected data on the number of cooperation between cities and measurable economic and environmental indicators of the 11 cities in GBA from 2010 to 2019 through reliable sources. In the next place, we established a fixed effects model to quantitatively analyze the specific impact of the number of inter-city cooperation on GDP per capita, PM10 concentration, and PM2.5 concentration. In this process, considering vehicle exhaust affects environmental quality and economic benefits, we added per capita car ownership as one of the independent variables. In addition to that, the distance between cities was introduced as an instrumental variable to alleviate the issue of endogeneity (Endogeneity refers to the correlation between explanatory variables and error terms in regression models. When endogeneity occurs, the common linear models will have inconsistent estimators. Through using instrumental variables, consistent estimators can be obtained). The main finding in this paper is that, holding other things equal, each time increase in the cooperation between cities raises GDP per capita by 180%. In the meantime, the concentration of PM 10 and PM2.5 decreased by 3.8% and 0.97%, respectively. Therefore, we finally come to a conclusion that inter-city cooperation in GBA has a positive impact on the local economy and environment.

Compared to existing methods, we improve in the following ways. First, we collect new data; Second, we fix the issue of potential endogeneity using the distance as the instrumental variable. It contributes to solving the endogeneity problem in a reasonable way relatively.

The remainder of this paper is organized as follows. Section 2 briefly reviews the relevant literature about the use of instrumental variables and the impact of inter-city cooperation on GBA's economy and environment. Section 3 introduces the data and econometric models in this study. The specific empirical results are presented in section 4. The last section discusses some policy implications and provides some concluding remarks.

2. Literature Review

2.1. The Effect of Inter-city Cooperation on Economy

In recent years, many scholars have studied the economic effects of intercity cooperation in GBA in specific sectors. Despite a large body of research showing that inter-city cooperation drives department development, Yang et al. (2021) point out that small and medium-sized cities in GBA have not benefited from the development of knowledge and innovation networks of the core cities, but are trapped in their

agglomeration shadow. In terms of urban land use, Zhang et al. (2021) argue that de facto (shared) geopolitical scale, divergent deepening mechanisms, and concrete politico-economic setting have co-determined the conceptual typology of China's intercity cooperation. The understanding of mechanisms underlying the city-regionalization in general, especially intercity cooperation, will offer critical insights into the ongoing organizational, and land-use reforms within the framework of Territorial Spatial Planning. Scholars have also quantified the traffic impact of intercity cooperation in GBA. As intercity cooperation strengthens, the differentiated employment composition drives increased intercity human mobility, which in turn increases intercity high-speed rail traffic. (Hu et al., 2022).

2.2. The Effect of Inter-city Cooperation on the Environment

In the era of rapid urban development, the relationship between the urban ecological environment and urban construction is receiving increasing attention. Douglass, M. (2002) proposes the idea that the major dilemma posed by inter-city cooperation in the context of globalization is how to make cities more livable and environmentally. In a challenging context developing countries face environmental management capacity issues, inter-city cooperation is an important way to assist cities in strengthening their capacity to manage urban environmental challenges. (Memon et al., 2005) Based on Japan's cooperation with developing countries, Nakamura et al. (2011) argue some Japanese local governments have engaged in international cooperation with local governments in developing countries in Asia to improve environmental management. Zeng et al. (2022) put forward the innovation cooperation among cities exerts impacts on efficiency to gain both economic and environmental performances. They validate the innovation cooperation through control ability of information resources for other cities could significantly improve the environmental regulation efficiency.

2.3. The Use of Instrumental Variables

Philip G. Wright first mentioned instrumental variable theory in his book 《The Tariff on Animal and Vegetable Oils》. Following Wright, Pearl proposed a formal definition of instrumental variables in 2000 using proof by contradiction and graphical evaluation method. Since then, instrumental variables have been widely used in regression estimation. In Caner and Hansen's (2004) estimation of threshold models, instrumental variables were used to break the restriction that variables on the right side of a sample splitting model must be exogenous. Thanks to instrumental variables, they successfully considered a model with endogenous variables but an exogenous threshold variable. Scholars (Altonji et al., 2005) have been discussing the validity of instrumental variables and providing a template for the assessment of instrumental variables strategies in other applications. In 2008, Heckman discussed the representation of causal laws in econometrics and the relationship with instrumental variables and other methods. Treatment preferences of groups (e.g., clinical centers) have often been proposed as instruments to control for unmeasured confounding-by-indication in instrumental variable (IV) analyses. Evaluation of group-preference-based IV suggests that the IV estimator remains advantageous in reducing bias from confounding-by-indication. (Li et al., 2015)

3. Data and Econometric Models

3.1. Data

This paper is conducted with a comprehensive dataset that includes the number of inter-city cooperation, per capita car ownership, GDP per capita, PM10 concentration, PM2.5 concentration, and an average distance of one city to other

cities from various sources. All the data comes from the Chinese statistical yearbook (Website address: <http://www.stats.gov.cn/tjsj/ndsj/>), except for the data referring to distance. Besides, the average distance between one city and other cities in this region is from Google Maps (Website address: <https://www.google.com/maps/>). Fig. 2 illustrates one sample distance from Macao to Hong Kong.

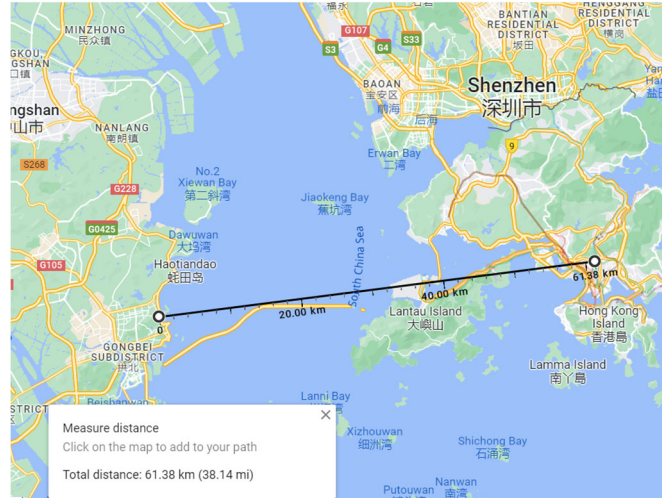


Figure 2. Distance of sample city

3.1.1. Economic Indicator

From Figure 1, we can see clearly that, in the past decade, the GDP per capita of BGA has accounted for more than one-tenth of the national GDP. The sample data, including 110 units represents that there is wide range among cities, from 24875 CNY to 566180.9 CNY.

3.1.2. Air pollution

Apart from economic effects, environmental effect also takes an important part in the study of inter-city cooperation. As one of the major indicators measuring a city's environment quality, air quality has always been a focus topic for scholars. This paper selects two critical indicators of air quality, PM10 and PM2.5, since they have been included in air quality guidelines by World Health Organization. In our sample data, the average concentration of PM10 is only $3.84 \mu\text{g}/\text{m}^3$. Conversely, the mean concentration of PM2.5 is as high as $33.28 \mu\text{g}/\text{m}^3$.

3.1.3. Other Attributes

In the context of the sharply increase of GBA's economic, we select consecutive years from 2010 to 2019. With the support of 《Outline Development Plan for the Greater Bay Area》, inter-regional cooperation has flourished. During the

10 years, the average number of inter-city cooperation is as high as 144,941. Considering per capita car ownership also has a considerable impact on environment quality except inter-city cooperation, we collect data on per capita car ownership in GBA. Besides, there is a relationship between the number of cooperation and the average distance between one city and others. We introduce an exogenous attribute, i.e., distance, to correct the results. Among the data, the average distance between Zhongshan city and other cities is the smallest (69.12 kilometers). As the utmost average distance, Zhaoqing city is 133 kilometers away from 10 other cities.

3.1.4. Summary Statistics

Table 1 reports the descriptive statistics of key variables. Both GDP per capita of each city and the number of inter-city cooperation have the widest range in the study period of the sample, with a twenty times difference. In addition, per capita car ownership varies dramatically, from 0.03 to 0.33. By contrast, there is not a considerable difference in the average distance of one city to other cities. When it comes to air pollution, PM10 concentration varies significantly (from 1.73 to 14.84) while PM2.5 concentration changes slightly (from 19 to 51) between cities.

Table 1. Descriptive statistics of key variables

Variable Label		N	Mean	SD	Min	Max
Economic Attribute						
GDP	GDP per capita, CNY as unit	110	144941	128763.2	24875	566180.9
Air pollution						
PM10	PM10 pollution, $\mu\text{g}/\text{m}^3$	110	3.84	2.02	1.73	14.84
PM25	PM25 pollution, $\mu\text{g}/\text{m}^3$	110	33.28	7.43	19	51
Other attributes						
Num_c	the number of inter-city cooperation	110	144941	128763.2	24875	566180.9
Car	per capita car ownership	110	0.15	0.07	0.03	0.33
Dist	average distance of one city to other cities, km in unit	110	90.02	18.92	69.12	133
Year	10 consecutive years	110	2014.5	2.89	2010	2019

3.2. Econometric Models

Following the multiple linear regression OLS model, I employ a logarithm form of GDP per capita, PM10 pollution and PM2.5 pollution as the dependent variable and regress it on the number of inter-city cooperation and per capita car ownership. The baseline specification becomes:

$$\ln(Y) = \theta_0 + \theta_1 C_{it} + \theta_2 X + \delta_t + \varepsilon_{it} \quad (1)$$

Where Y , is the effect which is quantified, GDP per capita, PM10 pollution, or PM2.5 pollution in that year. C_{it} is the number of inter-city cooperation. X is per capita car ownership. δ_t is yearly fixed effect that control for unobserved attributes over time. Standard errors ε_{it} are clustered at the district level.

In the meantime, for the purpose of solving endogeneity better, we use instrumental variable model further process data. Model as follows:

$$C_{it} = \theta_0 + \theta_1 Dist_t + \varepsilon_{it} \quad (2)$$

$Dist_t$ is on behalf of the average distance of one city to other cities in GBA, which is exogenous. ε_{it} is standard error.

4. Empirical Results

Table 2 displays the empirical results with yearly fixed effect. For column 1, the negative coefficient on Num_c shows that increase in the number of inter-city cooperation helps improve air quality. Each time increases in the number of cooperation between cities drops PM10 concentration by 0.1% if holding other things equal. Not only that, PM2.5 concentration decreases 0.09% on the situation that cooperation increases once. In terms of economy, positive coefficient on GDP per capita which is 0.0125 reveals the facilitation of economic benefits.

Car ownership per capita which has a bad influence on the environment is of great benefit to economic development. It can be seen from table 2 that, other things being equal, for every 1 unit increase in car ownership per capita on average, the concentration of PM10 and PM2.5 rises by 38% and 98%, respectively. Conversely, GDP per capita shows a 155% growth if car ownership per capita increases once when controlling for other variables.

Table 2. Empirical results of effect on economy and environment

	Column 1	Column 2	Column 3
variables	ln_PM10	ln_PM2.5	ln_GDP per capita
Num_c	-0.001	-0.0009	0.0125
Car	0.3807	0.9842	1.5555
Constant	1.2045	3.3499	11.1618
Year FE	Y	Y	Y
R2	0.6501	0.5681	0.1286
N	110	110	110

Now we consider two-stage least squares (2SLS) and simple instrumental variable (IV) type estimation of panel

data models. Table 3 shows that the introduction of IV alleviates the issue of endogeneity. After using instrumental variables, the coefficient and R-squared of three dependent variables all have changed.

Table 3. Empirical results of IV

	Column 1	Column 2	Column 3
variables	ln_PM10	ln_PM2.5	ln_GDP per capita
Num_c	-0.0376	-0.0097	1.7976
Car	-0.8229	0.6921	60.3642
Year FE	Y	Y	Y
Root MSE	0.5631	0.1981	24.15
N	110	110	110

5. Conclusion

This paper documents how regional cities strategically interact with each other in improving environmental quality and the local economy in the context of GBA. Empirical results suggest inter-city cooperation improves economic development and environmental quality, other factors being equal. GDP per capita, PM10 concentration and PM2.5 concentration are used to quantify the quality of the local economy and environment. It is estimated that each time increase in the number of inter-city cooperation on average would put a premium of about 180% GDP per capita, which has an indispensable effect on economic development. Meanwhile, inter-city cooperation has also brought great benefits to air quality. In the econometric model, which uses an instrumental variable, it can be seen clearly that PM10 concentration reduced by 3.8 percent and PM2.5 concentration drops by 0.97 percent.

From a real regional planning perspective, the results of the fixed effects model should be useful. In some instances, government departments will simulate the effect of inter-city cooperation in advance and need to formulate the best cooperation policy based on the analysis of economic and environmental benefits ahead of time. In addition, understanding different interactions between cities is also important for a wide range of city planning purposes. The results in this paper could be used as a reference point to help governments evaluate if the cooperative project is worthwhile.

According to the main findings, we propose the following policy-related suggestions. First, strengthen cooperation among cities in a region. Secondly, increase the likelihood of cooperation by lowering the barriers to entry of it, such as add more public transport facilities between cities. Last but not least, enhance regional integration by getting on the road of promoting harmonious development of environment and economy.

In summary, the findings in this study may be used in cost-benefit analyses of urban cooperation projects and help establish a future urban design for policy-makers. These empirical results advance our understanding of regional cooperation, which promotes regional cooperation in China further.

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