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

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This study aims to identify 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, and resulted in a reduction of GDP per capita in Hebei province.

Key Words: Policy Analysis; Treatment Effects; Synthetic Control Method; Beijing-Tianjin-Hebei Collaborative Development strategy.
JEL Classification Numbers: O18, R11.

1. INTRODUCTION

Beijing- Tianjin- Hebei region is an important economic growth pole in northern China. As one of the important national strategies, the collaborative development strategy of Beijing, Tianjin and Hebei aims to promote the economic development of the region and the transformation of urban functions in Beijing through the cooperation of Beijing, Tianjin and Hebei. In 2014, China established Xiong'an New Area, which is positioned to focus on undertaking Beijing's industrial transfer and promoting the coordinated development of Beijing, Tianjin and Hebei. 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. In the years after Beijing's 2001 success-

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ful bid to host the 2008 Olympic Games and the unveiling of the Beijing-Tianjin-Hebei Collaborative Development Plan in 2001 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 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. 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.

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.

2. BACKGROUND:THE EVOLUTION OF THE BEIJING-TIANJIN-HEBEI COLLABORATIVE DEVELOPMENT

China has three major urban agglomerations, namely Beijing-Tianjin-Hebei region, Yangtze River Delta and Pearl River Delta. 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. Due to the existence of urban diseases such as environment, population and traffic pressure, 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.

Because of its special status as the capital, Beijing has become a key development city after the founding of the PRC, and has rapidly developed from an ancient historical capital to an important economic central city. Due to historical reasons, Tianjin has become the largest port city in northern China, a window for opening to the outside world and an important industrial city. And Hebei plays the important role of "the guard around the capital". After a long period of development, Beijing-Tianjin-Hebei region is one of China's three major urban clusters (the Yangtze Delta region, the Pearl River Delta region, and the Beijing-Tianjin-Hebei region). This region has two of China's four municipalities directly under the central government (Beijing, Tianjin, Shanghai and Chongqing). The development quality of this urban cluster affects the economic development quality of northern China and even the whole nation in the future. The regional economic policy of this urban agglomeration may be valuable to other urban clusters, and is also of great significance for exploring the development model of capital economic circle.

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 an 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 an uni-functional center for national political and cultural activities, like the capitals of Washington D.C., Canberra, etc. The other is the development model for a multi-functional national capital, such as capitals of London, Tokyo, etc. 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, which means it has been playing multiple roles of political center, cultural center and economic center for a long time. After the dawn of the new century, Beijing began to focus on building an uni-functional national capital. The central government proposed that Beijing should ease its non-capital functions, just to be a political center, a cultural center, international exchange center and a scientific and technological innovation center. The evolution of regional policies in the Beijing-Tianjin-Hebei region consists of four stages as described in the next sections.

2.1. 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 eco-

nomic 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.

2.2. 1981-2000: The nascent period for Beijing-Tianjin-Hebei regional collaboration.

During this period, regional cooperation in Beijing, Tianjin and Hebei began to sprout, and took several forms of regional cooperation as time progressed. As a start, North China Economic & Technical Cooperation Zone (including Beijing, Tianjin, and Hebei) was founded in 1981. Then, 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). Later, the State Planning Commission organized a research group to produce the "Summary Outline of Economic Development Plans for the Bohai Sea Rim Region" in the 1990s, 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.

2.3. 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 region[1][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.

[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.

2.4. 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 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.

3. EMPIRICAL METHOD

3.1. 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.

$$Y_{it}^N = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{ti} \tag{1}$$

where δ_t is the time-invariant effect that equally impinges on all regions; the variable Z_i is an $r \times 1$ dimensional vector of eigenvalues for regions not under impact of the Beijing-Tianjin-Hebei collaborative development policy; θ_t is a $1 \times r$ dimensional parameter vector; μ_i is a $Ftimes1$ dimensional vector of region-invariant effects; $\lambda_t$is a $1 \times F$ 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 $J \times 1$ dimensional weight vector $W = (\omega_2, \omega_3, \ldots, \omega_{J+1})$, 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:

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

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

$$\sum_{j=2}^{J+1} \omega_j^* Y_{j1} = Y_{11}, \sum_{j=2}^{J+1} \omega_j^* Y_{j2} = Y_{12}, \ldots, \sum_{j=2}^{J+1} \omega_j^* Y_{jT_0} = Y_{1T_0} \tag{3}$$

and

$$\sum_{j=2}^{J+1} \omega_j^* Z_j = Z_1 \tag{4}$$

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:

$$\hat{\alpha}_{1t} = Y_{1t}^I - \sum_{j=2}^{J+1} \omega_j^* Y_{jt}, T_0 < t \leq T \tag{5}$$

To find the optimal weight vector W^*, we choose the minimized distance between X_1 and $X_0 W$, i.e., $\|X_1 - X_0 W\|$ 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:

$$\|X_1 - X_0 W\| = \sqrt{(X_1 - X_0 W)' V (X_1 - X_0 W)} \tag{6}$$

where V is an order K, 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.

3.2. Benchmarks and Datasets

The selected outcome variables are the economic outputs of various regions expressed as GDP per capita. For regional economic policies in this period, promoting economic growth, especially the growth of per capita output, is the most concerned goal of policy implementers. Therefore, per capita output becomes the most intuitive indicator to conduct this counterfactual analysis and measure these policy effect. 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.

4. RESULTS OF EMPIRICAL ANALYSIS

4.1. 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,

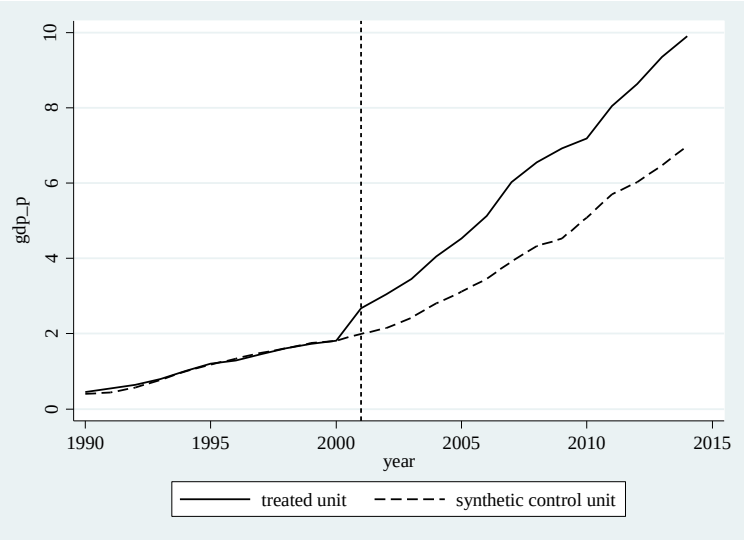
TABLE 1.

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

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.

FIG. 1. Actual Growth Curve and Synthetic Growth Curve for Beijing



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

FIG. 2. Actual Growth Curve and Synthetic Growth Curve for Tianjin

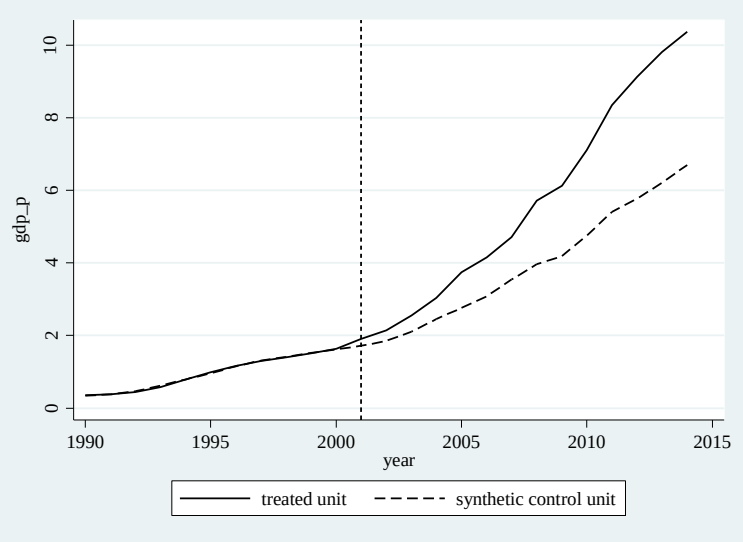
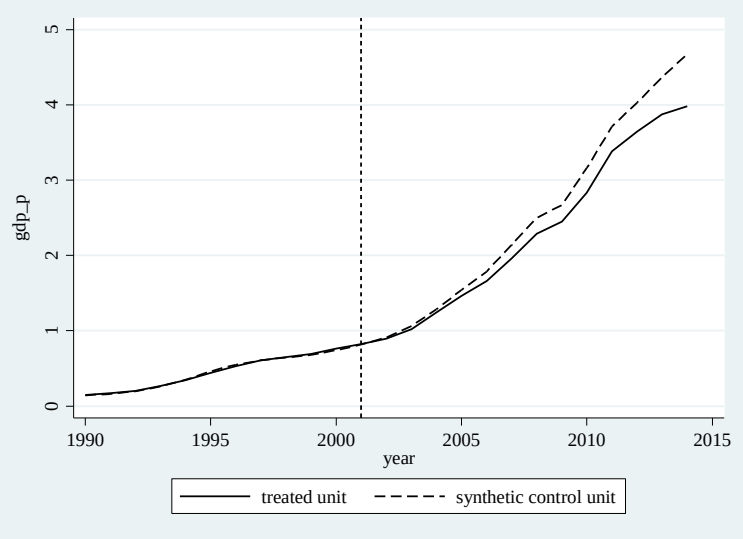


FIG. 3. Actual Growth Curve and Synthetic Growth Curve for Hebei



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.

4.2. 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.

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

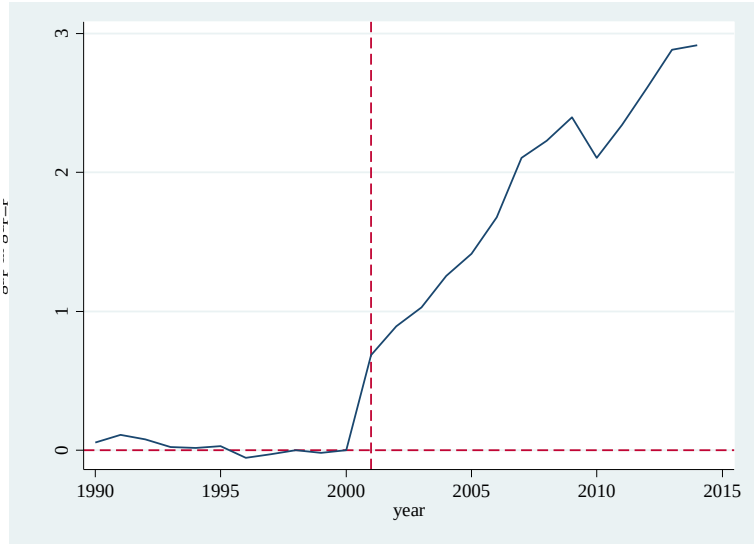
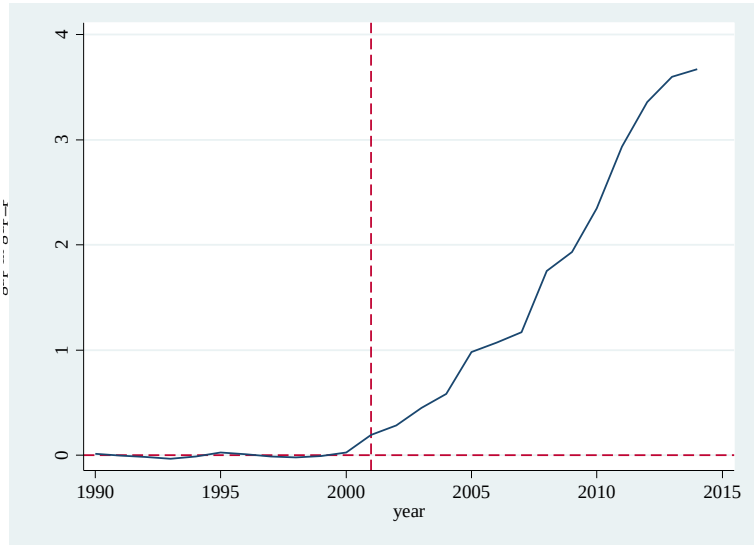
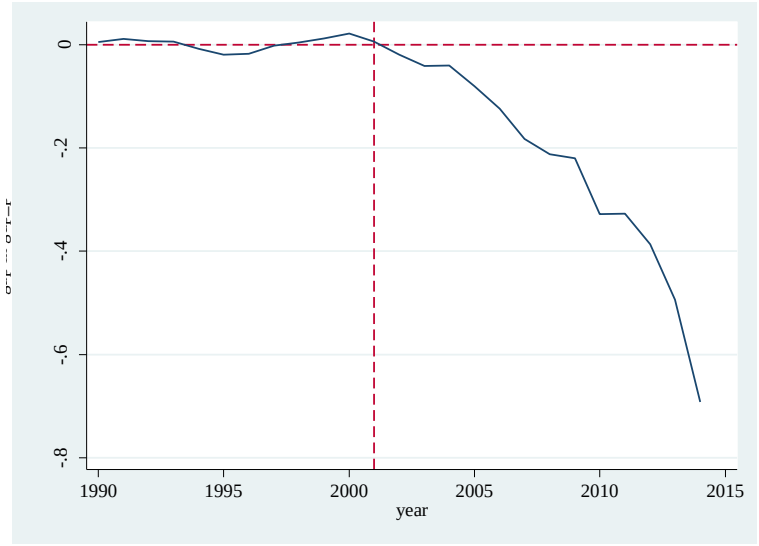


FIG. 5. Net Effect of Policy Impact on GDP Per Capita Tianjin



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

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



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.

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.

4.3. 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.

FIG. 7. Placebo Test of Net Policy Effect for Beijing

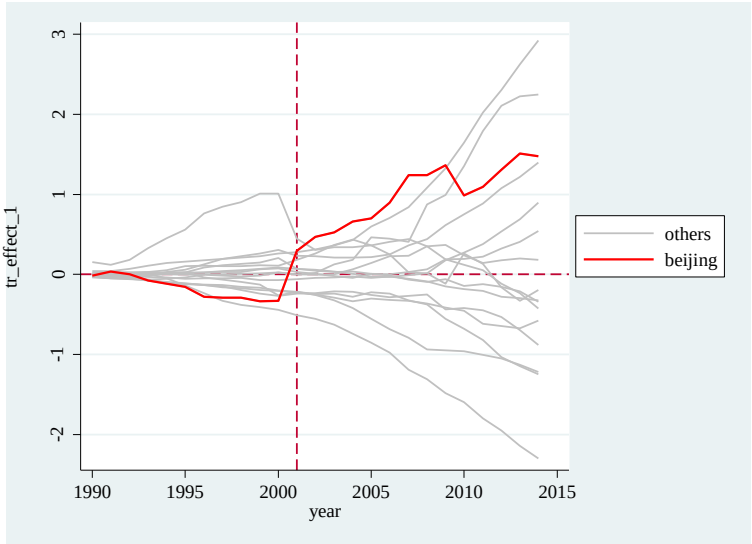


FIG. 8. Placebo Test of Net Policy Effect for Tianjin

FIG. 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 ($1/16 \approx 0.06$). 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.

5. MECHANISM ANALYSIS

After obtaining the results of the synthetic control analysis, we are more concerned about the reasons for different growth effects. Although the Beijing-Tianjin-Hebei Region has achieved economic growth as a whole, the three regions have big differences in terms of industrial foundation, public service level, and resource endowment accumulation. The flow of elements brought about by policies will reflect the deviation of direction and intensity from expectations, and the distribution of element increments may reflect the characteristics of imbalance. Therefore, the impact on factors driving economic development such as human resources and capital investment are different in these regions, and ultimately the impact on local economic growth show some heterogeneity characteristics while the region witnesses overall development.

In order to study the specific reasons for the heterogeneity of Beijing-Tianjin-Hebei cooperative development, this paper attempts to identify the reason and mechanism of action for heterogeneous impact on economic output by examining the effect of the Beijing-Tianjin-Hebei cooperation on various factors driving economic development. By referring to the method developed by Tan Zhouling et al. (2018), this paper uses the double difference method to explore the mechanism of action. According to the effect of Beijing-Tianjin-Hebei cooperation on regional economic development, this paper divides Beijing Municipality, Tianjin Municipality and Hebei Province into two regions, namely promotion area (Beijing and Tianjin) and the inhibition area (Hebei), which are regarded as treatment groups. Through the double difference method, this paper estimates the effect of Beijing-Tianjin-Hebei cooperation on factors driving economic development. A model is built as follows.

$$I_{it} = \alpha_0 + \alpha_1 \mathrm{Treat}_i * \mathrm{Time} + \varphi X + \delta_i + \gamma_t + \varepsilon \tag{7}$$

Among them, I_{it} is the explained variable and is a driving factor affecting economic development. This paper selects four types of driving factors all of which are important indicators that promote economic development:

Government financial resources, expressed with the per capita level of local general budget fiscal expenditures, reflects the participation of local governments in economic activities to a certain extent;

Infrastructure level, expressed with per capita highway mileage, reflects to a certain extent the infrastructure of economic development and the accumulation of capital elements;

Human capital level, expressed with the average years of education of local residents, reflects the quality of labor force elements;

Industrial structure, expressed with the ratio of the output value of the secondary industry to the output value of the tertiary industry, reflects the degree of optimization of the internal structure of the regional industry.

TABLE 2.

Impact of Beijing-Tianjin-Hebei Cooperation on Factors Driving Economic Development.

Explained variable	Government financial resources		Infrastructure level		Human capital level		Industrial structure	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment group	Promotion group	Inhibition group	Promotion group	Inhibition group	Promotion group	Inhibition group	Promotion group	Inhibition group
Interaction term coefficient	0.120^{***} (3.70)	-0.080^{***} (-3.23)	$0.437^{\square}$ (0.45)	-4.383^{***} (-5.00)	0.197^{**} (2.35)	$-0.077^{\square}$ (-1.15)	-0.102^{*} (-1.66)	$-0.042^{\square}$ (-0.85)
Other control variables	Control	Control	Control	Control	Control	Control	Control	Control
Time fixed effect	Control	Control	Control	Control	Control	Control	Control	Control
Regional fixed effect	Control	Control	Control	Control	Control	Control	Control	Control
Number of observations	370	344	370	344	370	344	370	344
Constant term	0.592^{***} (4.16)	0.451^{**} (2.68)	20.165^{***} (3.96)	19.898^{***} (3.58)	6.486^{***} (58.41)	6.292^{***} (60.83)	1.258^{***} (3.87)	0.639^{*} (1.78)
R^2	0.97	0.97	0.91	0.92	0.98	0.98	0.84	0.81

The number in parentheses below the coefficient is the t value; ***, **, and * indicate significant at the level of 1%, 5%, and 10%, respectively

$\text{Treat}_i * \text{Time}_{\square}$ is an interaction term, and Treat_i is the cooperative development policy variable. It is 1 for an area affected by Beijing-Tianjin-Hebei cooperative development (promotion group or inhibition group), and

0 for a province (municipality) in the control group. 13 control groups in the synthetic control analysis are still used here as treatment groups in the double difference analysis. Time is a time dummy variable, and was 0 before 2001 and 1 from 2001. α_1 is an interaction term coefficient we care about, and reflects the effect of Beijing-Tianjin-Hebei cooperative development on factors driving economic development; X is a collection of control variables which are derived from the predictor variables used by synthetic control method; δ_i is a regional fixed effect and δ_i is a time control effect.

By taking the promotion area and the inhibition area as the treatment groups, this paper analyzes the four types of factors driving economic development, and obtains the regression results as shown in Table 2. It can be seen from the table that the factors driving economic development in different areas are impacted in different directions and levels, and such different impacts on these driving factors are ultimately reflected in the heterogeneous impact on economic development.

5.1. Impact on government financial resources

Columns (1) and (2) in Table 2 report the different impacts on the province (municipalities) in the promotion group and the inhibition group in terms of government financial resources. It can be seen that Beijing-Tianjin-Hebei cooperative development has a positive and very significant impact on the promotion group (Beijing, Tianjin), and has a negative and very significant impact on the inhibition group (Hebei). This shows that Beijing-Tianjin-Hebei cooperative development has opposite effects on the financial resources of the governments of the three regions. Government financial resources can reflect the government's participation in economy to a certain extent. For Beijing and Tianjin, collaborative development has increased the government's fiscal expenditure, strengthened government participation, and increased the government's willingness and ability to intervene in economy. For Hebei, collaborative development has a weakening effect on the level of government participation. For example, in cooperation of environment protection and smog control, Hebei Province often needs to shut down some factories to reduce emissions. The lack of corresponding compensation mechanism makes Hebei Province not have high enthusiasm in this cooperation.

This may be mainly because of the unequal political status of the three regions and the political barriers arising from local interests and government competition. Beijing is the national capital; Tianjin was once defined as the economic center of northern China; while Hebei mainly serves the capital or Beijing-Tianjin and is usually in a subordinate position in environmental protection, element protection, and even economic development. For a considerable period before 2014, the government behaviors of Beijing-Tianjin-Hebei were still largely choices based on local interests and the

unequal status in coordinated development has weakened Hebei Province's government expenditure level and degree of participation. In the face of unequal economic and political status and their respective interests, only the formation of a comprehensive multi-level coordination mechanism can solve the government-level cooperation dilemma to the greatest extent, such as a mature compensation mechanism of emission right, a transfer payment mechanism, and an equal & effective consultation mechanism. Looking back at the Beijing-Tianjin-Hebei cooperation after 2001, no such mechanism has been effectively established. This problem not only restricts the economic development of the relatively weak Hebei Province, but also creates obstacles to the integrated development of the entire Beijing-Tianjin-Hebei Region.

5.2. Impact on infrastructure level and human capital level

Columns (3) and (4) in Table 2 report the different impacts on province (municipalities) in the promotion group and the inhibition group in terms of infrastructure level. It can be seen that the interaction term coefficient of the promotion group (Beijing, Tianjin) is not significant, indicating that the infrastructure level is not affected by Beijing-Tianjin-Hebei cooperative development; while the interaction term coefficient of the inhibition group (Hebei) is negative and significant, showing that Beijing-Tianjin-Hebei cooperative development has restricted the infrastructure investment level of Hebei Province to a certain extent. In some sense, the investment in fixed assets brought about by cooperative development has not benefited all regions equally. Due to Beijing's special political and economic status, policies that aim at promoting regional fixed investment have more effects on Beijing, such as a large amount of investment for the 2008 Olympic Games and the rapid development of Beijing's urban construction. In other words, due to the strong attraction of Beijing, more production factors, such as capital, flow to the city intentionally or unintentionally.

Columns (5) and (6) in Table 2 report the different impacts on province (municipalities) in the promotion group and the inhibition group in terms of human capital level. The interaction term coefficient of the promotion group (Beijing and Tianjin) is positive and significant, indicating that collaborative development has improved the human capital level of Beijing and Tianjin; while the interaction term coefficient of the inhibition group (Hebei) is insignificant, indicating that the human capital level of Hebei is not benefited from collaborative development.

Infrastructure level represents investment level to a certain extent and reflects the condition of capital elements; while human capital level reflects the condition of labor force elements. The inhibition of infrastructure in Hebei and the promotion of human capital in Beijing and Tianjin reminds us that in the collaborative development process of Beijing-Tianjin-Hebei

after 2001, relevant elements may have such features as relatively prominent unidirectional flow and imbalanced allocation.

There is a historical gap in the level of development among Beijing, Tianjin and Hebei. Although collaborative development was constantly advanced after 2001, due to the "core-periphery" development pattern, the attractiveness to the flow of elements is different in different regions. The core-periphery distribution pattern formed from internal economic development can enable core areas such as Beijing and Tianjin to achieve faster development through scale economy and agglomeration effect. However, as this effect accumulates, the development gap between the core area and the peripheral area (mainly Hebei) will be larger and larger, which will intensify the imbalance in the flow and allocation of elements. Before the easing of Beijing's non-capital functions and the in-depth advancement of the equalization of public services in Beijing, Tianjin and Hebei, the huge gap between Beijing-Tianjin and Hebei in terms of resource input and medical service, education and other social public services has further brought about a gap in the attractiveness of urban elements. Hebei's economic growth has been thus restrained to a certain extent, and it is difficult for the three regions to achieve coordinated development.

5.3. Impact on industrial structure and industrial transfer

Industrial structure and industrial transfer are important factors that affect economic growth. For Beijing-Tianjin-Hebei cooperative development, the mechanism of action for this factor may be relatively complicated, including the transformation and upgrading of the industrial structure of the three regions, the industrial division of labor and cooperation in the Beijing-Tianjin-Hebei Region, as well as the industrial transfer of the Beijing-Tianjin-Hebei Region across the country. This paper will try to study and explain from the following three angles.

5.3.1. Industrial structure upgrade

Columns (7) and (8) in Table 2 report the impact on province (municipalities) in the promotion group and the inhibition group in terms of industrial structure. For Beijing and Tianjin in the promotion group, the interaction term coefficient is negative and significant. Since this indicator represents the proportion of the secondary industry to the tertiary industry in a region, it can be considered that Beijing-Tianjin-Hebei cooperation has lowered such proportion in these regions, reflecting the increase in the relative weight of the service industry and the optimization and upgrade of industrial structure. For Hebei in the inhibition group, the interaction term coefficient is insignificant, indicating that the industrial structure within Hebei Province has not been significantly optimized from

Beijing-Tianjin-Hebei cooperative development. The reason behind this result may be the difference among the three regions in terms of industrial foundation and industrial development stage. Beijing and Tianjin has early completed industrialization and were in a period of "retreating from the second industry to the tertiary industry" and vigorously developing the modern service industry for a considerable period after 2001. Hebei had relatively weak industrial foundation and during the collaboration period after 2001, its economic development still relied strongly on the secondary industry, and the internal economic center was not shifted to the tertiary industry. In particular, some industrial enterprises in Hebei Province are high-pollution, high-energy-consumption, and low-value-added enterprises, and even have overcapacity, which also restricts Hebei Province's economic growth to a certain extent.

5.3.2. Regional division of labor and cooperation

In addition to the differences among the three regions in terms of industrial structure, the industrial division of labor and industrial linkage within the Beijing-Tianjin-Hebei Region is not complete. From 2001 to 2014, in terms of industrial chain, Beijing's industrial advantage lay in automobile and equipment manufacturing and other high-tech industries, as well as modern Internet and other service industries, and had certain industrial chain advantages; while Tianjin's traditional economic advantage lay in petrochemicals, machinery, pharmaceuticals and other fields, and were transitioning to high-end manufacturing industries such as electronic information, energy conservation and environment protection, and aerospace; while Hebei Province's leading industries were steel, chemical, and machinery manufacturing, homogeneous to those in Tianjin and with low level of development. Beijing, Tianjin and Hebei have quite different industrial structure, relatively weak correlation and dependence of upstream and downstream industries, and fail to achieve high-level interaction through industrial cooperation or cluster development through industrial integration. The three regions mainly promote economic development through their own industrial systems, as a result of which Hebei Province with relatively weak industrial foundation was inevitably at a disadvantage in the development. Coupled with the influence of factors such as the preparation for Beijing Olympic Games and environmental protection, related enterprises featuring high pollution and high energy consumption in Hebei Province also encountered certain obstacles in the process of starting production. Therefore, with the advancement of Beijing-Tianjin-Hebei co-

operative development after 2001, Hebei Province gradually lagged behind Beijing and Tianjin in terms of economic growth due to its weak position in the regional industrial chain and its lagging regional industrial cooperation level.

5.3.3. Relative industrial transfer

The policy effects brought about by economic cooperation will also have a certain impact on industrial transfer. Industrial transfer is closely related to macroeconomic development. In particular, there have been many explorations in industrial transfer within the Beijing-Tianjin-Hebei Region. As such, this paper will further evaluate the impact of the 2001 collaboration policy on the industrial transfer of Beijing, Tianjin and Hebei. It needs to be emphasized that the industrial transfer studied in this paper is not the internal industrial transfer of Beijing-Tianjin-Hebei in the narrow sense, but the relative industrial transfer in the broad sense, which is defined as the change in the relative output value of all sample provinces (municipalities). The relative output value is divided into that of the secondary industry and that of the tertiary industry. By referring to the methods developed by Gao Bo et al. (2012), Hu Anjun, Sun Jiuwen (2014), and Liu Youjin (2018), the relative output value is obtained by dividing the output value of the secondary industry and the tertiary industry in the province (municipality) by the average output value of all sample provinces (municipalities).

This research is designed based on two considerations: first, the industrial transfer in Beijing, Tianjin and Hebei cannot be limited to the three regions, so it is necessary to consider relative industrial transfer on a larger scale. In the follow-up study, the selected sample cities will still be Beijing, Tianjin and Hebei as well as the 13 provinces (municipalities) used in the synthetic control method. These 13 provinces (municipalities) are from Central China and Eastern China and happen to be the areas with the closest economic ties and industrial interactions with the Beijing-Tianjin-Hebei Region. Research on relative industrial transfer within this scope is very reasonable and representative. Secondly, there is currently a lack of more accurate industrial transfer data such as changes in enterprise location, so static indicators are used instead of dynamic changes, and it is practically operable to use industry share indicator to study relative industrial transfer.

This paper calculates the relative output values of the secondary and tertiary industries in each sample area. As the explained variable, its changes

reflect the industrial transfer of the second and tertiary industries in the sample area, that is, an increase in relative output value indicates industrial inflow, and a decrease in relative output value indicates industrial outflow. The aforementioned mechanism is still used to identify the framework and explanatory variables of the model, and the regression results of the double difference are shown in Table 3.

TABLE 3.

Impact of Beijing-Tianjin-Hebei Cooperative Development on Industrial Transfer.

Explained variable	Relative output value of secondary industry		Relative output value of tertiary industry	
	(1)	(2)	(3)	(4)
Treatment group	Promotion group	Inhibition group	Promotion group	Inhibition group
Interactive item	0.160^{***}	-0.112^{***}	0.124^{***}	-0.136^{***}
	(5.46)	(−4.56)	(3.64)	(−4.89)
Other control variables	control	control	control	control
Time fixed effect	control	control	control	control
Regional fixed effect	control	control	control	control
Number of observations	370	344	370	344
Constant term	-0.604^{***}	-0.563^{***}	-0.321^{*}	-0.311^{***}
	(−4.17)	(−4.68)	(−2.05)	(−2.14)
R^2	0.99	0.99	0.99	0.99

The number in parentheses below the coefficient is the t value; ***, **, and * indicate significant at the level of 1%, 5%, and 10%, respectively.

It can be seen that the policy intervention after 2001 increased the relative output value of the secondary industry and the tertiary industry of Beijing and Tianjin in the promotion group, and lowered the relative output value of the secondary industry and the tertiary industry of Hebei in the inhibition group. According to the empirical results, in the period after 2001, policy interventions promoted the relative transfer of industries (whether secondary industry or tertiary industry) across the country to Beijing and Tianjin to some extent, and inhibited the relative transfer of industries to Hebei to a certain extent. Even though this was not the absolute relocation and movement of enterprises, it at least showed that Beijing and Tianjin had stronger attractiveness to enterprises and industries, while Hebei gradually lagged behind the average level of the sample area in attracting industries.

Ma Guoxia (2010) believes that from 1993 to 2007, Beijing and Tianjin were the two major polar nuclei of the Beijing-Tianjin-Hebei metropolitan

area, and the spatial polarization trend was expanding over time; Zhang Xuebo (2016) found that from 2000 to 2013, the spillover effect of the Beijing-Tianjin-Hebei core area was negative, the Beijing-Tianjin-Hebei Region was still in the stage of agglomeration economy as a whole, and the relatively developed areas of core position still played quite limited role in leading other regions. From a factual perspective, from 2001 to 2014, the Beijing-Tianjin-Hebei Region showed a clear "center-periphery" pattern, and Beijing-Tianjin was at the center, and constantly accumulated industries and elements from all over the country; while most areas in Hebei Province were peripheral areas and did not enjoy the strong diffusion effect from the center. Hebei's relatively weak strength and the reality that it is close to the powerful polar core have led to its disadvantaged position in the nationwide industrial transfer and competition.

6. 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. We divides Beijing, Tianjin and Hebei into promotion group and inhibition group based on the results of synthetic control analysis. It studies the impacts of Beijing-Tianjin-Hebei cooperative development on factors driving economic growth, and discusses the mechanism of action for different effects on regional economic output. Specifically, with the impact of Beijing-Tianjin-Hebei cooperative development, Beijing and Tianjin enjoyed higher degree of government participation, improved human capital level, optimized internal industrial structure, and relative industrial inflow throughout the country. In contrast, Hebei saw lower degree of government participation, weakened infrastructure level, and relative industrial outflow across the country. These factors lead to the different effects of Beijing-Tianjin-Hebei cooperative development on the three regions.

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. Specifically, future policies can be inspired as follows:

1. Strengthen the top-level coordination mechanism. The regional management mechanism generally has two forms: governmental organization established by the central government legislation, and the coordination organization formed between industries and departments within the region. The former is a high-level normative organization form, and the latter is a flexible pluralistic coordination mechanism. At present, the State Council established the leading group for the collaborative development of Beijing-Tianjin-Hebei. The next step should focus on accelerating the cultivation of non-governmental organizations such as industry cooperation.

2. Remove the obstacles restricting the free flow of production factors and promote the optimal allocation of talent, capital and technical factors. It is necessary to accelerate the interconnection of various resources such as medical care and education in Beijing, Tianjin and Hebei, and accelerate

the integration of regional infrastructure. The construction of regional standardization system should be promoted. In particular, Beijing's non capital functions should be relieved, and the diffusion effect of Beijing and Tianjin should be developed so as to promote the economic development of Hebei.

3. Optimize industrial division. In the process of relieving and undertaking non capital functions, the three regions, Beijing, Tianjin and Hebei, should identify their own position respectively in the regional industrial chain, strengthen the vertical connection and horizontal agglomeration through the collaborative development mechanism. In particular, it is important to avoid homogeneity and duplication of industrial development in the three regions.

APPENDIX

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

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