An Analytical Case Study of Government Policy Effects Using Synthetic Control Method: The Beijing-Tianjin-Hebei Collaborative Development strategy

DAI Hongwei

School of Economics, Central University of Finance and Economics, Beijing

daihw@163.com

CHU Yichen

School of Economics, Central University of Finance and Economics, Beijing

yichenchu@foxmail.com

Abstract: In 2001, after Beijing's successful bid to host the 2008 Olympic Games and the unveiling of the Beijing-Tianjin-Hebei Collaborative Development Plan by WU Liangyong of the Chinese Academy of Sciences, efforts of collaboration among Beijing, Tianjin, and Hebei began to take on new impetus. This study aims to answer the following issues: identifying the effective outcomes that can be attributed to the Beijing-Tianjin-Hebei collaborative development and determining the different effects that this collaboration has had on Beijing, Tianjin, and Hebei province since 2001. This paper applies the synthetic control method to a policy analysis of the current status of the Beijing-Tianjin-Hebei collaborative development by using provincial-level panel data for the 1990–2014 period. The findings show that the Beijing-Tianjin-Hebei collaborative development has had positive effects on growth for Beijing and Tianjin, increasing the average annual GDP per capita growth by 3.14% and 3.45%, respectively, in the two municipalities; the effects are statistically significant. However, the implementation of this policy has, in fact, resulted in a reduction of GDP per capita in Hebei province.

Keywords: Policy Analysis, Treatment Effects, Synthetic Control Method, Beijing-Tianjin-Hebei Collaborative Development strategy

JEL codes: O18, R11

I. Introduction

In the growth center of the Beijing-Tianjin-Hebei region, an area that has been the target of government policy support, collaborative development is a focus of attention in academic and media circles. China has a national strategy for regional collaborative development. The progress in the development of the Xiong'an New Area has bestowed new significance upon this strategy—the Tianjin-Hebei region is heralding a new era with abundant fresh development opportunities. Before the official policy was developed, Beijing, Tianjin, and Hebei had a long evolutionary process of regional cooperation. In the years after Beijing's 2001 successful bid to host the 2008 Olympic Games and the unveiling of the Beijing-Tianjin-Hebei Collaborative Development Plan in 2004 by Wu Liangyong from the Chinese Academy of Sciences, such cooperation began to take on new impetus. The year 2001 was the "beginning of an era" for collaborative development in Beijing-Tianjin-Hebei. In the ensuing period of over a decade, there has been rapid regional economic growth in this region. Some questions arise: what particular outcomes have been brought about during the process of the Beijing-Tianjin-Hebei collaborative development? What different impacts have taken effect in these three localities? A thorough assessment of these issues would be valuable to deepen understanding of the effects of regional collaborative development in this region and should elucidate direction for the next phase in intensifying the collaboration among Beijing, Tianjin, and Hebei.

The most commonly used methodologies in global policy analysis circles are mainly based on the causal effect recognition framework; these include difference in differences (DID), regression discontinuity (RD), instrumental variables (IV), and so forth. Yet, practical applications of such inference methodologies have limitations. For example, the relatively widely adopted DID method has a crucial assumption premise—the parallel trend assumption. That is to say, if the data points in the processing set are not subject to policy impact, the processing set's outcome trend variation should correlate with the trend variation of the control set. This is another way of saying that after removing the policy effects, the other factors must exert the same influence on Beijing, Tianjin, and Hebei as that on the other provinces used as controls. However, because there are great disparities in the levels of development in different provinces, parallel trends do not actually exist in the real world. Hence, rejecting the limitations and possible endogeneity problems associated with the DID method, this study applies the synthetic control method to analyze the effects of the Beijing-Tianjin-Hebei collaborative development. Panel data, during the 1990–2014 period, aggregated by province, is used to examine the effects after 2001. By using the synthetic control method, fairly good control sets can be constructed through the nonparametric method; this will also resolve the inherent problems of

time-variant unobserved factors that cannot be adequately handled by DID. Many academic papers on policy analysis that use the synthetic control method have appeared in recent years. In Abadie et al. (2010), the synthetic control method is used to analyze the impacts of California's tobacco control policy measures. Abadie et al. (2015) applied the synthetic control method to analyze the policy effects on West German economic growth after the unification of East and West Germany in 1990. Moreover, by adopting the distinctive salient characteristics of the synthetic control method, many scholars have been applying this methodology to perform analyses on the effects of regional policy implementation. In Wang et al. (2010), the synthetic control method was used to investigate the re-demarcation of the administrative boundaries in the city of Chongqing's severance from the provincial administration of Sichuan to become a separate capital territory in 1997. The findings show notable growth effects for the Chongqing region subsequent to the event but show no observable economic growth for the Sichuan province. The synthetic control method is also used in Yang et al. (2017) to analyze the regional economic policies aimed at reviving the northeastern region of China, finding that the implementation of the policy measures brought about increases in the economic growth rates of 1.1–1.6 percentage points in the three provinces of the northeastern region in the years after 2003. The study also explored the sustained effects and action mechanisms of these policies. Liu, N. et al. (2017) used the synthetic control method in an investigation of the economic impact of the administrative expansion of the Yangtze Delta region in 2010; they found notable effects of regional economic policies on economic growth in the cluster of cities around the Yangtze Delta region, while also observing differences in the extent of policy effects between older cities and newly developed cities.

However, research papers on applying the causal effect recognition framework to policy analysis vis-à-vis the Beijing-Tianjin-Hebei collaborative development remain relatively scarce. A majority of papers focus on subjects such as analyses of the Beijing-Tianjin-Hebei region's internal structures, proposals for infrastructure innovation, and creating assessment mechanisms for development outcomes. Most papers typically fall into two major categories. The first centers on the elucidation of the background history, current status, and existing problems of the Beijing-Tianjin-Hebei coordinated regional development, which usually offers recommendations for advancing collaborative development in the region. Lu et al. (2015) expound on the key features, comparative advantages, economic interactions, and conflicts of interest during the development in the three localities of Beijing, Tianjin, and Hebei province and suggested rational orientations for the three localities. Zhang (2014) presented a recapitulation and overview of historical perspectives on regional collaboration among Beijing, Tianjin, and Hebei during 1976–2014 with an analysis of the

constraining factors impinging on integration and development in the region, as well as direction for development in the future. Sun and Yuan (2014) give a fact-and-figure analysis of the strategy for the Beijing-Tianjin-Hebei collaborative development, temporally dividing it into three phases of passive actuation, proactive action, and coordination. Research by Bo (2015) reports that there are still three major perennial challenges for development in Beijing, Tianjin, and Hebei province, namely, impeded optimal interaction between industries, unidirectional flow of key factors, and the lack of a coordinating mechanism for governance. Bo (2015) then presented an analysis of the practical problems currently encountered in moving forward with collaborative development. The other category of research is devoted to assessments of the quality of development or the status of development in specific sectors in Beijing, Tianjin, and Hebei province through data analysis. The paper by Dai and Liu (2010) is based on a sectoral comparison between Beijing, Tianjin, and Hebei province on one side and the Yangtze Delta region on the other, which applies the objective weighting method and data envelopment analysis (DEA) to arrive at the conclusion that the overall competiveness of the metropolis sphere in Beijing, Tianjin, and Hebei is lower than that in the Yangtze Delta region. Li and Zhang (2014) offer a treatise on formulating a quality assessment benchmark system for city clusters by invoking a four-dimensional scheme comprising the level of smartness of facilities and services, standard of public service, degree of modernization in basic infrastructure, and eco-sustainability; the scheme is then applied to a comparative assessment of the development quality in city clusters and prefectural-level municipalities in Beijing, Tianjin, and Hebei province, as well as a comparative assessment with major cities in the Yangtze Delta region. The paper by Liu and Zhang (2015) is a comparative analysis of the key factors that influence innovation and the general environment for innovation in Beijing, Tianjin, and Hebei; in addition, DEA is applied to examine the coordinated innovative potential of industries in the region. The authors found that generally the overall innovative capabilities of industries in Beijing are relatively strong and that Tianjin shows strength in the domain of industry upgrades and renewal; meanwhile, coordinated innovation in Hebei province is rather poor.

On the basis of the analytical overview of the research literature, this paper has three intentions. The first is to recognize causal effects and obtain analytical results of the current status of the Beijing-Tianjin-Hebei collaborative development. The second is to apply the synthetic control method to overcome the limitations and endogenous problems associated with other methodologies such as DID. The third task is to individually assess the policy effects on the three localities of Beijing, Tianjin, and Hebei province to conduct a comparative analysis of the policy impact on the three localities.

II. Background:
The Evolution of the Beijing-Tianjin-Hebei Collaborative Development

In comparison to the Yangtze Delta region and the Pearl River Delta region, the Beijing-Tianjin-Hebei collaborative development comes with certain idiosyncrasies. Before the dawn of the 21st century, individual cities tended to focus on their own municipal development, with relatively little coordination between the different cities and regions. After 2000, Beijing was faced with a historic mission to transform its municipal functions as the national capital, and the whole region spanning across Beijing, Tianjin, and Hebei province was expected to evolve and push ahead with collaborative development.

Dai and Song (2013) state that national capitals in the world generally fall into two categories of development models. The first is the development model for a uni-functional national capital; that is to say, municipal development revolves around the objective of the national capital as a political and cultural hub with an emphasis on building a uni-functional center for national political and cultural activities. The other is the development model for a multifunctional national capital. In other words, municipal development revolves around the objective of having a national capital as a political, economic, and cultural center, with the dual intention of building a major metropolis with comprehensive municipal functions. From 1949 to 1999-end, Beijing's development followed the multifunctional model. After the dawn of the new century, Beijing began to focus on building a uni-functional national capital. The evolution of regional policies in the Beijing-Tianjin-Hebei region consists of four stages as described in the next sections.

1. 1949–1980: A period of no collaboration under the effect of the planned economy

During this period, Beijing completed its transformation from a consumption city to a production city, the multifunctional national capital development model took shape, and the city became an important economic center in the country. Tianjin and Hebei province also achieved very rapid socioeconomic development. However, for the Beijing-Tianjin-Hebei region in its entirety, in coming off a long period of central planning with no overall collaborative planning for development, the sectoral distributions and internal industry structures were clearly suboptimal. There were great disparities in the levels of development within regions. Each city went its own way, there was extremely limited economic cooperation, and there was fierce competition for projects and funding.

2. 1981–2000: The nascent period for Beijing-Tianjin-Hebei regional collaboration.

This period witnessed deliberation on and experimentation with different forms of regional collaboration. China's very first regional collaboration body—the North China Economic & Technical Cooperation Zone—was founded in 1981, and it involved Beijing, Tianjin, and Hebei. In 1986, the mayor of Tianjin, Li Ruihuan, inaugurated the Joint Mayoral Committee for Bohai Sea Rim Regional Economic Cooperation (now renamed Joint Mayoral Commission for Bohai Sea Rim Regional Cooperation), promoting cooperation among the three localities. During the 1990s, the State Planning Commission organized a research group to produce the "Summary Outline of Economic Development Plans for the Bohai Sea Rim Region," putting forth for the first time the notion of a Bohai Sea Rim regional economic area spanning Beijing, Tianjin, Hebei, Shandong, Liaoning, Shanxi, and central Inner Mongolia. On the whole, however, the North China Economic and Technical Cooperation Zone never played an effective role in coordinating regional economic development. The Joint Mayoral Committee for Bohai Sea Rim Regional Economic Cooperation was nominally chaired by Tianjin; however, it never fully included the leadership position of Beijing in the development of regional cooperation, which resulted in rather limited practical outcomes. Since the initial planning stage, cooperation between the member localities of the Bohai Sea Rim region remained loosely organized and did not attain any depth of intensive or practical interaction; consequently, the enormous potential for this region to drive economic development was far from realized.

3. 2001–2013: The period witnessing development and progress in Beijing-Tianjin-Hebei integration.

After the dawn of the new century, the Beijing-Tianjin-Hebei regional collaboration heralded a new era. On the one hand, as the city of Beijing's population and the scale of its economic activities continued to expand, municipal facilities in the city were subjected to increasing strain. In addition, Beijing's successful 2001 bid to host the 2008 Olympic Games initiated major efforts to upgrade the city's infrastructure, its general environment, and its ecological condition. Beijing relocated parts of its municipal functions, and regional economic collaboration was needed to coordinate industry relocation and restructuring. The Beijing-Tianjin-Hebei region, an important economic area in China, further strengthened its intraregional cooperation to create an economic growth center that was well coordinated and had a strong impact. Amid this backdrop and the introduction of a steady flow of relevant policy measures, there was growing momentum of integration in the decade after 2000. In

2001, Wu Liangyong and his research group conducted a planning study for "greater Beijing," which garnered resounding responses from government ministries and community centers alike. November 2004 marked the formal initiation of the administrative process to formulate regional planning schemes for the Beijing-Tianjin-Hebei metropolis sphere. The regional policy for Beijing-Tianjin-Hebei was part of a national strategy and included in program catalogs for the "11th Five-Year-Plan" and the "12th Five-Year-Plan." However, it should be stressed that although the Beijing-Tianjin-Hebei region truly ushered in an era of integration development in this period, many studies reported that the quality of integration development in the Beijing-Tianjin-Hebei region lagged behind other regions such as the Yangtze Delta region and the Pearl River Delta region① ②. It is worth mentioning that in 2005, the Asian Development Bank introduced the notion of a "Poverty Belt around Beijing and Tianjin,③" which drew further interest to the issue of unbalanced regional development in the Beijing-Tianjin-Hebei region. Although the Beijing-Tianjin-Hebei region saw a period of rapid economic development, it also faced serious problems, such as the homogenization of industry sectors, un-optimal industry structures, and intraregional disparities.

4. 2014–present: A period highlighting the Beijing-Tianjin-Hebei collaborative development elevated to national strategy status

On February 26, 2014, President Xi Jinping introduces the "Seven Requirements" for the Beijing-Tianjin-Hebei collaborative development to elevate this development program to the status as part of national strategy. August 2014 saw the State Council establishing the Leading Group for Promoting Beijing-Tianjin-Hebei Collaborative Development; in April 2015, the Central Politburo deliberated and voted to pass the "Beijing-Tianjin-Hebei Collaborative Development Program Outline," enabling a gradual refinement of the top-level design, coordinating bodies, and implementation platforms for the Beijing-Tianjin-Hebei collaborative development heralding an all-new era for the Beijing-Tianjin-Hebei collaborative development with the core objective of relieving Beijing of its noncapital municipal functions. In 1st April 2017, the CCCPC and the State Council jointly decided to establish the nationally designated Xiong'an New Area in Hebei province with a view to exploring new models for optimizing development in densely populated regions while

① ZHANG Keyun (2014) measured the correlation coefficients of economic development for cities and provinces in the Beijing-Tianjin-Hebei region and the Yangtze Delta region (2000-2012), with the results of the calculations showing intraregional economic interactions in Beijing-Tianjin-Hebei being far lower than those in the Yangtze Delta.
② MAO Hanying et al. (2017) proposed that in contrast to the Yangtze Delta and the Pearl River Delta regions, which are economically more developed with more balanced intraregional development, the cities and province of the Beijing-Tianjin-Hebei region are beset with not only serious development disparities but also severe disequilibrium in intraregional development, quite suboptimal operation of free market, impeded flow of essential economic factors, and relatively weak policy effects.
③ ADB published a research report titled "Hebei Provincial Development Strategy" (2005). This report alluded to the 32 impoverished counties and 3,798 impoverished villages within the six prefectures and municipalities adjoining Beijing and Tianjin, collectively forming a "poverty belt around Beijing and Tianjin" hosting an impoverished population of up to 2,726,000.

fostering new growth centers in regional economic development. The schemes for metropolitan expansion and economic development blueprints in the Beijing-Tianjin-Hebei region are also subject to extensive revamping and enhancement to usher an all-new period of comprehensive collaborative development.

It can be seen from the preceding review of the Beijing-Tianjin-Hebei regional policy and the historical perspectives that there were two important turning points in the evolution of the Beijing-Tianjin-Hebei collaborative development: the year 2001 and the year 2014. In this synthetic control study, we selected 2001 to investigate the impact of government policy. The period from 2001 to the present spans a longer prediction interval and offers more data, which will prove to be helpful in analyzing the complex conditions underlying collaborative development in the three localities.

III. Empirical Method and Analytical Data

1. Overview of the Synthetic Control Method

This study adopts the synthetic control method to estimate the effects of collaborative development on Beijing, Tianjin, and Hebei. The synthetic control method is a nonparametric scheme that was originally proposed by Abadie et al. (2003). Its central notion is to use a mass of control data points to synthesize a control set with the same economic characteristics as the actual processing set, thereby facilitating a decent simulation of the latter. From the perspective of policy implementation, the processing set of data is under the influence of the policy's impact; however, the synthetic control set is not. The processing set traces out an actual growth path; however, the synthetic control set traces out the growth path in the scenario under which the policy remains unintroduced. Hence, the growth curve of the synthetic control set becomes the "counterfactual state" that is needed in causal inference. The gap between the processing set and the synthetic control set being the net effect of policy impact. In contrast to DID, the synthetic control method has a number of advantages. First, DID cannot resolve the endogeneity problem arising from time-variant unobserved factors; that is, DID must meet the parallel trend assumption in its application. In contrast, the synthetic control method overcomes the endogeneity problem. Second, the subjectively chosen control set in DID makes it prone to selection bias. Contrariwise, the weighting in the synthetic control method is obtained by nonparametric computation, in which all constituent weights sum to one, hence engendering more objectivity.

More particularly, this study assumes a total of J+1 regions, with region 1 (Beijing, Tianjin, or Hebei) being subject to policy intervention (the Beijing-Tianjin-Hebei collaborative development policy) at time T_0, while other regions are unaffected by policy intervention. Y_{it}^N denotes the outcome variable for region *i*, which is not under policy impact at time *t*, Y_{it}^I denotes the outcome variable for region *i* under policy impact at time *t*; hence, $\alpha_{it} = Y_{it}^I - Y_{it}^N$ represents the net effect of policy impact on region *i* at time *t*. As an example, for region 1, which is under policy impact, the net effect of policy impact is simply denoted by α_{1t}. When time *t* is greater than T_0, Y_{it}^I is observable; as Y_{it}^N is the counterfactual state, it is not directly observable. Therefore, the crux of the issue is to find a way to construct an appropriate control set to derive the counterfactual state. Drawing on research by Abadie (2010), we make the assumption that Y_{it}^N can be represented by the model below.

$$Y_{it}^N = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{ti},$$

where δ_t is the time-invariant effect that equally impinges on all regions; the variable Z_i is an $\mathrm{r}\times 1$ dimensional vector of eigenvalues for regions not under impact of the Beijing-Tianjin-Hebei collaborative development policy; θ_t is a $1\times\mathrm{r}$ dimensional parameter vector; μ_i is a $\mathrm{F}\times 1$ dimensional vector of region-invariant effects; λ_t is a $1\times\mathrm{F}$ dimensional vector of the time-variant common factor; and ε_{ti} is a random disturbance term.

On the basis of this model, and to obtain the counterfactual state Y_{it}^N, we need to apply a weighting method to construct a suitable control set. Consider the $\mathrm{J}\times 1$ dimensional weight vector $\mathrm{W} = \left(\omega_2,\ \omega_3 \ldots\ldots \omega_{J+1}\right)$, where for any J, with $\omega_j \geq 0$, we have $\omega_2 + \omega_3 + \cdots + \omega_{J+1} = 1$. Hence, for the weight vector W, the outcome variable becomes the following expression:

$$\sum_{j=2}^{J+1} \omega_j\, Y_{jt} = \delta_t + \sum_{j=2}^{J+1} \omega_j\, \theta_t Z_j + \sum_{j=2}^{J+1} \omega_j\, \lambda_t \mu_j + \sum_{j=2}^{J+1} \omega_j\, \varepsilon_{tj}$$

In the proof by Abadie (2010), if there exists an optimal weight vector W^* taking into consideration the following:

$$\sum_{j=2}^{J+1} \omega_j^*\, Y_{j1} = Y_{11}, \sum_{j=2}^{J+1} \omega_j^*\, Y_{j2} = Y_{12}, \ldots\ldots, \sum_{j=2}^{J+1} \omega_j^*\, Y_{jT_0} = Y_{1T_0} \text{ and } \sum_{j=2}^{J+1} \omega_j^*\, Z_j = Z_1$$

And if $\sum_{t=1}^{T_0} \lambda_t' \lambda_t$ is nonsingular, then $\sum_{j=2}^{J+1} \omega_j^* Y_{jt}$ converges on the limit Y_{it}^N; therefore, $\sum_{j=2}^{J+1} \omega_j^* Y_{jt}$ may be used as an unbiased estimate for Y_{it}^N. The estimate of the policy effect that we are interested in can hence be expressed as follows:

$$\widehat{\alpha_{1t}} = Y_{1t}^I - \sum_{j=2}^{J+1} \omega_j^* Y_{jt} \quad , \quad T_0 < t \leq T$$

To find the optimal weight vector W^*, we choose the minimized distance between X_1 and $X_0 W$, i.e., $\left||X_1 - X_0 W|\right|$ for this purpose, where X_1 denotes the eigenvalues for the processing set data points prior to the policy impact. It is a linear combination of various predictor variables affecting economic growth, expressed as a K $\times 1$ dimensional vector. X_0 denotes the eigenvalues for the control set data points prior to policy impact, and it is an order K $\times$ J matrix. The formula for the distance minimization function is as follows:

$$\left||X_1 - X_0 W|\right| = \sqrt{(X_1 - X_0 W)' V (X_1 - X_0 W)},$$

where V is an order K $\times$ K symmetric positive semi-definite matrix, and the choice for V would affect the mean square error in this equation. Therefore, we use the mean square prediction error (MSPE) method to derive V^*, which can then yield the optimal weight vector W^*. With this weight vector W^*, we can proceed to perform computations for the synthetic control method.

2. Benchmarks and Datasets

The selected outcome variables are the economic outputs of various regions expressed as GDP per capita. The predictor variables are, respectively, the regional industry structure, rate of urbanization, economic openness, standard of HR capital, standard of basic infrastructure, level of science and technology development, and government's fiscal capacity.

Of these, industry structure, which represents intraregional industry characteristics and the level of development for each region, is measured as the ratio of secondary and tertiary industry value-added; the rate of urbanization as a specific embodiment of the level of urban development in each locality is measured as the proportion of the nonagricultural population to the total population;

economic openness, a reflection of the intensity of economic interactions between the local economy and its external environment, is measured as a ratio of total imports and exports to GDP in each region; the standard of HR capital, which has sustained effects on the development of the local economy, is measured by the average education level per capita in each region (please refer to Appendix 1); the standard of basic infrastructure, embodying the latent regional potential for development, is measured by highway mileage per capita for each region; the level of science and technology development, embodying the role of technology in economic development, is measured by patent application authorizations per capita in each region; and government fiscal capacity, reflecting the economic impact of government expenditures, is measured by local general public budget expenditure per capita.

The data used in this study are provincial-level panel data for the 1990–2014 period, mainly sourced from the "China Statistical Yearbook" and the "China Population and Employment Statistics Yearbook," with some missing data supplemented from the "China Science and Technology Statistics Yearbook." The areas selected for the control set are 28 provinces, municipalities, and autonomous regions (other than Beijing, Tianjin, Hebei, and Taiwan as lacked of data) divided into four groups, namely, northeastern, central, eastern, and western regions (refer to Appendix 2), and each group is individually considered for inclusion into the control set. After due consideration of the various factors and performing preliminary simulation analysis, we eventually come to the determination that the 13 provinces (municipalities) of the central and eastern regions should be used as the control set. There are several reasons for selecting this set. First, because of the state's introduction of the *Strategy for Development of the Western Regions* in 1999 and the *Strategy for the Revival of Old Industrial Bases in the North-Eastern Region* in 2003, the provinces in the western and northeastern regions were under the effect of major policy impacts in the years before and after 2001. Second, during a placebo test of the empirical analysis, described in Section 3 in chapter IV, we experiment with alternating each of the 28 provinces as a processing set in the synthetic control analyses, with the results showing that the actual growth curves for the western and northeastern regions indeed start to diverge with quite significant variations from the synthetic growth curve after 2001. This constitutes data-supported evidence that these provinces were indeed affected by impacts from their own regional policies. If we suppose that these provinces were used as constituents for a conjured up Beijing-Tianjin-Hebei region, the manifested policy effects after 2001 may be intermingled with the effects brought about by the *Strategy for Development of the Western Regions* and the *Strategy for Revival of Old Industrial Bases in North-Eastern Region*; hence, provinces of the western and northeastern regions are excluded from the control set. Conversely, the reform, opening-up process, and economic booms in the provinces of the eastern region all occurred in earlier periods, and by 2001, no other

significant policy effects are present—all the eastern region provinces experienced relatively stable economic growth. As to the central region provinces, although the state introduced the *Program for the Rise of the Central Region in 2004*, the policy document *Recommendations of CCCPC and the State Council on Promoting the Rise of the Central Region* was only formally released after April 2006. Consequently, the policy effects of the *Program for the Rise of the Central Region* could not significantly impinge on a synthetic Beijing-Tianjin-Hebei around 2001; therefore, the provinces of the central region may be used as a suitable control set.

IV. Results of Empirical Analysis

1. Analysis of the Effects of Beijing-Tianjin-Hebei Collaboration on the Three Localities

The software packages Stata and Synth were used to perform the data computations. By analyzing the data for the provinces in the control set, provincial weightings for synthetic Beijing, Tianjin, and Hebei were obtained, which were then used to produce a synthetic Beijing, Tianjin, and Hebei as a control set. The computation results included full details of a set of weightings for the constituents of the control set. The growth curves for the processing set and the control set were compared in graphic form. The gap when the two growth curves diverge is what is of interest to us.

Table 1 shows that from all of the provincial (municipal) localities with the biggest weightings (weightings greater than 0.1) in synthetic Beijing, synthetic Tianjin, and synthetic Hebei, it is readily apparent that the weightings for Shanghai tend to be fairly substantial for both synthetic Beijing and synthetic Tianjin. This reflects the fact that there are structural similarities among the capital municipalities. For synthetic Hebei, the locality with the biggest weighting is Henan province; this also illustrates the structural similarity between the economies of Hebei province and Henan province.

Table 1 Constituents of Synthetic Beijing, Tianjin, and Hebei and their Weightings

Synthetic Beijing		Synthetic Tianjin		Synthetic Hebei	
Provincial locality	Weighting	Provincial locality	Weighting	Provincial locality	Weighting
Shanghai	0.534	Shanxi	0.123	Shanxi	0.089
Henan	0.466	Hubei	0.450	Henan	0.535
		Shanghai	0.427	Hunan	0.105
				Zhejiang	0.257

Figures 1, 2, and 3, respectively, show the actual and synthetic growth curves for the three localities of Beijing, Tianjin, and Hebei. The horizontal axis is time, and the vertical axis represents GDP per capita. The actual growth curve depicts the temporal variations of actual GDP per capita in the three localities. Growth is shown to be affected by the policy measures for the Beijing-Tianjin-Hebei collaborative development in the periods after 2001. In contrast, the synthetic growth curve is unaffected by policy measures. The amount of divergence between the actual and synthetic growth curves encapsulates the effects of the regional economic policy measures. It is readily apparent from Figures 1, 2, and 3 that the actual and synthetic growth curves for the three localities of Beijing, Tianjin, and Hebei were highly correlated prior to 2000; by fitting the data for 1990 to 2000, the synthesized Beijing-Tianjin-Hebei control curves indeed reflect the actual Beijing-Tianjin-Hebei economic structures and their characteristic traits of development. Hence, they constitute a valid control set (Appendix 3 shows the actual and synthetic values of each predictor variable for Beijing, Tianjin, and Hebei before policy implementation; these results indicate that the actual and synthetic figures are largely correlated in this time period).

Divergences between the actual and synthetic growth curves are observed in all three localities of Beijing, Tianjin, and Hebei after policy implementation in 2001. In the case of Beijing, its actual growth curve starts to trace a higher trajectory than the synthetic curve after 2000, and subsequently, it gradually widens even further. This shows that positive effects on economic growth were arising from the policy for the Beijing-Tianjin-Hebei collaboration and that the policy effects were temporally accruing and widening. On the other hand, this also reflects that policy measures engendered a certain degree of anticipation effect, which may be due to the Olympic bid and other

causes encouraging implementation of infrastructure projects and industry relocation adjustments prior to 2001; hence, the divergence of these two curves appears at the onset of 2000.

In the case of Tianjin, the policy effect on this city shows similar dispositions to that of Beijing; there is a positive and widening effect on local economic growth. However, in contrast to Beijing, the positive policy effect is somewhat smaller than that experienced by Beijing during the initial period of policy implementation after 2001.

In the case of Hebei, no immediate divergence between the actual and synthetic growth curves is observed after 2001; this situation persists until around 2005, when the actual growth starts to drop below the synthetic growth curve although the magnitude of the divergence remains relatively small. This shows that the policy had a relatively small negative effect on Hebei's economic growth. There is a lag in the negative effect; it starts to manifest a few years after the implementation of the collaboration policy.

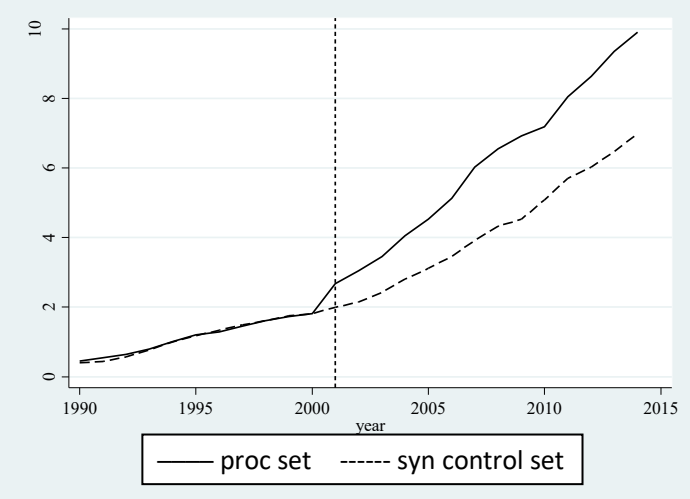

Figure 1 Actual Growth Curve and Synthetic Growth Curve for Beijing

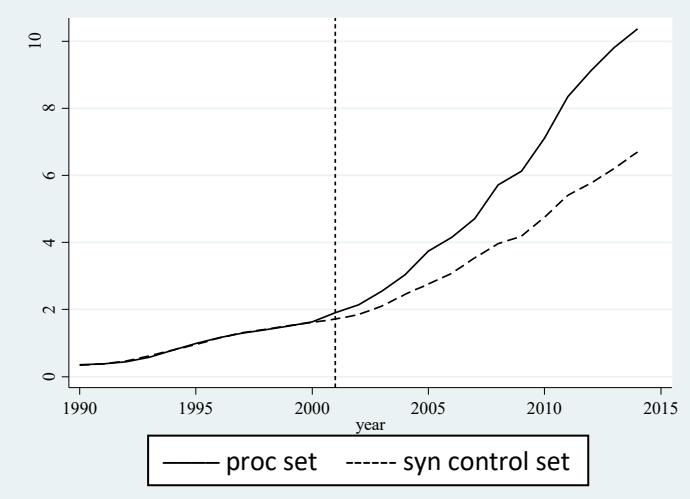

Figure 2 Actual Growth Curve and Synthetic Growth Curve for Tianjin

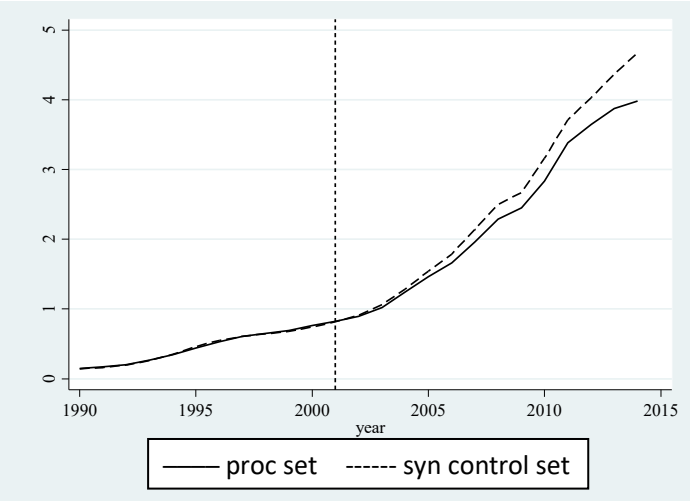

Figure 3 Actual Growth Curve and Synthetic Growth Curve for Hebei

2. Comparison of Net Policy Effects on the Three Localities of Beijing, Tianjin, and Hebei

To further characterize the different effects on the three localities of Beijing, Tianjin, and Hebei arising from the collaboration, the GDPs per capita are calculated, respectively, for synthetic Beijing, synthetic Tianjin, and synthetic Hebei in the 1990–2014, period while quantifying the differences between the actual and synthetic values to determine the magnitudes of net policy effects on these three localities as shown in Figures 4, 5, and 6.

In Figures 4, 5, and 6, the effect of the Beijing-Tianjin-Hebei collaboration policy is almost zero prior to 2001, with a net effect only starting to show after 2001. This is further evidence that the synthesized Beijing, Tianjin, and Hebei are an ideal control set, as the actual and synthetic growth curves for the three localities are highly correlated prior to 2001. In the periods after 2001, both

Beijing and Tianjin play host to steadily widening net positive policy effects, indicating that the collaboration is leading to increases in GDP per capita for Beijing and Tianjin and that such effects on economic growth are also temporally accruing. In the case of Hebei, during the first few years after 2001, the policy impact from the Beijing-Tianjin-Hebei collaboration seems to have produced no real effect on economic growth, yet from 2005 onward, the policy impact has in fact been causing a reduction in GDP per capita in Hebei province.

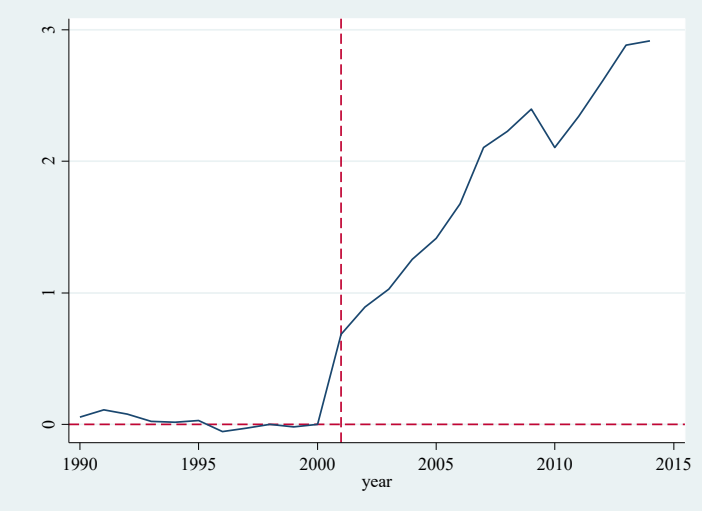

Figure 4　Net Effect of Policy Impact on GDP Per Capita for Beijing

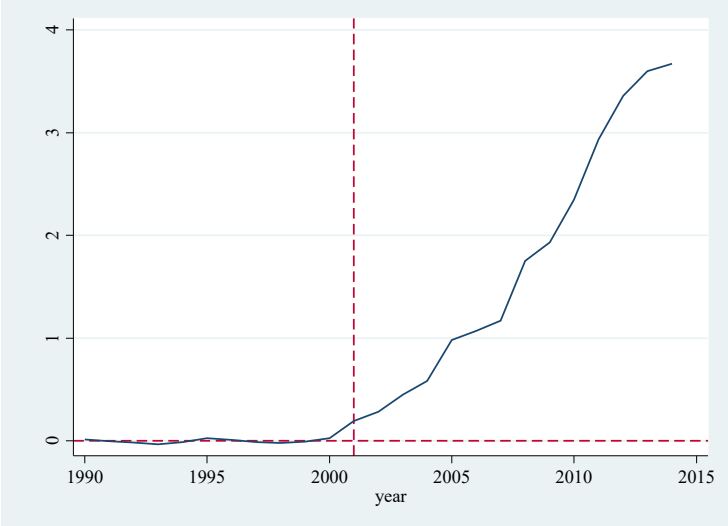

Figure 5　Net Effect of Policy Impact on GDP Per Capita Tianjin

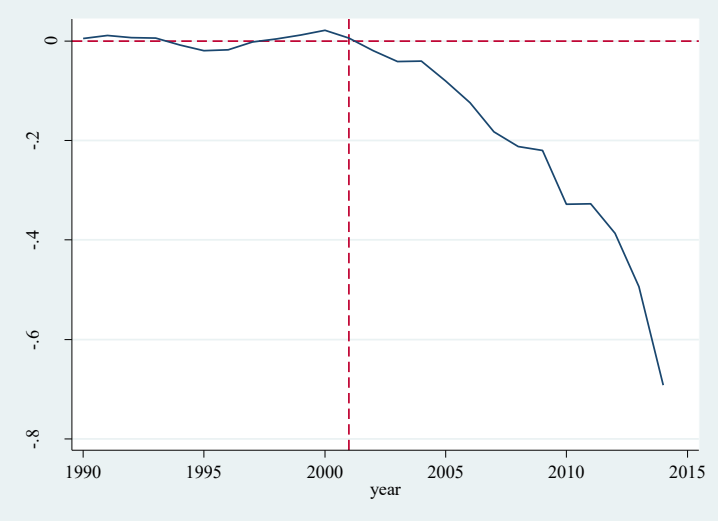

Figure 6 Net Effect of Policy Impact on GDP Per Capita for Hebei

The results of the data computation show that during the 2001–2014 period, the net effect of the Beijing-Tianjin-Hebei collaboration on GDP per capita for Beijing resulted in average annual increases of over RMB 18,960. The net effect on GDP per capita for Tianjin was average annual increases of RMB 17,380. For Hebei province, however, the average annual GDP per capita decreased by RMB 2,240. When these figures are recast in terms of growth rates, during the 2001–2014 period, the actual average annual growth of GDP per capita in Beijing was 13.29% and the average annual growth of GDP per capita in the synthetic Beijing curve was 10.15%; therefore, the collaboration resulted in up to a 3.14-percentage-point rise in average annual growth in GDP per capita for Beijing. During the same period, the actual average annual growth of GDP per capita for Tianjin was 14.22%, and the average annual growth of GDP per capita in the synthetic Tianjin curve was 10.77%; therefore, the collaboration resulted in an up to 3.45-percentage-point rise in average annual growth of GDP per capita for Tianjin. During the same period, the actual average annual growth of GDP per capita for Hebei province was 12.68%, and the average annual growth of GDP per capita in the synthetic Hebei curve was 14.17%; therefore, the i collaboration resulted in a reduction in the average annual growth of GDP per capita of 1.49 percentage point for Hebei province.

3. Robustness Test

After deriving the effects from the Beijing-Tianjin-Hebei collaboration, we move on to examining the robustness of the estimate results. Because synthetic control is a nonparametric method, there is no way to apply statistical inferences for a significance test. We instead adopt the placebo method as proposed by Abadie (2010) for the statistical test. The main idea behind the placebo method is to perform analysis on the 13 provinces (municipalities) constituting the control set in a fashion

similar to that performed on the Beijing-Tianjin-Hebei data—individually analyzing each of the 13 provinces (municipalities) as a processing set to evaluate the policy effects using the synthetic control method. If divergence between actual GDP per capita and synthetic GDP per capita—similar to the divergence in Beijing-Tianjin-Hebei—is not observed in these other provinces (municipalities), then it is strong evidence to support that Beijing-Tianjin-Hebei's economic growth effect arose from the collaboration.

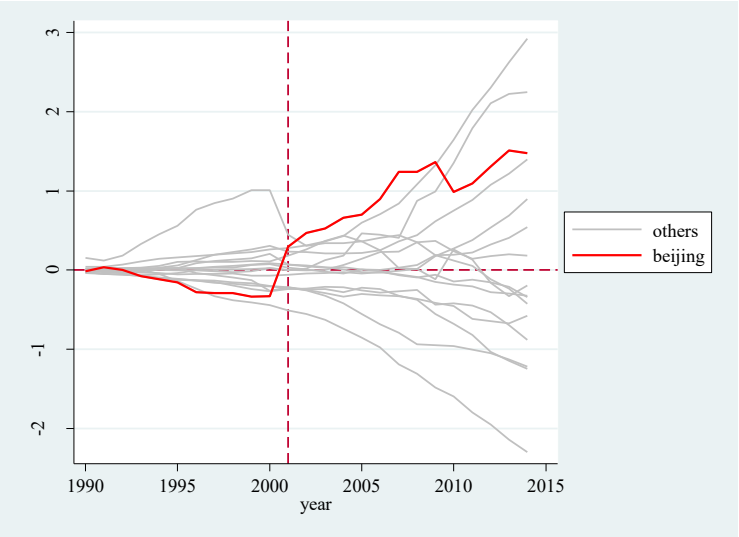

Figure 7 Placebo Test of Net Policy Effect for Beijing

Figure 8 Placebo Test of Net Policy Effect for Tianjin

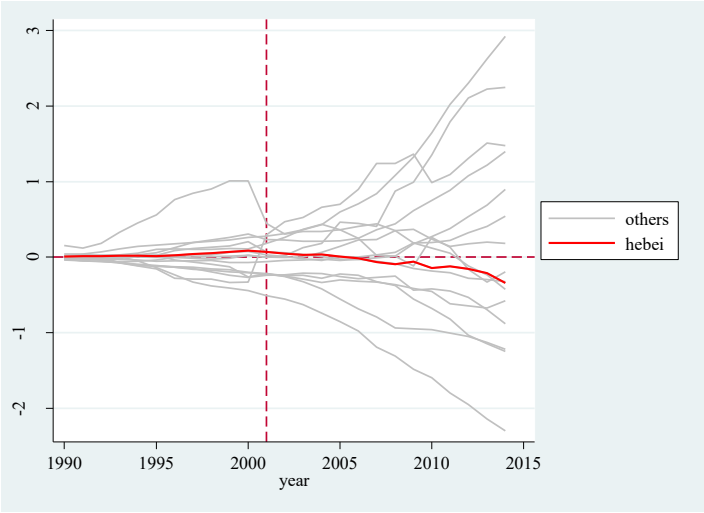

Figure 9 Placebo Test of Net Policy Effect for Hebei

Figure 7 shows the net effect curve for the city of Beijing as being consistently higher than the curves for all of the control set provinces (municipalities) over the 2001–2008 period after policy implementation. Two curves surpassed Beijing after 2008 (one of which is Tianjin). This means that for a long period of time after the 2001 policy implementation, there is only a 1 in 16 probability (3 in processing set plus 13 in the control set) of observing the same effect as that on Beijing; that is to say, the policy effect on Beijing has 95% significance (1/16≈0.06). Likewise, in Figure 8, although the policy effect on Tianjin does not show particularly high significance in 2001 when the policy measures were implemented, as the net effect continued to rise, and still does, by 2010 and in later years, there is only one control set curve that is higher than that of Tianjin; consequently, the policy

effect on Tianjin can be considered to have approximately 95% significance. In contrast, for Hebei province, Figure 9 shows that the policy effect on Hebei never overtakes any of the control set curves. Therefore, we deem that the policy effect on Hebei province was not particularly significant.

V. Conclusions and Explanatory Notes

By applying the synthetic control method, we find that the implementation of the Beijing-Tianjin-Hebei collaborative development policy measures has engendered growth effects for the region. In particular, the collaboration has resulted in raising the average annual growth of GDP per capita by 3.14% and 3.45%, respectively, for Beijing and Tianjin. For these two localities, the policy effects are statistically significant. At the same time, the GDP per capita in Hebei province has contracted by -1.49%; however, the negative effect is not particularly significant.

In light of the different effects of the collaboration on the three localities of Beijing, Tianjin, and Hebei, we argue that Beijing, with the most attractive economic factors as a major city in the region; the most optimal industry structure; and the most dynamic innovative driving force, has been able to reap most of the benefits of policy measures from the implementation of the collaborative development. In the case of Tianjin, by leveraging its high-quality shipping port resources and its comparative advantage of a solid industrial base, it has also been able to achieve rapid economic development by riding the wave of the collaborative development. However, it should be stressed that, from the perspective of absolute value of net policy effect, Tianjin only surpasses Beijing after 2010; prior to that, the policy effect for Tianjin was consistently lower than that for Beijing. Considering that China implemented a massive economic stimulus program post-2008, the relevant industry sectors in Tianjin should have been more notably affected by this economic stimulus. The achievable increases in Tianjin's economic growth attributed to the collaborative development may have always been lower than Beijing's. This is also related to the fact that Tianjin has had insufficient proactive initiatives for integration into the Beijing-Tianjin-Hebei region; on numerous occasions, it squandered good opportunities for development. Finally, in the case of Hebei province, its economic growth was constrained during the implementation process of the policy measures for collaborative development. Although the constraint was relatively small in numerical value, the existence of such objective facts as the "Poverty Belt around Beijing and Tianjin" reminds us that the next phase of development should work to eliminate the enormous internal disparity in the region. Only through means such as paradigm shifts in development, innovations in coordination mechanisms, readjustments of industry structures, and efforts to break away from the small-minded notion of "caring only for one's small plot," can development in this region be achieved..

Appendixes

Appendix 1

Per capita education level is calculated by substituting the number of years of education for different levels of education for the population of age 6 and over in the region, yielding a normalized figure of education level for the regional population.

Appendix 2

Provinces in the northeastern region include the following: Liaoning, Jilin and Heilongjiang; provinces in the central region include the following: Shanxi, Anhui, Jiangxi, Henan, Hubei, and Hunan; provinces in the eastern region include the following: Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan; provinces in the western region include the following: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

Appendix 3 - Tabulated Data

Schedule 1 Actual and Synthetic Values of Predictor Variables

	Beijing		Tianjin		Hebei	
	Actual	Synthetic	Actual	Synthetic	Actual	Synthetic
Value-Added Ratio: Secondary/ Tertiary Industry	0.87	0.97	1.42	1.31	1.46	1.46
Proportion of Nonagricultural Population to Total Population	0.58	0.45	0.54	0.42	0.17	0.17
Ratio of Total Import/Export to GDP	0.26	0.08	0.07	0.04	0.01	0.02
Per Capita Education Level (No. of Years)	9.04	7.71	7.97	7.62	6.88	6.78
Per Capita Highway Mileage	9.77	10.90	5.33	6.68	8.13	7.37
Per Capita Patent Application Authorizations (Applications/ 10k of Population)	3.31	0.82	1.15	0.71	0.27	0.32
Per Capita Fiscal Expenditure (CNY 00,000)	0.14	0.13	0.10	0.11	0.03	0.03

Schedule 2 Actual and Synthetic GDPs Per Capita and Net Policy Effect for the Beijing-Tianjin-Hebei Region (2001-2014)

	GDP Per Capita: Beijing (CNY 10,000)			GDP Per Capita: Tianjin (CNY 10,000)			GDP Per Capita: Hebei (CNY 10,000)		
Year	Actual	Synthetic	Net Effect	Actual	Synthetic	Net Effect	Actual	Synthetic	Net Effect
2001	2.679	1.995	0.684	1.911	1.719	0.193	0.824	0.817	0.006
2002	3.043	2.151	0.893	2.136	1.852	0.284	0.894	0.913	-0.020
2003	3.450	2.423	1.028	2.550	2.101	0.449	1.022	1.064	-0.041
2004	4.059	2.804	1.255	3.038	2.455	0.583	1.245	1.285	-0.040
2005	4.532	3.118	1.413	3.745	2.764	0.981	1.461	1.542	-0.081
2006	5.135	3.457	1.678	4.151	3.078	1.073	1.662	1.786	-0.124
2007	6.030	3.924	2.106	4.711	3.540	1.171	1.960	2.143	-0.183
2008	6.558	4.329	2.228	5.713	3.963	1.751	2.291	2.503	-0.212
2009	6.925	4.528	2.397	6.125	4.191	1.934	2.450	2.670	-0.220
2010	7.193	5.087	2.106	7.101	4.754	2.347	2.835	3.163	-0.328
2011	8.049	5.708	2.342	8.345	5.411	2.933	3.386	3.713	-0.327
2012	8.642	6.028	2.613	9.125	5.766	3.359	3.646	4.033	-0.386
2013	9.362	6.479	2.883	9.811	6.211	3.600	3.879	4.373	-0.494
2014	9.912	6.994	2.918	10.367	6.697	3.670	3.984	4.677	-0.692

References

Abadie, Alberto and Gardeazabal, Javier，2003，“The Economic Costs of Conflict: A Case Study of the Basque Country”，*The American Economic Review*, Vol. 93, No. 1，pp.113-132

Abadie, Alberto, Diamond, Alexis, and Hainmueller, Jens，2010，“Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program”，*Journal of the American Statistical Association*, Vol. 105, No. 490，pp.493-505

Abadie, Alberto, Diamond, Alexis, and Hainmueller, Jens，2015，“Comparative Politics and the Synthetic Control Method”，*American Journal of Political Science*, Vol. 59, No. 2，pp.495-510

Bo Wenguang, 2015, “Beijing-Tianjin-Hebei Collaborative Development: Challenges and Dilemmas” - “Nankai Journal (Philosophy, Literature and Social Science Edition)”, Vol. 1, p.110-118.

Dai Hongwei, Liu Min, 2010, “Comparative Analysis of Competiveness between the Beijing-Tianjin-Hebei Region and the Yangtze Delta Region”, “Finance & Trade Economics”, Vol. 1, pp.127-133.

Dai Hongwei and Song Xiaodong, 2013, “An Comparative Analysis and Insights into the Development Model for the National Capital”, “Urban Development Studies”, Vol. 6, pp.87-93.

Lu Dadao, 2015, “Positioning the Municipal Functions and Collaborative Development for City Clusters in the Beijing-Tianjin-Hebei Region”, “Progress In Geography”, Vol. 3, pp.265-270.

Li Lei and Zhang Guixiang, 2015, “Quality of Development for Beijing-Tianjin-Hebei City Cluster”, “Economic Geography”, Vol. 5, pp.61-64.

Liu Naiquan, Wu You, 2017, “Can Expansion in the Yangtze Delta Region Engender Across-the-Board Regional Economic Growth?”, “China Industrial Economics”, Vol. 6, pp.79-97.

Liu Xueqin, ZHANG Gui, 2015, “Coordinated Innovative Capabilities of Beijing-Tianjin-Hebei Industry: Assessment and Strategic Choices”, “Journal of Hebei Normal University (Philosophy, Literature and Social Science Edition)”, Vol. 1, pp.142-148.

Mao Hanying, 2017, “Innovation in the Mechanisms for Beijing-Tianjin-Hebei Collaborative Development and Regional Policy Study”, “Progress In Geography”, Vol. 1, pp.2-14.

Sun Jiuwen, YUAN Qian, 2014，“Comparison and Salient Aspects of Evolution in Beijing-Tianjin-Hebei Collaborative Development Strategy”, “Comparative Economic & Social Systems”, Vol. 5, pp.1-11.

Wang Xianbin, 2010, “Administrative Boundary Adjustment and Economic Growth”, “Management World”, Vol. 4, pp.42-53.

Yang Tianyu and Rong Yufei, 2017, “Can Regional Development Strategy Drive Economic Growth - An Example in Case Study: Revival of Old Industrial Bases in North-Eastern Region”, “Economic Theory and Business Management”, Vol. 10, pp.88-99.

Zhang Keyun, 2014, “The Experience, Constraining Factors, and Future Direction for Beijing-Tianjin-Hebei Collaborative Development”, “Hebei Academic Journal”, Vol. 11, pp. 101-105.