

Policy Innovation Diffusion and PPP Spatial Distribution

Shikun Qin, Yaling Wang, Xiaowen Yang*

Since 2014, PPP policy has been promoted rapidly in China. Based on the theory of policy innovation diffusion, this paper explores the formation mechanism of PPP spatial disequilibrium at the micro level using Chinese municipal-level panel data from 2014 to 2019. According to the research, the innovation diffusion of China's PPP policy at the local-government level exhibits R-shaped non-progressive characteristics and is influenced by both internal and external factors. On the internal side, the debt pressure of local governments is an important determinant with an inverted U-shaped influence on PPP policy. On the external side, imitation and competition among neighboring local governments are the main external determinants. This spatial strategic interaction occurs not only in same-province regions with close proximity and similar economic development but also in different-province regions with close proximity. The above studies offer certain insights into optimizing the spatial distribution pattern of PPP and guarding against fiscal risks.

Keywords: policy innovation diffusion, PPP spatial distribution, local government's debt, fiscal pressure

1. Introduction

Since 2014, the PPP (Public-Private Partnership) model has been in full swing in China. This model means a long-term contract between a private party and government entity for the provision of public assets or services, in which the private party generally assumes significant risk and management responsibility and receives a return linked to performance. Since the PPP model introduces social capital and converts short-term large construction expenditures into installment payments over the cooperation period, PPP can improve infrastructure construction while balancing the pressure from financial payment. In recent years, as an important investment & financing policy in China's infrastructure and public services, PPP has played an essential role in stabilizing growth, shoring up shortcomings and improving people's living.

The practice of PPP in China has distinctive features, one of which is the

¹ Shikun Qin (email: shikunqin@foxmail.com), PhD Candidate of the Center for China Fiscal Development, Central University of Finance and Economics; Yaling Wang, Associate Professor of School of Economics, Qingdao University; Xiaowen Yang, Postdoctor of Chinese Academy of Fiscal Sciences.

disequilibrium of spatial distribution (Cheng *et al.*, 2018). For example, regarding economic level, Shanghai varies significantly from Qinghai and Ningxia, yet their bid winning scales are at a similar level. In terms of population, the regions with larger PPP bid-winning scales include both large-population provinces such as Henan and Sichuan as well as less densely populated regions like Yunnan and Guizhou. From the perspective of location, PPP has been implemented at a larger scale in the eastern coast, southwest and northwest. Thus, spatial disequilibrium has become a typical feature of China's PPP development, which is difficult to be explained by a single factor. Attention paid to the spatial distribution of PPP is crucial to the long-term institutional building of PPP. The reason lies in that there may be a mismatch between the supply and demand sides of PPP, even triggering fiscal risks at the regional level. The focus on the PPP spatial distribution helps understand the incentives and constraints faced by local governments in their policy decision-making so as to improve the institutional arrangements. However, there is a lack of adequate discussion in the existing literature on the micro-level formation mechanism for the PPP spatial disequilibrium.

The theory of policy innovation diffusion can systematically shed light on this issue from a policy perspective. This theory, originating in the US in the 1960s, focuses on the policy implementation and explores the internal and external factors that influence the adoption of new policies by local governments. For local governments, PPP can be perceived as a new policy, while the PPP spatial pattern results from the policy innovation diffusion. With the theory of policy innovation diffusion, this paper collects panel data of 284 cities from 2014 to 2019 to empirically analyze the causes of the PPP spatial distribution. According to the research, it is found that (1) regarding internal factors, debt pressure has a non-linear influence on implementing local governments' PPP policies, showing an inverted U-shaped and heterogeneous effects on different types of PPP policies; (2) in terms of external factors, PPP policies may be disseminated among geographically neighboring regions due to the inter-regional competition and imitation mechanism. The contributions of this study are as follows. First, this paper makes a move away from the usual event history analysis (EHA) in the literature of the policy innovation diffusion theory and explores the characteristics and causes of the spatial distribution of PPP with the spatial econometric method. Second, the paper has focused on opting for financing alternatives by local governments since the implementation of the new 2014 Budget Law, revealing that local government debt has a non-linear effect on PPP policy. Since debt and PPP are the two main channels of external financing for local governments, this finding sheds light on studies related to the financing behavior of local governments. Third, the paper further identifies the horizontal mechanism for the PPP policy innovation diffusion, one reference for understanding the behavior of China's local governments and improving the intergovernmental incentive mechanism.

The following parts of this paper are organized as follows. Part 2 is a literature review; part 3 introduces the research background; part 4 presents two theoretical hypotheses; parts 5 and 6 develop empirical tests of the two theoretical hypotheses, respectively; and part 7 contains conclusion and insight.

2. Literature Review

As more social information interactions are conducted, the policy innovation diffusion has become a current research focus and related studies are increasing (Wang and Lai, 2013; Shipan and Volden, 2012). Similar to individual innovation, policy innovation can be seen as non-incremental government innovation under specific incentives. The understanding of this policy process helps better analyze government behavior. Early research on the policy innovation diffusion can be traced back to Walker's analysis (1969) of innovation policies among US states, where Walker defined policy innovation as the adoption of a policy by government that had not been adopted in the past. Unlike policy invention, policy innovation has a broader meaning. With respect to the temporal dimension, relevant studies on the policy innovation diffusion theory can be divided into three stages (Chen, 2014): the first stage (before 1980) mainly focused on analyzing individual influencing factors of policy innovation diffusion, during which the national interaction model, the regional diffusion model, internal determinants models and other explanatory frameworks were formed to conduct the empirical analysis with the statistical methods such as factor analysis and cross-sectional regression; the second stage (1980 to 2000) further expanded the scope of research based on previous studies, focusing not only on the diffusion of policies themselves but also on the diffusion of policy instruments. The event history analysis (EHA) was introduced for the first time to incorporate more explanatory factors into the analytical model; and the third stage (2000–present) began to address the shortcomings of the policy innovation diffusion theory involving unclear concepts and research objects, integrate the fragmented concepts and refine the quantitative analysis methods. Despite the limitations of this three-stage division approach (Howlett and Rayner, 2008), it is easy to see that with the expanding applicability, the policy diffusion theory has become one of more established theoretical frameworks in policy process studies (Sabatier and Weible, 2014).

The factors influencing policy innovation are one of the central issues of the policy diffusion theory which has been tested empirically by scholars based on the explanatory framework. Berry and Berry (1990) analyzed the lottery policies of states across the US by introducing the EHA, unveiling that the internal characteristics (e.g., fiscal status, revenue level, etc.) of states and the policy adoption in neighboring states influence the implementation of local governments' lottery policies. Gilardi (2005) studied the establishment of independent regulatory agencies in Western

Europe, unveiling that three types of factors (credibility and political uncertainty at the primary level, the top-level Europeanization, and the horizontal inter-state dependence) explain the diffusion of regulatory capitalist system features across European countries. By constructing a dynamic Probit model, Meseguer (2006) found that countries' trade liberalization policy choices are influenced by the successful experiences of other countries. Wang and Zhao (2014) analyzed the factors influencing the adoption of the PPP model for toll roads in US states with the policy innovation diffusion theory, revealing that factors such as fiscal pressure and transportation demand influenced the PPP policy innovation in each location. Based on the results of related studies, it is made clear that the factors influencing policy innovation include both differences in local governments' endowments and interactions between local governments at both horizontal and vertical levels, an interactive process that often results in policy convergence (Sabatier and Weible, 2014). Horizontal mechanisms include learning, competition, imitation, etc., while vertical mechanisms include bottom-up and top-down influences (Gilardi, 2005). In past studies, horizontal mechanisms have received the most attention from scholars, while vertical mechanisms have started to attract more attention in recent years (Zhang and Zhu, 2019).

Although a lot of empirical studies have analyzed the mechanism of policy innovation diffusion in Western countries, studies on China have lacked sufficient attention (Zhang and Zhu, 2019). China's studies on the policy innovation diffusion began in 2004. Such studies have been on an upward trend since 2012 (Zhang *et al.*, 2019), with research efforts in related areas mainly including the urban subsistence allowance system (Zhu and Zhao, 2016), characteristic town policies (Yang and Wei, 2018), reforms of counties directly-administered by a province (Zhang, 2017), provincial administrative licensing reforms (Zhang and Zhu, 2019), PPP policies (Zhang, 2015) and others. Zhang (2015) used EHA to analyze the probability of influencing PPP adoption based on the prefecture-level PPP implementation data in China from 1992 to 2008, finding that there is a policy diffusion effect in China's PPP. Endogenous factors, vertical macro policies, and horizontal competition and imitation of local governments co-influence the PPP policy diffusion.

There is still room for improvement of the current literature on the spatial distribution of PPP. The reason is that the traditional EHA is used to study the time points at which PPP policy has been introduced across China. However, as PPP policy is a continuous improvement, a single time point of the introduction can hardly be utilized to depict the actual PPP policy diffusion of local governments. Due to data availability and other reasons, existing studies have ignored the institutional context of PPP promotion since 2014 and the causal relationship between government debt and PPP policy in the new era has not been sufficiently discussed. This paper will try to fill this gap.

3. Research Background

A review reveals that the PPP policy has been promoted in tandem with macro-institutional reforms at the national level. For example, the timing for promoting the PPP model of developed countries like the UK corresponds to the fiscal system reform implemented in response to fiscal deficits at the end of the twentieth century. The use of PPP in emerging countries tends to be linked to the urbanization context. In China, multiple important time points in the early introduction of PPP corresponded to the opening-up strategy in the 1980s, the fiscal system reform in 1994, and the accelerated urbanization in the early 21st century. However, PPP was not promoted on a large scale in China before 2014, with only 428 projects implemented in total (Tan and Zhao, 2019). BOT (Build-Operate-Transfer) is the main model of operation.

Since 2014, there has been a major change in the local government debt management model, which has become an important driver for the large-scale promotion of PPP policy. Before the implementation of the newly revised 2014 Budget Law, local governments had to resort to financing platforms and public institutions to achieve disguised financing due to the long-term lack of compliant financing channels. This debt model lacking transparency and restraint mechanisms has caused large-scale accumulation of debt. The Chinese Debt Audit Results published in 2013 disclosed the accumulated debt, of which the direct debt for which local governments alone are liable exceeded RMB 10 trillion. In order to resolve debt risks and fill the infrastructure investment gap, China's PPP has been developed unprecedentedly under the guidance of central policies, with rapid growth in the transaction size (Tan and Zhao, 2019; Qin *et al.*, 2022). As shown in Figure 1, PPP has covered the country's most cities in just a few years.

According to the Western theory of policy innovation diffusion, policy promotion generally shows a progressive S-shaped characteristic (Sabatier and Weible, 2014) because of complex constraints for adopting public policy. In other words, the promotion changes from the slow growth at the beginning to gradual decline at the end. This feature has become the mainstream description of the policy innovation diffusion. However, China's PPP policy process does not seem to conform to this feature. In some other areas (e.g., characteristic towns), some scholars have found that the policy process may also exhibit an explosive R-shaped feature (Yang and Wei, 2018), a phenomenon known as policy outbreaks. According to the promotion history of China's PPP, it can be found that the promotion of local PPP shows R-shaped non-progressive characteristics from the perspective of policy release and actual implementation (Figure 1).

4. Theoretical Hypothesis

The explanatory models in the policy innovation diffusion theory can be divided

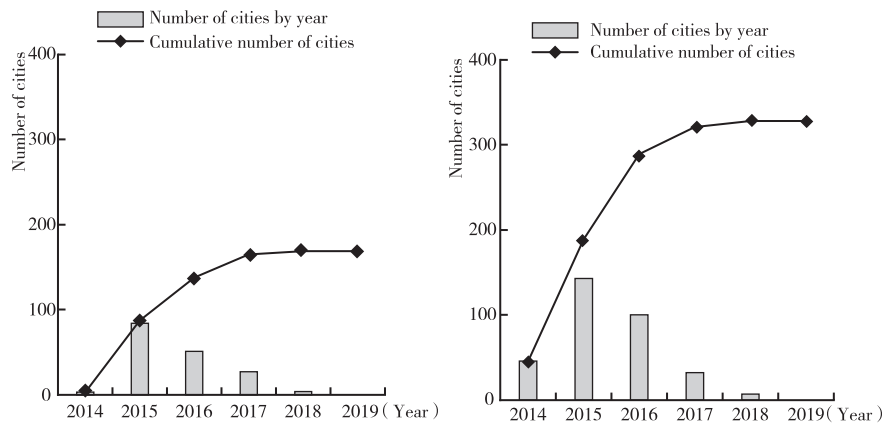


Figure 1. Number of China's Cities with PPP Policy (left) and PPP Project (right) from 2014 to 2019

Note: Cities refer to prefecture-level administrative units, the total number of which is 333; the sources include PKULAW.com, Bridata and local municipal government websites.

into two categories. The first category, or the internal decision model, regards the internal government factors as the main driving force of policy implementation. The second one takes the inter-governmental behavioral interaction as the focus of analysis, including the regional diffusion model.

4.1. Internal Decision Model

The internal decision model assumes that whether and when a local government policy is adopted depends on its own endowment or the political, economic and social characteristics within a region (Sabatier and Weible, 2014). The model is also inspired by individual experiences. Those with a higher social and economic status tend to have a higher probability of innovation behavior. In an internal decision model, the choice of explanatory variables depends on whether this factor can influence the adoption of new policy.

According to the research background, it is clear that the imbalance between the local debt risk and investment demand around 2014 is the direct cause for the central government to promote the PPP model. Thus, debt may be a key internal factor affecting the implementation of the PPP policy across the country. The debt ratios of China's local governments mostly stand at about 20%, but some regions far exceed the normal range of debt ratio and have high debt risk. In the context of strictly controlling local governments' debt, they tend to relieve debt pressure through PPP. However, for regions with debt ratios above a certain level, the debt service pressure of local governments and the central government's concern for high-risk regions curb the investment impulse of local governments, thus weakening the demand for PPP investment. Through empirical analysis at the project level, some scholars have found an inverted U-shaped nonlinear relationship between a local government's financial resources gap and PPP projects for

investment attraction (Shen *et al.*, 2020). This relationship may also exist between debt pressure and PPP investment, so this paper proposes:

Hypothesis 1: Debt pressure has a non-linear effect on local governments' PPP policies. The higher the debt pressure, the more local governments are motivated to pursue PPP investments. However, the investment demand for PPP may be relatively weakened when the debt pressure exceeds a certain level.

4.2. Regional Diffusion Model

The regional diffusion model assumes that there is a mechanism of strategic interaction between geospatial “neighbors” and that local governments adjust their policy choices by observing the behavior of other individuals (Graham *et al.*, 2013; Shipan and Volden, 2012), leading to convergence of PPP policies between regions. A consensus explanatory framework for how regional diffusion mechanisms are formed has not been developed (Graham *et al.*, 2013; Wang and Lai, 2013). Marsh and Sharman (2009) summarized the diffusion mechanism as learning, competition, coercion and imitation. Graham *et al.* (2013) compiled 104 descriptive terms about the policy diffusion mechanism through a literature analysis and outlined them as learning, competition, coercion and socialization. Overall, learning, competition and imitation among local governments are the main mechanisms of regional diffusion.

According to the regional diffusion model, the PPP policy diffusion may be related to geographical factors. To initially test whether there is a horizontal strategic interaction between neighboring local governments, this paper calculates the Local Moran's I for PPP investment and draws the Moran's scatter plots (Figure 2). In the Moran's scatter plots, the horizontal and vertical axis represent the PPP investment of the local region and neighboring regions, respectively. The slope of the line fitted by elements denotes the Moran's index value. It can be seen from Figure 2: (1) the spatial correlation of PPP investment always shows significant positive correlation over time and fluctuates upward in general; and (2) the scatter of most regions is concentrated in the first quadrant, meaning that regions with higher PPP investment tend to be surrounded by other regions with higher PPP investment. Therefore, it can be preliminarily assumed that there is a strategic interaction of PPP policies in geographic space. Based on the definition of learning, competition and imitation mechanisms in the regional diffusion model, this paper argues that the horizontal diffusion mechanism of PPP policies is caused by imitation and competition rather than the learning mechanism. The reason is that the key feature of the learning mechanism is a rational choice based on successful experiences of other regions, a condition that China's PPP policy does not seem to satisfy. Therefore, this paper proposes as follows.

Hypothesis 2: There are co-directional strategic interactions in PPP policies due to imitative and competitive mechanisms among local governments. Such interactions usually occur between regions that are geographically close to each other.

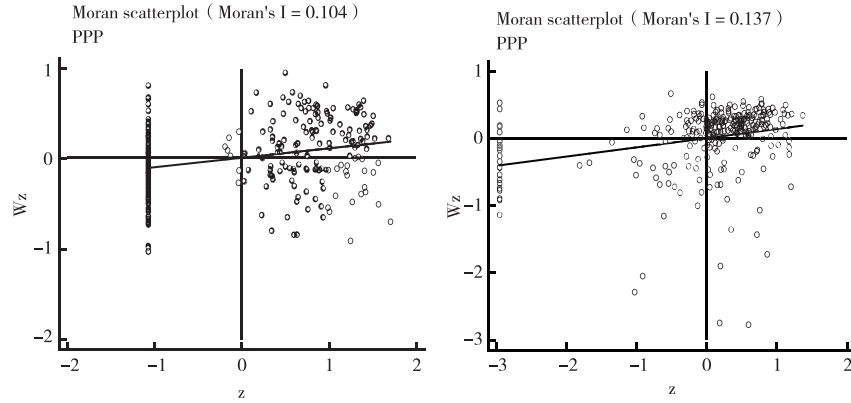


Figure 2. Moran's Scatter Plots of PPP Investment in 2015 and 2018

5. Test of Internal Decision Model (Hypothesis 1): PPP Policy Innovation under Debt Pressure

5.1. Research Design

To study the nonlinear impact of local government's debt on the PPP policy innovation, the following econometric model is developed in this paper.

$$PPP_{it} = \alpha + DEBT_{i,t-1}\beta + DEBT_{i,t-1}^2\gamma + X_{i,t-1}\theta + \eta_i + \delta_t + \varepsilon_{it} \quad (1)$$

The explained variable PPP_{it} is the PPP investment per capita in the region i in the year t ; the core explanatory variable $DEBT_{i,t-1}$ is the debt ratio of the region i in the year $t-1$, with a quadratic term for measuring the nonlinear effects; $X_{i,t-1}$ represents a series of control variables, and all explanatory variables are treated with a one-period lag to control endogeneity; η_i is a region fixed effect to control regional characteristics that do not change over time; δ_t is a time fixed effect to control macro situation shocks in each year; α is a constant term; ε_{it} is a random disturbance term.

5.2. Variable and Data

5.2.1. Explained Variable

The explained variable in this part is the PPP investment per capita. Based on the data support of Bridata (www.bridata.com), this paper collects the investment information of PPP projects from 2014 to 2019 published by the PPP Center of China's Ministry of Finance and further removes the provincial-level and central-level projects.

Finally, this research obtains the information of 8019 PPP projects with the investment totaling RMB 12.55 trillion. Since different types of PPP have large differences, this paper divides PPP into economic and social infrastructures. The former involves transportation, energy, science and technology, while the latter covers municipal engineering, social security, culture, elderly care, and medical and health care.

5.2.2. Core Explanatory Variable

Under the current debt management system, the debt balance of local governments can be used to directly measure their debt burden, so this paper uses the debt ratio (debt balance/GDP) as a core explanatory variable. To obtain the debt balance data, this paper manually collected budget and final accounts reports of each city from 2014 to 2018 and drew on the practice of Mao and Huang (2018) to fill in a small number of missing values and finally compile the debt stress data of 284 cities.

5.2.3. Control Variable

In order to explore the impact of debt stress on PPP investment, it is necessary to exclude confounding factors that affect both at the same time. This paper introduces the following control variables: (1) GDP per capita, which is used to measure the overall economic development at the city level; (2) population density, which controls the population distribution characteristics of cities; (3) the fiscal revenue per capita, which is measured by the general public budget revenue per capita, reflects the financial strength of a city; (4) the financial self-sufficiency rate refers to the ratio of general public budget revenue to expenditure, and the larger the number, the greater the proportion of financial resources originating from its own sources and the relatively higher the freedom of expenditure; (5) the financial development, which is measured by the ratio of loan balance of financial institutions to local GDP in this paper; (6) the characteristics of local leaders, which is collected from the age data of municipal Party secretaries and mayors in recent years to construct dummy variables to control their characteristics. Since local leaders approaching 60 years old may have greater promotion pressure (Luo and Qin, 2021), this paper defines as 1 if municipal Party secretaries/mayors aged 55~58 and 53~56, respectively, and as 0 otherwise; (7) the equalization index of basic public services, this paper uses the comprehensive evaluation method to construct the equalization index of basic public services and measure the level of basic public services from social security, public culture, health care, basic education, infrastructure and environmental protection, and the smaller the data, the lower the level of basic public services.

Among the above variables, the data of PPP awarded projects are derived from Bridata, the debt data from budget and final accounts reports of regions, and the data concerning age of municipal Party secretaries and mayors from government websites

and news reports. Other data sources are China City Statistical Yearbook and Wind Database. This paper collects balanced panel data for 284 prefecture-level cities (excluding municipalities, autonomous regions and leagues) in China from 2014 to 2019. Since the independent variable is treated with a lag period, the time span of the explained variable ranges from 2015 to 2019 and that of the explanatory variable ranges from 2014 to 2018. In order to mitigate the effect of heteroskedasticity, the data of PPP investment per capita, GDP per capita, fiscal revenue per capita, population density and financial development are taken in logarithmic form by adding 1, as in Table 1.

Table 1. Descriptive Statistics of Data

Variable	Observations	Mean	Standard deviation	Minimum value	Median	Maximum value
Total PPP investment per capita (add 1 to take the logarithm)	1704	0.11	0.16	0.00	0.04	1.18
Social PPP investment per capita (add 1 to take the logarithm)	1704	0.08	0.13	0.00	0.03	1.16
Economic PPP investment per capita (add 1 to take the logarithm)	1704	0.03	0.09	0.00	0.00	1.18
Debt ratio	1420	0.20	0.12	0.00	0.18	1.04
GDP per capita (log)	1420	1.76	0.44	0.72	1.72	3.41
Population density (log)	1420	0.04	0.04	0.00	0.03	0.50
Government revenue per capita (log)	1420	0.34	0.22	0.07	0.28	1.45
Financial self-sufficiency rate	1420	0.44	0.22	0.04	0.41	1.71
Financial development (log)	1420	0.68	0.25	0.11	0.62	1.92
Dummy variable for municipal Party secretary (equals 1 if aged 55~58)	1420	0.37	0.48	0.00	0.00	1.00
Dummy variable for municipal Party secretary (equals 1, if aged 53~56)	1420	0.48	0.50	0.00	0.00	1.00
Dummy variable for mayor and municipal Party secretary (equals 1, if aged 55~58)	1420	0.20	0.40	0.00	0.00	1.00
Dummy variable for mayor and municipal Party secretary (equals 1, if aged 53~56)	1420	0.38	0.49	0.00	0.00	1.00
Equalization index of basic public services	1420	0.20	0.06	0.08	0.19	0.62

5.3. Empirical Results

Since the standard error of the coefficient may be spatially correlated and subsequently affect the estimation results, this paper uses two ways to calculate the robust standard errors of core explanatory variables. The first way is to cluster standard errors at the provincial level and allow the correlation of disturbance terms in same-province cities. The second one is a spatially correlated calculation method for robust standard errors that sets the critical value at 100 km to calculate robust standard errors. According to the results in Table 2, it can be seen that the squared debt ratio term is significantly negative at the 1% level under the clustering-robust standard error, while the squared debt ratio term remains significantly negative at the 5% level under the spatially correlated robust standard error. With the continuous addition of explanatory variables, the coefficient is stabilized at the level of about -0.5 , and changes less. Therefore, the results are more robust, proving that there is indeed a nonlinear effect of debt pressure on PPP investment. In addition, although the significance level of the control variable coefficient is not the focus of this paper, it can be preliminarily speculated based on the regression results that the level of basic public services is not the main basis for local governments to adopt PPP.

By taking column (7) of Table 2 as the main analysis object, the turning point of the marginal impact of debt ratio on PPP investment can be calculated to be at around 36% based on the coefficient of the squared and primary terms of debt ratio. When the local debt ratio is below 36%, the PPP investment increases as the debt ratio rises, and the increased marginal magnitude gradually decreases as the debt ratio rises. When the debt ratio exceeds the critical value, the PPP investment begins to decrease as the debt ratio rises, and the decreased marginal magnitude gradually increases as the debt ratio rises. The impact of debt ratio on PPP investment shows an inverted U-shaped relationship.

Table 2. Parameter Estimations of Core Explanatory Variables

Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Debt ratio	-0.0467 (-0.39)	0.311* (1.85)	0.392** (2.43)	0.368** (2.41)	0.376** (2.38)	0.361** (2.20)	0.415** (2.48)
Squared debt ratio term		-0.484*** (-3.32) [-2.23]	-0.523*** (-3.39) [-2.32]	-0.502*** (-3.37) [-2.23]	-0.515*** (-3.32) [-2.34]	-0.499*** (-3.20) [-2.32]	-0.579*** (-3.69) [-2.74]
Financial development			-0.116 (-1.64)		-0.124 (-1.68)	-0.129* (-1.71)	-0.150* (-1.96)
GDP per capita			0.0378 (0.64)	0.074* (1.93)	0.026 (0.44)	0.005 (0.08)	-0.084 (-1.01)
Basic public services				0.023 (0.10)	0.045 (0.18)	0.026 (0.11)	-0.032 (-0.14)
Population density					-1.559 (-0.97)	-1.432 (-0.86)	-2.205 (-1.37)

Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Financial self-sufficiency rate						0.170 (1.19)	0.045 (0.32)
Fiscal revenue per capita							0.303 (1.32)
Dummy variable for age of leaders	No control	No control	No control	No control	No control	No control	Control
Region/year effect	Control	Control	Control	Control	Control	Control	Control
<i>Selection ratio</i>	–	–	13.410	23.905	39.62	31.186	7.238
R ²	0.154	0.157	0.159	0.158	0.160	0.163	0.172
N	1420	1420	1420	1420	1420	1420	1420

Note:***, **, * denote the significance levels of 1%, 5% and 10%, respectively. The values in parentheses are the clustering-robust t-statistics of regression coefficient estimates. The spatial GMM standard errors (100km) calculated for the squared debt ratio term are in the square brackets. The same holds for the rest tables.

The impact of debt ratio on PPP investment may be heterogeneous, so this paper further performs group regressions to test the various impacts of debt ratio on PPP projects of social and economic infrastructures. As shown in Table 3, the debt ratio has a significant non-linear effect on social infrastructure at the 1% level, and the direction and magnitude of the coefficient are closer to those in the total sample. In contrast, the impact of debt ratio on economic infrastructure PPP is not significant, indicating that the impact of debt ratio on the current round of local government PPP investment mainly acts on social class infrastructure, while economic infrastructure PPP projects are not sensitive to debt ratio because they have certain operating space of their own and can generate cash flow that covers certain costs.

Table 3. Parameter Estimation Results of Core Explanatory Variables

Explanatory variable	Social infrastructure PPP	Economic infrastructure PPP
Debt ratio	0.374** (2.51)	0.054 (0.67)
Squared debt ratio term	–0.487*** (–2.91) [–2.99]	–0.103 (–0.69) [–0.67]
Control variable	Control	Control
Region-year effect	Control	Control
R ²	0.155	0.043
N	1420	1420

From this part of the analysis, it is clear that debt and PPP, as the two major financing instruments for local governments, do not present a complete substitution relationship but have an obvious order of preference. As the debt size is small, local governments are less likely to use the PPP model. As the debt size increases,

PPP becomes the second-best choice. This is partly in line with the Pecking Order Hypothesis that local governments prioritize the debt financing followed by the PPP financing in their financing behavior (Zhao *et al.*, 2019; Qin and Luo, 2022).

6. Test of the Regional Diffusion Model (Hypothesis 2): PPP Policy Innovation through the Interaction of Intergovernmental Behaviors

6.1. Identification Strategy

According to the traditional EHA, whether a policy is implemented (0 or 1) or the probability of policy implementation (0 to 1) is used as the explained variable to analyze the law of policy diffusion between regions. Although this identification strategy captures the chronology of policy adoption, it is difficult to measure the depth of policy promotion. The PPP policy has covered most regions in the first three years of rollout, but the implementation of policy varies significantly. The long-term dynamics of the PPP policy cannot be portrayed using the traditional EHA. The neglect of spatial characteristics in the policy diffusion research is a “surprising” phenomenon compared with a wide range of applications in other fields (Mitchell, 2017). The combination of policy diffusion and space has not received sufficient attention. Since interactions between individuals, groups and organizations are fundamental to understanding most social phenomena (Cook *et al.*, 2019), the spatial characteristics of policy diffusion can be explored to help increase the breadth of the policy diffusion theory.

Spatial econometric models can be used to depict whether PPP is adopted and the scale of adoption in a particular geographical unit and temporal context, and to examine temporal variation and spatial performance (Mitchell, 2017). Accordingly, this paper develops a spatial econometric model to test whether there is spatial correlation in the implementation of PPP policies across regions. For the explained variable, this paper uses the cumulative PPP investment amount per capita as a proxy variable for the implementation of policy to verify whether the policy innovation in other regions have had an impact on themselves. Regarding model selection, to better portray the spatial interaction of PPP investment and not to cause unidentifiable coefficients, the paper, following LeSage and Pace (2009), introduces the spatial lag terms of explained and explanatory variables and uses the Spatial Durbin Model (SDM) as a starting point for analysis. For one thing, such a model setup can solve the omitted variable problem to some degree. For another, the SDM model can still yield unbiased estimates even if the true applicable model is of other types (Atella *et al.*, 2014). Regarding control variables, in addition to introducing economic characteristics, regional leader characteristics and basic public service levels, the spatial correlation of PPP investment between cities may be the result of joint shocks by provincial governments due to the vertical fiscal interactions between municipal and provincial governments in China (Yu *et al.*, 2011). Thus, this paper further includes

provincial vertical variables to exclude the spatial correlation of PPP investment caused by provincial policies. The final dynamic SDM is established as follows:

$$PPP_{it} = \gamma PPP_{i,t-1} + \lambda \sum_{j \neq i}^n w_{ij} PPP_{jt} + X_{i,t-1(t)} \beta + \sum_{j \neq i}^n w_{ij} X_{j,t-1(t)} \theta + \eta_i + \delta_t + \varepsilon_{it} \quad (2)$$

wherein the explained variable PPP_{it} is the PPP investment per capita in the region i as of the year t ; γ measures the dynamic effect due to policy inertia; $\sum_{j \neq i}^n w_{ij} PPP_{jt}$ represents the spatial lag term of the explained variable, and λ is the spatial response coefficient; $X_{i,t-1(t)}$ denotes a set of core explanatory and control variables, including the provincial-level PPP investment per capita in the year that is used to overcome the common shock. To control endogeneity, all explanatory variables, except the provincial-level PPP investment per capita, are treated with a one-period lag. $\sum_{j \neq i}^n w_{ij} X_{j,t-1(t)}$ is the spatial lag term of the explanatory variable; η_i is the individual fixed effect; δ_t is the time fixed effect; ε_{it} is the random disturbance term.

6.2. Empirical Results

To analyze the influence of geographic and economic environment on spatial correlation, this paper introduces both the spatial weight matrix of geographic distance and economic distance, focusing on the results of spatial response coefficients. As shown in columns (1) and (2) of Table 4, the spatial response coefficient of 0.306 is at a significant level of 1% when the spatial correlation resulting from the provincial level is not controlled, while when the provincial factors are controlled, the spatial response coefficient drops to 0.106, which is still at a significant level of 10%. This suggests that after the provincial factors are excluded, the promotion of PPP policy by local governments is still influenced by other local governments with close geographical proximity. For robustness estimation, this paper introduces the geographic-distance spatial weight matrix with distance thresholds of 500km and 1,000km and the nearest-neighbor spatial weight matrix (the number of nearest-neighbor areas is 5) in columns (3)–(5), respectively. The results show that the spatial response coefficients are significantly positive and the significance is strengthened after the threshold range is set. According to this result, the estimates of spatial response coefficients are robust, local governments are more sensitive to the level of PPP investment in neighboring regions, and there exists a positive spatial strategy interaction mechanism.

Economic distance, as shown in column (6) of Table 4, does not have a significant effect on spatial correlation, probably due to the limited attention of local governments

that do not conduct significant strategic interactions with cities with similar economic characteristics but at a greater geographical distance. However, since PPP policy has a direct impact on the local economic development, local governments may still pay more attention to cities with similar economic characteristics and close geographical proximity when promoting PPP policy for the purpose of catching up. Therefore, this paper further introduces a spatial weight matrix of geographical-economic distance to measure their combined impact on the interaction of spatial strategies. According to the results in column (7) of Table 4, it can be seen that the spatial response coefficient is significantly positive at the 1% level, after considering both geographical proximity and similar economic characteristics. Comparing the results in column (2), it can be found that the significance and magnitude of the coefficient are significantly higher. It can be preliminarily speculation that there is a stronger interaction of spatial strategies across regions with similar distance and economic development in promoting PPP policy. The implied mechanism behind it will be analyzed in the next section.

Table 4. Estimation Results of Spatial Econometric Model MLE

Explanatory variable	(1) Geographic distance	(2) Geographic distance	(3) Geographic distance-500	(4) Geographic distance-1000	(5) KNN	(6) Economic distance	(7) Geographic and economic distance
Spatial response coefficient	0.306*** (6.34)	0.106* (1.88)	0.135*** (3.24)	0.147*** (3.10)	0.070* (1.76)	0.025 (0.47)	0.128*** (3.41)
Provincial investment per capita	No control	Control	Control	Control	Control	Control	Control
Other control variables	Control	Control	Control	Control	Control	Control	Control
Independent variable spatial lag	Control	Control	Control	Control	Control	Control	Control
Region-year effect	Control	Control	Control	Control	Control	Control	Control
R ²	0.504	0.502	0.559	0.534	0.603	0.646	0.609
N	1420	1420	1420	1420	1420	1420	1420

Note: ***, ** and * denote the significance levels of 1%, 5% and 10%, respectively. The values in parentheses are the heteroskedasticity-robust z-statistics of regression coefficient estimates (the same below). The spatial weight matrix elements of geographic distance are the inverse of the squared geographic distance between two locations. Those of economic distance are the inverse of the difference in mean GDP per capita between the samples of two locations.

6.3. Mechanism Analysis

The strategic interaction mechanism for PPP policies among local governments

may be simultaneously imitative and competitive. In this context, imitation refers to the symbolic adoption of similar policies by local governments coupled with other regions, which lack a rational concern for policies but are often motivated by the need to gain legitimacy (Marsh and Sharman, 2009). Competition mainly refers to strategic interactions at the economic level. For example, tax competition between local governments and neighboring regions is initiated to attract investment, in which imitation-like strategic interactions between local governments may occur in the same direction. Due to the subjective nature of behavioral mechanism, it is often difficult to distinguish imitation from competition in reality.

Compared with imitation, the unique feature of the competition mechanism is that there may be a certain “provincial boundary effect” that refers to the fact that strategic interactions across regions are influenced by “whether they belong to the same province or not”. If there is a provincial boundary effect, it means that local governments are more sensitive to their neighboring cities that belong to the same province when they interact strategically. The reason for the provincial boundary effect is that, driven by the “promotion contest”, local leaders tend to compete with those of other regions in the same province based on the logic of improving economic efficiency to get promoted to a higher rank. In contrast, the imitation mechanism, based on geographic distance, is less influenced by provincial administrative boundaries.

In the existing literature, Yu *et al.* (2016) verify that tournament competition among China’s local governments is influenced by provincial administrative boundaries by constructing a spatial econometric model. This paper uses a similar means to infer the role of competition mechanisms in the PPP policy diffusion. For model construction, this paper splits the spatial weight matrices of geographic and economic distances in the previous section into same-province and different-province matrices and completes the mechanism test using the spatial econometric model, respectively. Specifically, the distance elements of regions in different-province on the same-province matrix are 0, and those of regions in the same-province on the different-province matrix are 0. The sum of the same-province and different-province matrices is equal to the initial weight matrix. From the results in Table 5, it can be seen that the spatial response coefficients of both same and different provinces are significantly positive in the setting of geographic distance, without evidence of provincial boundary effects. This proves that the imitation mechanism does exist between neighboring regions.

This paper further uses the spatial weight matrix of economic distance to test if there is a provincial boundary effect. As shown in Table 5, although regions with similar economic characteristics did not significantly influence local PPP investment behaviors within the full sample, this co-directional interaction effect can be found when the scope is limited to a province. This can be explained by inter-regional competition. Local governments have a stronger competitive awareness for intra-provincial areas with similar economic characteristics to improve their provincial

rankings. This competition, embodied in the promotion of PPP policy, propels up PPP investments. In addition, the spatial response coefficient is not significant on the different-province economic distance matrix. Therefore, the provincial boundary effect exists, proving that the PPP investment behavior of local governments may also be influenced by the competition mechanism.

Table 5. Identification of Spatial Response Coefficients on Different Spatial Weight Matrices

Explanatory variable	Geographic distance			Economic distance		
	Full sample	Same province	Different province	Full sample	Same province	Different province
Spatial response coefficient	0.106* (1.88)	0.0587* (1.73)	0.197* (1.77)	0.025 (0.47)	0.063* (1.93)	0.044 (0.81)
Control variable	Control	Control	Control	Control	Control	Control
Independent variable spatial lag	Control	Control	Control	Control	Control	Control
Region/year effect	Control	Control	Control	Control	Control	Control
R ²	0.502	0.537	0.473	0.646	0.614	0.599
N	1420	1420	1420	1420	1420	1420

7. Conclusion and Implication

This paper explores the formation mechanism of the PPP spatial pattern from both internal and external aspects based on the theory of policy innovation diffusion. The main findings are as follows. First, the PPP policy innovation diffusion in China exhibits R-shaped non-progressive characteristics, shaping non-equilibrium at the spatial level. Second, local governments' debt pressure is an important internal factor for their PPP policy innovation. As debt pressure increases, local governments tend to invest in more PPP projects. However, when debt pressure exceeds a certain level, PPP policy innovation may be inhibited. This nonlinear relationship is mainly reflected in PPP projects for social infrastructure that lack sources of return. Third, the implementation of PPP policies among neighboring local governments has strategic interaction, and behind this interaction is the imitation and competition mechanism between regions.

Not all policy innovations have positive effects. The applicability of policies is related to local governance needs and adjustment costs (Yu and Huang, 2015). Regarding PPP policy, it is important to see both their improvement of infrastructure and public services and the disconnect between local financial resources and affordability that is caused by the process of following and imitating them. Since the financial payment responsibilities involved in PPP are only scattered at various time points, the blind adoption of PPP will increase the future fiscal pressure for regions with high debt pressure and poor economic level, thus forming imperceptible financial risks. This paper therefore recommends as follows.

First, the PPP fiscal risks need to be controlled by combining flow and stock control. Since economic infrastructure projects with operating revenues are limited, a large number of current PPP projects feature viability gap funding, resulting in a large-scale local government payment responsibility. It is recommended that the comprehensive statistics on the implementation and operation of each project be compiled and the total expenditure responsibility of existing PPP projects be disclosed in a government's budget and final accounts report, so that local governments can better plan their financial resources and the fiscal pressure of local governments can be more comprehensively reflected. With the continuous improvement of government accounting system, the PPP stock control has become feasible to some degree.

Second, the ex-ante evaluation system should be improved to optimize the spatial allocation pattern of PPP. PPP is a new model to improve operational efficiency and stimulate the vitality of social capital. According to their needs, local governments should be encouraged to explore the optimal path of PPP to avoid the possible imbalance of PPP supply and demand and the region-level fiscal risk, which are brought by the irrational spatial interaction. In order to avoid the narrowing of PPP policy objectives, it is recommended to improve the ex-ante "value-for-money" evaluation mechanism and incorporate more sustainable development concepts into the PPP evaluation mechanism, so as to guide local governments to achieve sustainable development as the policy objective and reduce the negative effects caused by irrational imitation and competition.

Third, the performance assessment system needs to be improved to strengthen collaborative governance. As more PPP projects make their way into the operation phase, the ability to assess PPP performance will become a key part. The current external incentives for local governments to implement PPP come from both the top-down central policy pressure and mutual influence among same-level local governments, without effective bottom-up constraints. It is recommended that relevant departments and industry experts pool their wisdom to refine PPP performance assessment indexes in various sectors and introduce public satisfaction into the performance assessment system, so as to transform the incentive orientation of local governments and include more relevant subjects to ensure the sustainable development of PPP.

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