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An Examination of the Spatial Spillover Effects of Tourism Transportation on Sustainable Development from a Multiple-Indicator Cross-Perspective

Huixin Gong [1], Yaomin Zheng [1,2,3,*], Jinlian Shi [1,2], Jiaxin Wang [2], Huize Yang [1], Sinead Praise A. Sibalo [1], Amani Mwamlima [1], Jingyu Li [1], Shuting Xu [1], Dandan Xu [1] and Xiankai Huang [1]

1 School of International Economics and Management, Beijing Technology and Business University, Beijing 100048, China
2 Institute for Culture and Tourism Development, Beijing Technology and Business, Beijing 100048, China
3 World Heritage and Tourism Monitoring Centre, Beijing Technology and Business University, Beijing 100048, China
* Correspondence: zhengym@btbu.edu.cn

Abstract: Tourism is linked to multiple dimensions, such as the economy, society, and environment, and the relationships among its influencing factors are complex, diverse, and overlapping. This study constructed an evaluation index system to measure the degree of coordinated development of tourism, transportation, and the regional economy, then built a tourism-transportation-based Spatial Durbin Model (SDM) regarding the process of the coordinated development of tourism in the Beijing-Tianjin-Hebei region (BTHR) from 2010 to 2020. This paper explains the current status of sustainable tourism development in the BTHR and the impact and spillover effects of transportation on tourism development. The results show that the normalized tourism coordinated development index (NTCDI) of the BTHR increased from 13.61 in 2010 to 18.75 in 2019, then decreased to 14.45 in 2020. The results of SDM show that different transportation modes have different spillover effects on tourism. Specifically, civil aviation transportation has a positive impact and significant spillover on a city's tourism revenue (TR), while high-speed railway transportation has a negative spillover effect. The model results also show that the degree of openness of the city and city economic development level have significant positive effects and spillover effects on tourism development. Finally, the implications of related variables are discussed, and some suggestions are put forward on tourism development in the BTHR. However, there are some limitations in this study. In the future, international cooperation and data sharing will be strengthened, and multivariate methods such as social network analysis, artificial intelligence, and machine learning will be further integrated to achieve accurate simulation and prediction of the spatial spillover effects of tourism transportation.

Keywords: tourism; sustainable development; spatial spillover effects; transportation; Beijing-Tianjin-Hebei region; coordinated development

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1. Introduction

The United Nations Sustainable Development Goals (SDGs) have received a great deal of attention since they were proposed, and a series of high-level research results concerning them have emerged [1–3]. Currently, scholars are beginning to shift their interest to the field of multi-indicator cross-research [4,5]. There are complex cross-relationships among the SDGs, such as synergies and trade-offs, and different factors that affect sustainable development on different scales and in different types of regions. Therefore, tracking and understanding the cross-relationships between sustainable development targets and indicators, and carrying out monitoring and evaluation of progress toward the SDGs is of great significance for achieving the 2030 Agenda for Sustainable Development and dynamically adjusting sustainable development pathways [6].

Tourism is part of the low-carbon sector and is one of the fastest-growing industries in the world. The tourism boom has had a profound impact on job creation and social development and is an important driver of global economic growth [7–9]. Before the outbreak of the coronavirus pandemic, global tourism accounted for 10.3% of world GDP ($9.6 trillion) and 10.3% of world employment ($333 million) [10]. Following the outbreak of the pandemic, travel bans were imposed in various countries around the world, and tourists postponed or canceled their travel plans to reduce the spread of infection—this had an enormous impact on the tourism industry [11]. According to the World Tourism Economic Trends Report (2022), total global tourism arrivals and revenues reached 6.60 billion and $3.3 trillion, respectively, in 2021, recovering to 53.7% and 55.9% of the corresponding figures for 2019 but still below pre-pandemic levels [12], indicating that continuing efforts for the recovery of the tourism sector still need to be made.

Transportation plays a crucial role in the tourism development. It can not only promote tourist flow between regions, providing safe, comfortable, and efficient travel modes for tourists, but it also strengthens existing tourism activities and promotes the development of tourist attractions in destinations [13,14]. Therefore, it is very important to understand the spillover effects of tourism traffic in China.

Existing research shows that tourism is linked to multiple dimensions, such as the economy, society, and environment, and the relationships among its influencing factors are complex, diverse, and overlapping [15,16]. As a result, it is relatively difficult to track sustainable development in tourism and relatively little cross-research has been conducted using multiple indicators related to tourism under the SDG framework. In order to bridge research gaps, from the perspective of cross-research on multiple SDG indicators, this study takes China's Beijing-Tianjin-Hebei region (BTHR) as a case study by constructing a system of indicators to assess the degree of synergy among tourism, transport, and the regional economy. This study uses tourism revenue and the number of tourists to reflect tourism development, building a model for the spatial spillover effects of tourism transportation. Exploring the tourism coordinated development index and the spatial spillover effects of transportation on sustainable tourism development in BTHR from a multiple-indicator cross-perspective better illustrates the impact of different transportation modes and economic development on tourism. Therefore, this study provides methodological considerations useful for monitoring and assessing tourism sustainability, and provides methodological tools and decision-making references for the development of tourism in the BTHR of China and other similar regions around the world.

2. Literature Review

2.1. Sustainable Tourism Research Status

In 1993, the World Tourism Organization (WTO) put forward the concept of Sustainable Tourism Development. In 1995, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), and WTO adopted the Charter for Sustainable Tourism at the first World Conference on Sustainable Development, and the sustainable development model gradually took a dominant position in the tourism industry [17]. In 2015, the United Nations (UN) endorsed the 2030 Agenda for Sustainable Development, which the WTO incorporated into tourism [18]. The United Nations Inter-agency Expert Group on SDG Indicators (IAEG-SDGs) has identified several SDGs that are closely related to tourism: SDG 8.9.1—Tourism Direct GDP as a Proportion of Total GDP (P-TDGDP), SDG 9.1.2—Passenger Volumes (PV), and SDG 12.b.1—Tourism Sustainability (TS). Kuzior et al. (2021) also found that tourism development can contribute to the realization of SDG 8.9 (Sustainable Tourism Policies), SDG 11.4 (The World's Cultural and Natural Heritage), and SDG 12.b.1 [19].

At present, research on sustainable development in tourism mainly focuses on the assessment of influencing factors [20], the construction of evaluation indicators [21], and the analysis of development trends [19]. The research methods used are mainly expert consultation, analytic hierarchy process, descriptive statistical analysis, exploratory factor analysis, and regression analysis [21,22]. Gao et al. (2021) evaluated the sustainable development level of 221 tourism cities in China by establishing an evaluation index system for sustainable development of tourism cities, and found that natural and cultural resources, protection systems and degree of tourism infrastructure construction had the greater weight; the sustainable development level of tourism cities is different, and no city had realized a strong sustainable development mode [20]. Tahiri et al. (2022) analyzed the development potential of sustainable tourism in Kosovo in terms of local tradition and culture, and diversity and inclusiveness through sustainable actions in the tourism and hospitality industry [23]. According to the STIRPAT model, Destek and Aydın (2022) assessed the sustainable development and economic impact of the 10 most visited countries by three factors: urbanization, energy intensity, and tourism, and found that the harmful effects of tourism on other aspects of sustainable development are greater than the beneficial effects of tourism on economic growth [24]. Therefore, it is important to consider the cross-cutting aspects of tourism in its inclusion in the SDGs [18]. This study analyzes the degree of coordinated development of the BTHR from three aspects: transportation, economy and tourism.

2.2. Transportation Spillover Effects Research Status

Transportation is an important part of the tourism system, and with the development of transportation infrastructure such as highway, railway, waterway and aviation, the movement of tourists has been expanded and accelerated [25,26]. Many existing studies have demonstrated the spillover effects of different modes of transportation on tourism development. For example, using spatial autoregressive models, Zhou et al. (2020) explored the spatial heterogeneity and dynamics of tourism-flow spillover between the non-high-speed train era and the high-speed train era of China, and showed that the emergence of high-speed trains led to a negative tourism flow spillover effect in neighboring regions [27]. Wang et al. (2021) proposed a customized bus demand model and investigated the dynamic adjustments, spatial dependence, and spatial spillover effects of customized bus services. these results revealed that customized bus services are more popular with long-distance travelling tourists and will have greater potential for development in areas with poor accessibility [28]. He et al. (2021) explored the temporal and spatial characteristics of Shenzhen tourism travel by taxi, and found that the spatial distribution of taxi travel was uneven, affected by both tourism resources and tourists' preferences [26]. Tian et al. (2022) estimated a spatial Durbin model to understand the spatial spillover effects of transportation improvements on regional tourism growth in 337 cities in China from 2007 to 2016, and found that high-speed rail and air transport had significant spillover effects on tourism, and the broader scope of air transport spillover [14].

In summary, with the continuous development of economy, tourism has become an essential activity in people's daily recreation [29]. The previous literature review summarizes the current research status on sustainable tourism and the impact of different modes of transportation on tourism spillover effects. The monitoring and evaluation research of sustainable tourism development indicators is still in its infancy, and the trade-offs and synergies among sustainable tourism development indicators are also complex. At the same time, transportation improvement also provides good infrastructure conditions for tourism development [30], and the spillover effects of different transportation modes on tourism can have different spatial and temporal variations. Therefore, this study focuses on the coordinated development among transportation, tourism and regional economy, and transportation spillover effects in the BTHR, and provides a decision-making reference for tourism sustainable development in the BTHR by constructing a tourism coordinated development index and a spatial Durbin model.

3. Materials and Methods

3.1. Overview of the Study Area

The BTHR is the largest and most economically dynamic region in northern China and has attracted global attention. Its total area is approximately 216,000 square kilometers, including 2 major municipalities (Beijing and Tianjin) and 11 cities in Hebei Province (Shijiazhuang, Baoding, Tangshan, Langfang, Qinhuangdao, Handan, Zhangjiakou, Chengde, Cangzhou, Xingtai, and Hengshui). Its geographical area is 113.458702 E—119.848297 E and 36.046104 N–42.617615 N.

The study area has eight World Heritage Sites, including the Forbidden City, the Summer Palace, the Temple of Heaven, the Peking Man Site at Zhoukoudian, the Imperial Tombs of the Ming and Qing Dynasty, the Great Wall, the Grand Canal, Chengde Summer Resort and the surrounding temples, 13 national scenic spots, 18 national nature reserves, and 464 national key cultural relics protection units (Figure 1c).

3.2. Methods Construction

3.2.1. Construction of the Tourism Coordinated Development Index

This study used the expert consultation method and an analytic hierarchy process to construct a system of indicators to assess the degree of coordinated development of tourism, transportation, and the regional economy in terms of three aspects—the tourism development level, the transportation development level, and the regional economic development level (Table 1)—and calculated a normalized tourism coordinated development index (NTCDI).

Table 1. Evaluation indicator system for the degree of coordinated development of tourism, transportation, and the regional economy in the BTHR.

General Objective Level	First Indicators	Weight 1	Secondary Indicators	Weight 2	Weight 3
Indicator system for assessing the degree of synergy between tourism, transport and regional economy	(I) Tourism development level	0.3	Number of Tourist Destinations (NTD)	0.3	0.09
			Number of Tourists (NT)	0.3	0.09
			Tourism Revenue (TR)	0.4	0.12
	(II) Transportation development level	0.4	Civil Aviation Passenger Volume (CAPV)	0.3	0.12
			Number of High-Speed Railway Lines (NHRL)	0.2	0.08
			Highway Passenger Volume (HPV)	0.1	0.04
			Waterway Passenger Volume (WPV)	0.1	0.04
			Rail Transportation Passenger Volume (RTPV)	0.1	0.04
			Bus (Electric) Vehicle Passenger Volume (BVPV)	0.1	0.04
			Number of Cabs (NC)	0.1	0.04
	(III) Regional economic development level	0.3	Permanent Resident Population (PRP)	0.4	0.12
			Gross Domestic Product (GDP)	0.4	0.12
			Actually Utilized Foreign Direct Investment (AUFDI)	0.2	0.06

The data normalization formula is as follows:

$$NS_i = 100 \times \{ S_i - \mathrm{Min}(S_i) \} / \{ \mathrm{Max}(S_i) - \mathrm{Min}(S_i) \} \tag{1}$$

where NS_i is the normalization results of the indicators, $\mathrm{Max}(S_i)$ and $\mathrm{Min}(S_i)$ are the maximum and minimum values of the indicators S_i, respectively, and the NS_i range is 0–100.

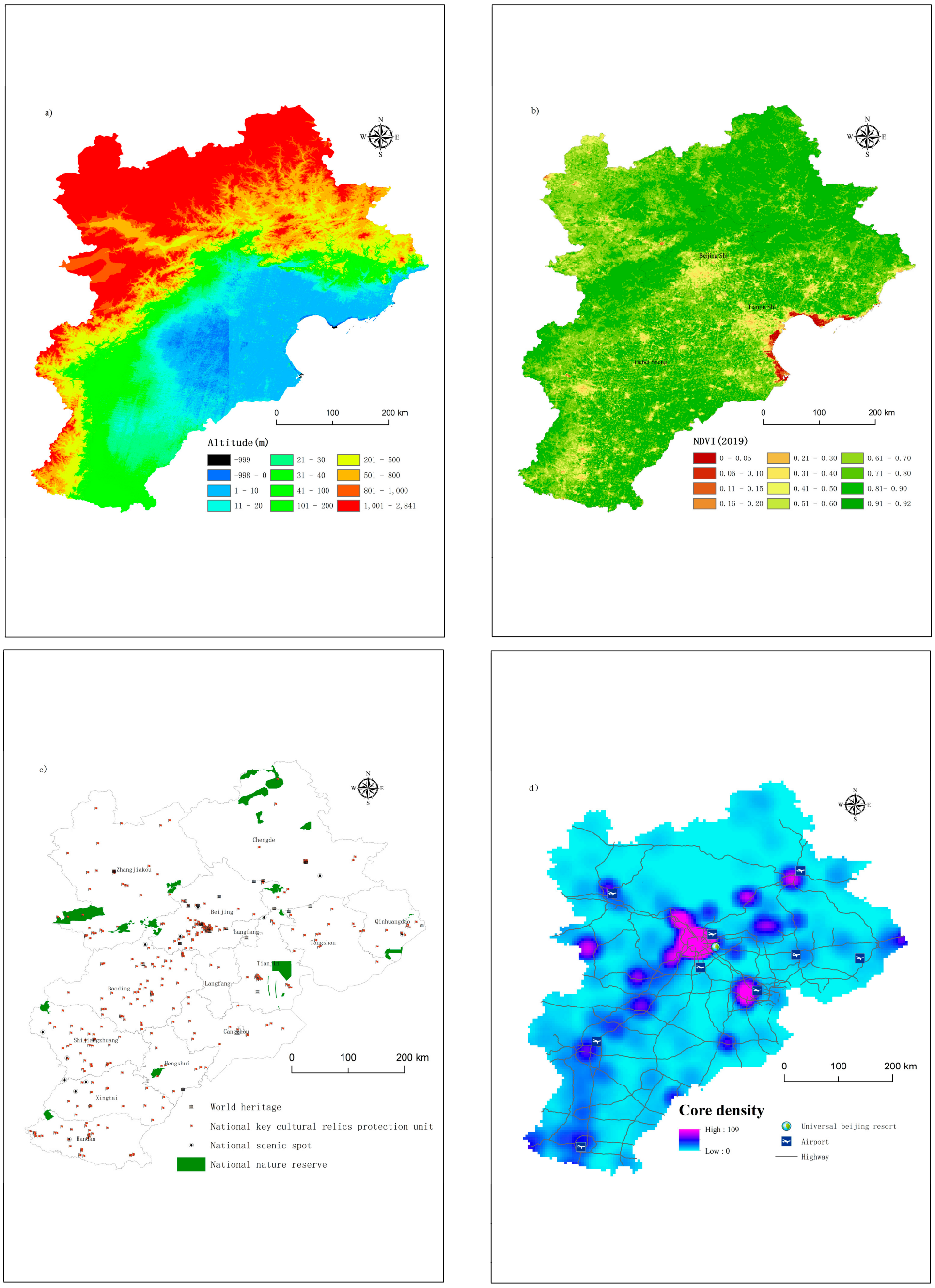

Figure 1. The distribution of the study area: (**a**) Altitude: the macro pattern of the BTHR terrain; (**b**) Vegetation index: the ecological environment in the BTHR; (**c**) Tourism destinations distribution: the tourism resources in the BTHR; (**d**) Tourism core density and transportation conditions: the transport network in the BTHR. [Source: The altitude map was made from the ASTER-GDEM V2 (Advanced Spaceborne Thermal Emission and Reflection radiometer, Digital Elevation Model), http://www.gdem.aster.ersdac.or.jp/index.jsp (assessed on 1 June 2022); the maximum NDVI map was made from Resource and Environment Science and Data Center, Institute of Geographic Sciences and Natural Resources Research, CAS. https://www.resdc.cn/DOI/DOI.aspx?DOIID=68 (assessed on 15 July 2022); the map of tourism destinations distribution was made from the vectorization of data from various official websites, including the UNESCO World Heritage Centre, Ministry of Culture and Tourism, Ministry of Ecology and Environment, National Forestry and Grassland Bureau, China; the map of tourism core density and transportation conditions was based on the map of tourism destinations distribution, and was add to transportation data from Civil Aviation Administration of China and Ministry of Transport of the People's Republic of China].

3.2.2. Construction of the Spatial Spillover Effect Model

This study conducted a global Moran's I test on the explanatory variables involved in the process of constructing the spatial econometric model. The results are shown in Appendix B Table A4. The results showed that the Moran's I results were all significantly positive; that is, there was positive spatial autocorrelation, and a spatial econometric analysis could be performed. The variance inflation factor (VIF) of all variables was below 10 (Appendix B Table A5), reflecting the absence of a multicollinearity problem among the explanatory variables [31]. After several trials, this study finally selected the bidirectional fixed effects (FE) of the Spatial Durbin Model (SDM) to assess the impact of improved transportation on tourism development in the study area. The formula is as follows:

$$y_{it} = \delta W y_{it} + X_{it}\beta + WX_{it}\gamma + \varepsilon_{it} + \alpha_i + \lambda_t \quad (2)$$

where i is the city, t is the year, y_{it} is the explained variable, X_{it} is the explanatory variable, W is the spatial weight matrix, δ is the spatial correlation coefficient of the explained variable, γ is the spatial correlation coefficient of the explanatory variable, β is the regression coefficient, ε_{it} is the normal error term, α_i is the individual effect that does not change with year, and λ_t is the time effect that does not change with city.

The explained variables, explanatory variables, and control variables involved in this paper are shown in Table 2.

Table 2. Variables involved in the model construction process.

Variable Type	Variable Name	Data Sources
Explained variables	Ln tourism revenue (*ln tr*)	City tourism industry overall size and development
	Ln inbound tourism revenue (*ln itr*)	City inbound tourism industry overall size
	Ln domestic tourism revenue (*ln dtr*)	City domestic tourism industry overall size
	Ln number of tourists (*ln nt*)	City capacity to receive tourist arrivals
	Ln number of international tourist arrivals (*ln nita*)	City capacity to receive inbound tourist arrivals
	Ln number of domestic tourists (*ln ndt*)	City capacity to receive domestic tourist arrivals
Explanatory variables	Ln highway passenger volume (*ln hpv*)	The impact of highway transportation infrastructure on tourism development
	Ln waterway passenger volume (*ln wpv*)	The impact of waterway transportation infrastructure on tourism development
	Ln civil aviation passenger volume (*ln capv*)	Impact of civil aviation transportation infrastructure on tourism development
	Ln rail transportation passenger volume (*ln rtpv*)	The impact of rail transportation infrastructure on tourism development
	Ln number of cabs (*ln nc*)	The impact of cab transportation infrastructure on tourism development
	Number of high-speed railway lines (*nhrl*)	Impact of high-speed railway transportation infrastructure on tourism development
Control variables	Ln number of tourism destinations (*ln ntd*)	Including high quality tourism sites such as World Heritage Sites, national protected areas, national scenic spots and national key cultural relics protection units
	Ln actual utilization of foreign direct investment (*ln aufdi*)	The degree of openness of the city and city attraction to inbound tourists
	Ln gross domestic product per capital (*ln GDP-per capital*)	City economic development level

3.3. Data Sources

This study collected data on 12 indicators concerning the tourism, transportation, and regional economy of 13 cities in the BTHR from 2010 to 2020 (Table 3).

Table 3. Data Description.

Data Name	Data Sources	Start Time	Closing Time	Unit
Tourism revenue Number of Tourists	Ministry of Culture and Tourism, China	2010	2020	Year
Highway Passenger Volume	Ministry of Transport of the People's Republic of China			
Waterway Passenger Volume	Tianjin Port official website			
Civil Aviation Passenger Volume	Annual Civil Aviation Development Report, Civil Aviation Administration of China			
Rail Transportation Passenger Volume	Ministry of Transport of the People's Republic of China			
Number of Cabs	Regional Statistical Yearbooks by province and municipality			
Number of High-Speed Railway Lines	https://www.12306.cn/index/ (accessed on 12 July 2022)			
World Heritage Sites, National Protected Areas, National Scenic Areas and National Key Cultural Relics Protection Units, etc.	UNESCO World Heritage Centre, Ministry of Culture and Tourism, State Administration of Cultural Heritage, Ministry of Ecology and Environment, National Forestry and Grassland Bureau,China, etc.			
Actually Utilized Foreign Direct Investment	Regional Statistical Yearbooks by province and municipality			
Permanent Resident Population Gross Domestic Product	National Bureau of Statistics, China			

4. Results

4.1. Contribution of Tourism to GDP

The P-TDGDP in the study area increased from 11.21% in 2010 to a peak of 23.77% in 2019. The outbreak of the pandemic broke the growth trend of tourism development in the BTHR, and the P-TDGDP decreased to 9.82% in 2020 (Figure 2).

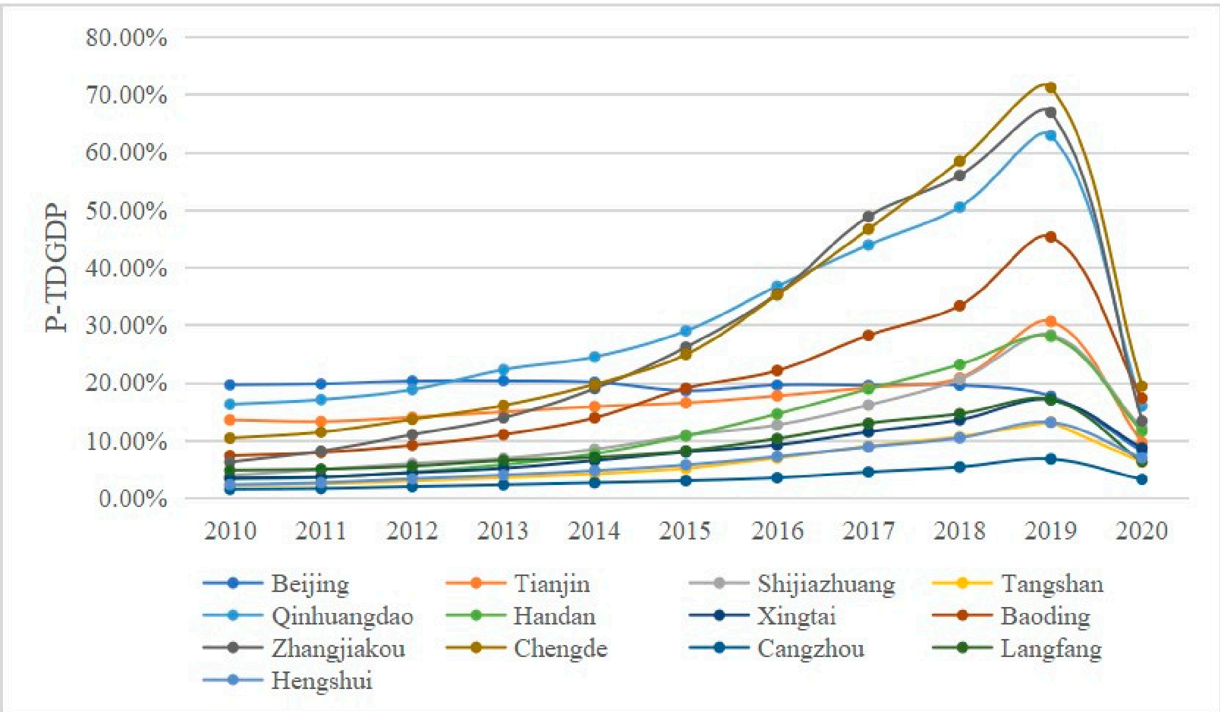

Figure 2. Contribution of tourism to GDP in 13 cities in the BTHR. (Source: From the Ministry of Culture and Tourism of China, National Bureau of Statistics of China).

In 2010, Beijing (19.60%), Qinhuangdao (16.24%), Tianjin (13.53%), and Chengde (10.36%) were in the first echelon, while Baoding (7.31%), Zhangjiakou (6.21%), Langfang (4.81%), and Shijiazhuang (3.89%) were in the second echelon. In 2019, Chengde (71.19%), Zhangjiakou (66.87%), Qinhuangdao (62.90%), and Baoding (45.28%) were in the first echelon, while Tianjin (30.61%), Shijiazhuang (28.29%), Handan (28.03%), and Beijing (17.60%) were in the second echelon. After 10 years of development, Qinhuangdao and Chengde remained in the first echelon, Baoding and Zhangjiakou jumped to the first echelon, and Beijing and Tianjin fell out of the first echelon. In terms of regional competitiveness, the tourism competitiveness of the twin cities of Beijing and Tianjin declined significantly. Specifically, the ratio of tourism revenue (TR) in Beijing and Tianjin to total tourism revenue (TR) in the BTHR decreased from 81.44% in 2010 to 53.09% in 2019.

4.2. Degree of Coordinated Development of Tourism

From the perspective of Beijing and Tianjin, the NTCDI of Beijing increased from 68.39 in 2010 to a peak of 100 in 2019 and decreased to 80.41 in 2020, which was equivalent to 80% of pre-pandemic levels; the NTCDI of Tianjin increased from 30.21 in 2010 to 49.41 in 2019, and decreased to 60% of pre-pandemic levels in 2020.

Figure 3 shows that from the perspective of Hebei Province, from 2010 to 2019, although the NTCDI of Baoding and Shijiazhuang were roughly comparable and showed an increasing trend year over year, the NTCDI of Baoding remained at a relatively high level (19.10) after the pandemic. The NTCDI of Handan and Tangshan showed a small fluctuating trend, and due to the impact of the pandemic, the NTCDI of Handan and Tangshan decreased from 12.62 and 9.81, respectively, in 2019 to 9.62 and 7.50, respectively, in 2020. The NTCDI of Zhangjiakou and Qinhuangdao both showed an increase, but the NTCDI of Chengde and Hengshui showed a declining trend. This was especially true of Hengshui, which decreased from 3.54 in 2010 to 0.80 in 2019, and dropped to the lowest value (0.00) in the BTHR after the pandemic. However, the Langfang tourism industry showed strong resilience, with its NTCDI steadily increasing from 4.28 in 2010 to 7.24 in 2020, and still maintaining a growth trend after COVID-19.

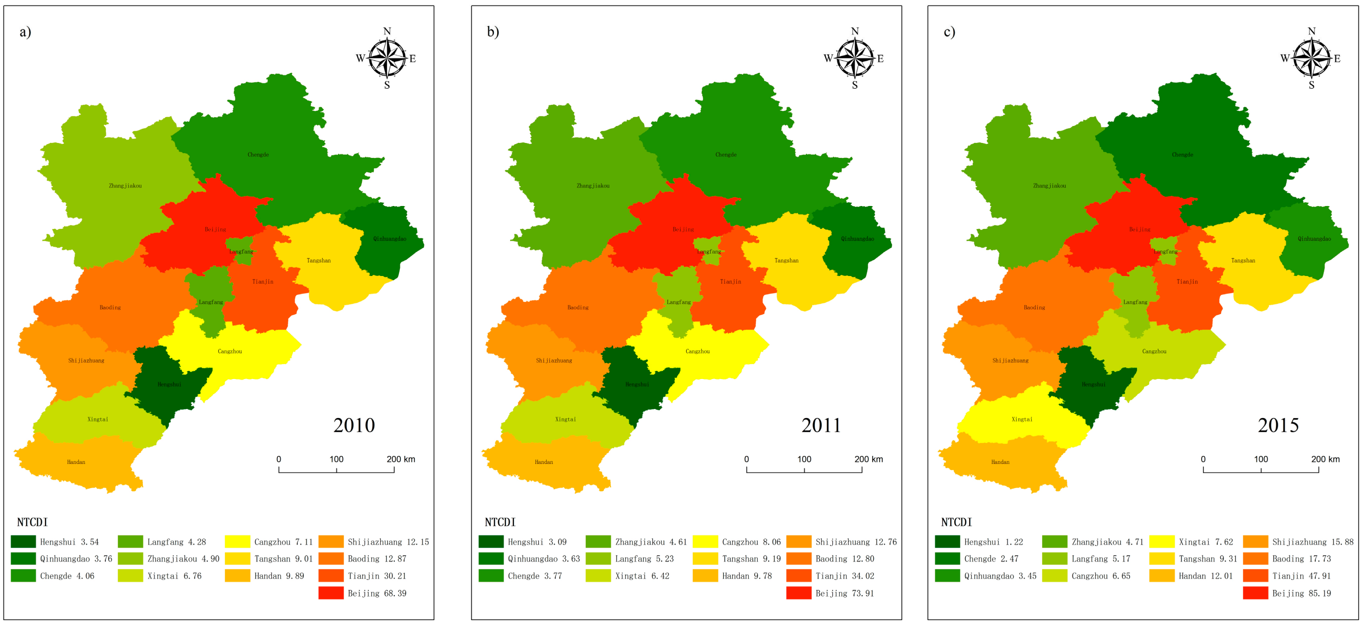

Figure 3. *Cont.*

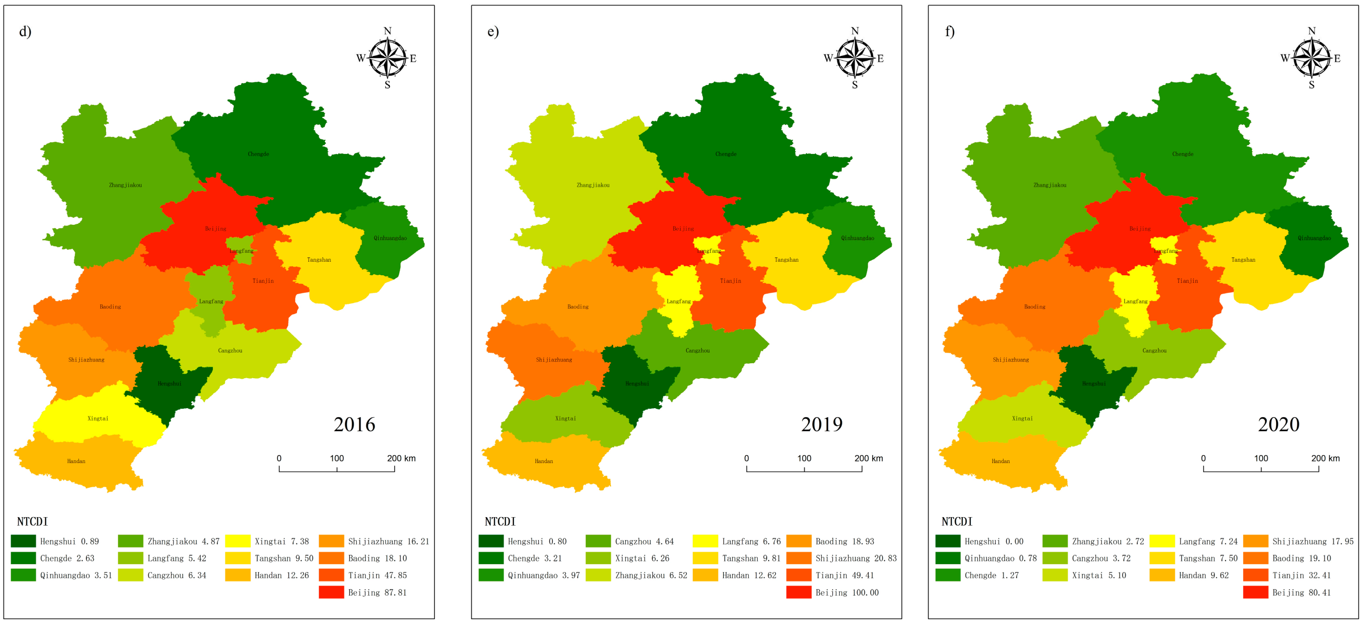

Figure 3. The degree of coordinated development of tourism in 13 cities of the BTHR. (Source: Made by the authors). The (**a**–**f**) in picture show the NTCDI of 2010, 2011, 2015, 2016, 2019 and 2020, respectively.

4.3. Spatial Spillover Effect

Tables 4 and 5 show that from the perspective of inbound tourism, ln capv has a significant spillover effect on the number of international tourist arrivals (NITA) and ln rail transportation passenger volume (ln rtpv) only has a significant spillover effect on inbound tourism revenue (ITR). From the perspective of domestic tourism, ln civil aviation passenger volume (ln capv) has a significant spillover effect on domestic tourism revenue (DTR). In addition, ln actual utilization of foreign direct investment (ln aufdi) has a significant positive effect on tourism revenue (TR) and number of tourists (NT), which reflects the boosting and spillover effects of actually utilizing foreign direct investment (AUFDI) on tourism development.

Table 4. Estimation results of the SDM for panel data from 2010 to 2019.

Variables	Model 1 *ln tr*	Model 2 *ln itr*	Model 3 *ln dtr*	Model 4 *ln nt*	Model 5 *ln nita*	Model 6 *ln ndt*
ln hpv	−0.0569 (−0.0520)	−0.1807 ** (−0.0844)	−0.0557 (−0.0503)	0.0026 (−0.0380)	−0.0360 (−0.0614)	0.1094 (−0.0912)
ln wpv	0.0093 (−0.0245)	0.0360 (−0.0396)	0.0073 (−0.0236)	0.0098 (−0.0179)	0.0131 (−0.0288)	0.0075 (−0.0429)
ln capv	0.0897 *** (−0.0200)	0.0435 (−0.0324)	0.0900 *** (−0.0194)	0.0768 *** (−0.0146)	−0.0020 (−0.0235)	0.0906 *** (−0.0351)
ln rtpv	0.0097 (−0.0132)	0.0015 (−0.0215)	0.0096 (−0.0127)	0.0047 (−0.0096)	0.0082 (−0.0155)	−0.0164 (−0.0230)
ln nc	−0.0064 (−0.0530)	0.1041 (−0.0857)	−0.0116 (−0.0512)	−0.0514 (−0.0387)	0.1232 ** (−0.0623)	0.0766 (−0.0929)
nhrl	−0.0762 *** (−0.0273)	−0.0532 (−0.0447)	−0.0743 *** (−0.0264)	−0.0509 ** (−0.0199)	−0.0310 (−0.0321)	0.0533 (−0.0477)
ln ntd	−0.2316 *** (−0.0854)	−0.0637 (−0.1380)	−0.2238 *** (−0.0825)	−0.2570 *** (−0.0625)	−0.1232 (−0.1012)	−0.2727 * (−0.1496)
ln aufdi	0.1824 *** (−0.0365)	0.3355 *** (−0.0588)	0.1713 *** (−0.0353)	0.1363 *** (−0.0270)	0.2504 *** (−0.0434)	0.2958 *** (−0.0634)
ln gdp_per capital	0.0135 (−0.2095)	0.0374 (−0.3381)	−0.0018 (−0.2026)	0.1074 (−0.1530)	−0.2883 (−0.2459)	−0.1224 (−0.3676)
W × ln hpv	0.0454 (−0.1860)	−0.4122 (−0.3019)	0.0407 (−0.1798)	0.1623 (−0.1359)	−0.1544 (−0.2193)	0.2966 (−0.3258)
W × ln wpv	0.1478 (−0.0933)	0.0986 (−0.1512)	0.1496 * (−0.0902)	0.1074 (−0.0681)	0.0451 (−0.1097)	−0.0878 (−0.1634)

Table 4. *Cont.*

Variables	Model 1 *ln tr*	Model 2 *ln itr*	Model 3 *ln dtr*	Model 4 *ln nt*	Model 5 *ln nita*	Model 6 *ln ndt*
W × ln capv	0.1150 (−0.0862)	0.1033 (−0.1384)	0.1059 (−0.0834)	0.0570 (−0.0631)	0.2216 ** (−0.1013)	0.1148 (−0.1504)
W × ln rtpv	−0.0245 (−0.0333)	0.1059 * (−0.0540)	−0.0232 (−0.0322)	−0.0129 (−0.0244)	−0.0275 (−0.0393)	−0.0303 (−0.0585)
W × ln nc	0.0049 (−0.1364)	0.1432 (−0.2207)	−0.0043 (−0.1318)	0.0232 (−0.0996)	0.2568 (−0.1604)	−0.0357 (−0.2390)
W × nhrl	−0.2341 *** (−0.0810)	−0.5159 *** (−0.1302)	−0.2264 *** (−0.0783)	−0.0962 (−0.0593)	−0.2794 *** (−0.0947)	0.0402 (−0.1411)
W × ln ntd	0.3168 (−0.2229)	0.1559 (−0.3590)	0.3120 (−0.2155)	0.4442 *** (−0.1624)	0.8194 *** (−0.2615)	0.5575 (−0.3889)
W × ln aufdi	0.3702 *** (−0.1358)	0.7139 *** (−0.2262)	0.3640 *** (−0.1312)	0.3602 *** (−0.1002)	0.6276 *** (−0.1627)	0.4709 ** (−0.2363)
W × ln gdp_per capital	2.0232 *** (−0.6629)	0.5774 (−1.0696)	1.9471 *** (−0.6408)	1.3146 *** (−0.4850)	0.8796 (−0.7777)	2.3086 ** (−1.1608)
N	130	130	130	130	130	130
R-sq	0.630	0.622	0.631	0.522	0.492	0.532
AIC	255.8059	377.8110	254.2000	203.8563	337.3994	222.6272
BIC	284.4812	406.4863	282.8753	232.5317	366.0748	251.3026
Hausman test	29.36 ***	1030.47 ***	31.89 ***	21.83 ***	28.55 ***	−8.93

Note: *** denotes significance at the 0.01 level, ** at the 0.05 level, and * at the 0.10 level. This table only considers data from 2010 to 2019. Appendix B Table A6 details the results if the data from 2010 to 2020 are considered.

Table 5. Spatial effects decomposition from 2010 to 2019.

Variables	Model 1 *ln tr*	Model 2 *ln itr*	Model 3 *ln dtr*	Model 4 *ln nt*	Model 5 *ln nita*	Model 6 *ln ndt*
Direct effects						
ln hpv	−0.0509 (−0.1011)	-0.1587 * (−0.0823)	−0.0510 (−0.0984)	0.0349 (−0.0617)	−0.0299 (−0.0614)	0.1095 (−0.0944)
ln wpv	0.0482 (−0.0458)	0.0296 (−0.0375)	0.0469 (−0.0448)	0.0290 (−0.0270)	0.0109 (−0.0274)	0.0070 (−0.0414)
ln capv	0.1406 *** (−0.0399)	0.0417 (−0.0311)	0.1389 *** (−0.0387)	0.0976 *** (−0.0224)	−0.0055 (−0.0228)	0.0929 *** (−0.0336)
ln rtpv	0.0042 (−0.0203)	−0.0044 (−0.0202)	0.0044 (−0.0197)	0.0025 (−0.0125)	0.0090 (−0.0147)	−0.0163 (−0.0221)
ln nc	−0.0057 (−0.0867)	0.0962 (−0.0792)	−0.0144 (−0.0843)	−0.0527 (−0.0532)	0.1159 ** (−0.0589)	0.0760 (−0.0886)
nhrl	−0.1497 *** (−0.0548)	−0.0212 (−0.0434)	−0.1463 *** (−0.0535)	−0.0717 ** (−0.0300)	−0.0208 (−0.0321)	0.0573 (−0.0478)
ln ntd	−0.1948 (−0.1381)	−0.0769 (−0.1425)	−0.1863 (−0.1343)	−0.2071 ** (−0.0871)	−0.1495 (−0.1042)	−0.2850 * (−0.1570)
ln aufdi	0.3164 *** (−0.0795)	0.2993 *** (−0.0546)	0.3032 *** (−0.0777)	0.2163 *** (−0.0459)	0.2333 *** (−0.0399)	0.2900 *** (−0.0599)
ln gdp_per capital	0.5687 (−0.4163)	0.0337 (−0.3132)	0.5361 (−0.4048)	0.3668 (−0.2410)	−0.2949 (−0.2344)	−0.1248 (−0.3599)
Indirect effects						
ln hpv	0.0510 (−0.7112)	−0.2724 (−0.2370)	0.0369 (−0.6953)	0.4012 (−0.3876)	−0.1212 (−0.1951)	0.3006 (−0.3252)
ln wpv	0.4776 (−0.3584)	0.0667 (−0.1148)	0.4846 (−0.3535)	0.2579 (−0.1823)	0.0359 (−0.0936)	−0.0904 (−0.1509)
ln capv	0.5842 * (−0.3494)	0.0827 (−0.1155)	0.5611 * (−0.3393)	0.2498 (−0.1711)	0.2099 ** (−0.0990)	0.1166 (−0.1486)
ln rtpv	−0.0638 (−0.1301)	0.0831 * (−0.0449)	−0.0602 (−0.1271)	−0.0275 (−0.0669)	−0.0282 (−0.0358)	−0.0321 (−0.0585)
ln nc	0.0175 (−0.5466)	0.0960 (−0.1758)	−0.0242 (−0.5342)	−0.0085 (−0.2829)	0.2211 (−0.1510)	−0.0291 (−0.2386)
nhrl	−0.9066 ** (−0.4272)	−0.4101 *** (−0.1075)	−0.8879 ** (−0.4199)	−0.2918 * (−0.1748)	−0.2502 *** (−0.0878)	0.0341 (−0.1324)
ln ntd	0.4670 (−0.8295)	0.1487 (−0.2845)	0.4730 (−0.8115)	0.6707 (−0.4442)	0.7572 *** (−0.2386)	0.5566 (−0.3771)
ln aufdi	1.6108 ** (−0.7371)	0.5109 *** (−0.1917)	1.5834 ** (−0.7238)	1.0432 *** (−0.3915)	0.5457 *** (−0.1663)	0.4609 * (−0.2624)

Table 5. *Cont.*

Variables	**Model 1** ***ln tr***	**Model 2** ***ln itr***	**Model 3** ***ln dtr***	**Model 4** ***ln nt***	**Model 5** ***ln nita***	**Model 6** ***ln ndt***
ln gdp_per capital	6.4501 ** (−3.2419)	0.4530 (−0.8365)	6.2389 ** (−3.1611)	3.2084 ** (−1.5562)	0.8306 (−0.6936)	2.2211 * (−1.1476)
Total effects						
ln hpv	0.0002 (−0.8038)	−0.4312 (−0.2697)	−0.0141 (−0.7856)	0.4361 (−0.4415)	−0.1510 (−0.2259)	0.4100 (−0.3784)
ln wpv	0.5259 (−0.3996)	0.0963 (−0.1226)	0.5316 (−0.3939)	0.2869 (−0.2050)	0.0468 (−0.1027)	−0.0834 (−0.1673)
ln capv	0.7248 * (−0.3855)	0.1244 (−0.1180)	0.7000 * (−0.3743)	0.3474 * (−0.1897)	0.2044 * (−0.1054)	0.2095 (−0.1583)
ln rtpv	−0.0596 (−0.1476)	0.0786 (−0.0500)	−0.0557 (−0.1441)	−0.0250 (−0.0769)	−0.0192 (−0.0412)	−0.0484 (−0.0678)
ln nc	0.0118 (−0.6250)	0.1923 (−0.2101)	−0.0386 (−0.6104)	−0.0612 (−0.3286)	0.3370 * (−0.1825)	0.0469 (−0.2891)
nhrl	−1.0563 ** (−0.4771)	−0.4313 *** (−0.1256)	−1.0343 ** (−0.4688)	−0.3634 * (−0.2005)	−0.2710 *** (−0.1043)	0.0914 (−0.1583)
ln ntd	0.2723 (−0.9484)	0.0718 (−0.3254)	0.2866 (−0.9273)	0.4636 (−0.5136)	0.6077 ** (−0.2804)	0.2716 (−0.4472)
ln aufdi	1.9272 ** (−0.8104)	0.8102 *** (−0.2043)	1.8866 ** (−0.7956)	1.2596 *** (−0.4317)	0.7789 *** (−0.1812)	0.7509 *** (−0.2873)
ln gdp_per capital	7.0188 * (−3.6241)	0.4867 (−0.9693)	6.7749 * (−3.5330)	3.5752 ** (−1.7678)	0.5357 (−0.8171)	2.0963 (−1.3578)

Note: *** denotes significance at the 0.01 level, ** at the 0.05 level, and * at the 0.10 level. This table only considers data from 2010 to 2019. Appendix B Table A7 details the results if the data from 2010 to 2020 are considered.

To further explain the significance of each variable coefficient, the total spatial effects are decomposed into direct effects and indirect effects in Table 5. In Model 1, the direct effects indicate that civil aviation transportation has a positive impact on the tourism revenue (TR) of the city, whereas the opening of a high-speed railway connection has a negative impact on the tourism revenue (TR) of the city. The indirect effects indicate that ln civil aviation passenger volume (ln capv) is significantly positive and that civil aviation transportation has a positive spillover effect; that is, improving civil aviation transportation in one city can stimulate the growth of tourism revenue (TR) in nearby cities. More specifically, when civil aviation passenger volume (CAPV) increases by 10% in one city, it leads to a 5.84% increase in tourism revenue (TR) in nearby cities. In Model 2, the direct effects indicate that highway transportation has a negative impact on the city's inbound tourism revenue (ITR). The indirect effects indicate that when rail transportation passenger volume (RTPV) increases by 10% in one city, it leads to a 0.83% increase in the inbound tourism revenue (ITR) of nearby cities. The estimation results of Model 3 are similar to those of Model 1. The reason for the significant negative number of high-speed railway lines (NHRL) may be that the opening of a high-speed railway has a siphon effect on tourism development [32], particularly in terms of promoting the development of cities with unique tourism resources [33]. Zhou et al. (2020) also proved that the opening of high-speed railways will have a negative spillover effect on the tourism flow of nearby cities [27], which is consistent with this paper. The fact that high-speed railway transportation attracts resources and tourists from smaller neighboring cities but does not promote or drive tourism development in smaller neighboring cities has been demonstrated by Tian et al. (2019) [34]. The results of the direct effects estimate for Model 4 are similar to those of Model 1. High-speed railway transportation has a negative impact on number of tourists (NT), which is also reflected in the research results of Zhou et al. (2020). Cities with high-speed railways will have a positive impact on nearby cities, while cities without high-speed railways will have a negative impact [27]. In Model 5, the direct effects indicate that taxi transportation has a positive impact on the number of international tourist arrivals (NITA). The indirect effects indicate that a 10% increase in civil aviation passenger volume (CAPV) and number of high-speed railway lines (NHRL) in one city will lead to a 2.10% increase and a 2.50% decrease in number of international tourist arrivals (NITA) in nearby cities, respectively. In contrast, Tian et al. (2022) showed that the spillover effect of air transport on the number of inbound tourists is not significant [14]. In addition, number of tourism destinations (NTD) also has a positive spillover effect on number of international tourist arrivals (NITA); that is, when the number of tourism destinations (NTD) in one city increases by 10%, it leads to an increase of 7.57% in the number of international tourist arrivals (NITA) in nearby cities. Consistent with the research results of Liu and Chen (2021), tourism resource endowment will have a positive spillover effect on inbound tourism [35]. The estimated results of Model 6 are similar to those of Model 4.

5. Discussion and Conclusions

Comparing the tourism revenue model and tourism number model reveals that civil aviation transportation has a significant spillover effect on the number of international tourist arrivals (NITA) and domestic tourism revenue (DTR). The airport is an important transportation hub and one of the most important modes of transport for inbound tourists to China [36], which is conducive to the increase in number of international tourist arrivals (NITA); however, Tian et al. (2022) considered civil aviation transportation to have only a significant spillover effect on inbound tourism revenue (ITR) [14]. In addition, for domestic tourists, civil aviation transportation is one of the modes of interregional mobility that improves the speed of interregional mobility and expands travel distance, thus generating greater tourism consumption expenditures. Comparing the inbound tourism model and the domestic tourism model shows that rail transportation has only a significant spillover effect on inbound tourism. The cities where rail transportation is located are large-scale cities with high levels of economic development and dense populations, which make them more attractive to inbound tourists and promote the development of inbound tourism. In addition, Tian et al. (2022) also found that road transport has a significant positive effect and spillover effect on domestic tourism [14], while the spillover effect of road transport in this study is not significant. A comprehensive comparison of the six models shows that inbound tourism is more influenced by actual utilization of foreign direct investment (AUFDI) and that GDP per capita has a greater impact on domestic tourism. Liu and Chen (2021) also showed that the degree of openness has a significant spillover effect on inbound tourism, which is consistent with the findings of this study, and the regional economic development has a significant negative spillover effect on inbound tourism, while this study shows that the spillover effect of city economic development level on inbound tourism is not significant [35]. The study also found that actual utilization of foreign direct investment (AUFDI) is closely related to inbound business tourism and cities with high actual utilization of foreign direct investment have higher international visibility, which promotes the development of inbound tourism. People's l standards of living and disposable income are higher in high-GDP cities, which is more beneficial to the development of domestic tourism.

In recent years, the BTHR has made remarkable achievements in "high-quality, integrated, and coordinated development", but there are still dual problems of fierce competition in external tourism markets and a mismatch between internal tourism supply and demand [37,38], in which the tourism attractions are characterized by "dense municipalities directly under the Central Government and scattered in Hebei Province". The grand opening of the Beijing Universal Resort in September 2021 brought more international, modern, and fashionable elements to the BTHR. The hosting of the 2022 Winter Olympic Games brought opportunities for the development of the ice and snow culture tourism industry in the BTHR. For example, Hebei plans to build Zhangjiakou and Chengde into famous national ice and snow tourism cities and world ice and snow tourism destinations. It provides a new attraction for visitors and drives the potential for sustained growth in the tourism industry in the future [39]. During the National Day holidays in 2021 and 2022, tourism revenue (TR) in Beijing reached RMB 10.82 billion and RMB 6.54 billion, respectively, recovering to 96.80% and 58.55% of the figures for the same period in 2019, which is significantly higher than the national average. By introducing a large amount of capital and advanced technology [40], Tianjin is focusing on building a new spatial layout for the integrated development of culture and tourism and striving to open up a new horizon in tourism development, as reflected by the increasing trend in P-TDGDP year by year. During the National Day holiday in 2022, per capita tourism spending increased by 27% year over year in Tianjin. Hebei Province received 219 million tourists and RMB 211.09 billion in tourism revenue in the first half of 2021, recovering to 63.48% and 55.03% of pre-pandemic levels, respectively.

Civil aviation transportation and railway transportation mainly connects high-level cities within a large range, whereas highway transportation is mainly an intercity mode of transport and supports local tourism [41]. The BTHR railway transportation network—with high-speed railways, intercity railways, and municipal railways as its framework—facilitates the integration of tourism and transport in the BTHR [26,42,43]. The opening of special tourism trains, such as "Hengshui Lake" and "Xibaipo" has provided visitors with more and more efficient travel opportunities [44], which has driven the growth of tourist flows to key scenic spots in Hebei Province. The NTCDI in Hengshui has always been at the bottom. Hengshui's tourism resources are relatively poor, but its transport network is relatively good [45]. Therefore, it can actively integrate itself into the process of the coordinated development of tourism in the BTHR by improving its tourism infrastructure and developing the Hengshui Lake tourism brand [46,47].

Studies have shown that under the influence of the pandemic, tourists tend to prefer low-tourism-density destinations [48], meaning that green space can play a role in helping the tourism industry recover [49], and that rural tourism can contribute to the recovery of domestic tourism [50]. The realization of a two-hour living circle in the BTHR has boosted the development of short weekend tourism. During the National Day holiday over the past two years, tourism in the BTHR has been dominated by local tourism, suburban tourism, and surrounding tourism—theme park tourism, camping tourism, and rural tourism have also been very popular. Therefore, cities in Hebei can promote interregional connectivity by improving their urban service facilities and tourism infrastructure, optimizing tourism products and improving service quality, and accelerating the improvement of transport networks and connection systems [45].

In addition, comparing the model results for 2010–2019 (Table 5) and 2010–2020 (Appendix B Table A7) shows that highway transportation and rail transportation boosted inbound tourism after the outbreak of the pandemic, possibly because the pandemic mitigation measures limited extensive movement by inbound tourists, and because inbound tourists with 144-hour visa-free transit needed to choose local tourism destinations due to the visa-free time limit. The spillover effect of number of tourism destinations (NTD) also indicates that high-quality tourism destinations are becoming increasingly important for inbound tourism development and that there is a need to provide inbound tourists with more routes that make sense for tourism, such as connections to the Beijing West Shuttle Bus Resort and the Beijing-Zhangjiakou Sports and Culture Tourism and Leisure Belt. As the "City of the Summer and Winter Olympic Games", Beijing is one of the top destinations for international tourists. The high-quality development of the integration of culture, tourism, and business has contributed to the construction of Beijing as an "International Consumption Center City" and "International Harmonious and Livable City". It is important for the commercial feasibility of Beijing to provide tourism products and bring a higher-quality tourism experience to tourists [44]. Tianjin can strengthen its tourism branding, enhance its tourism attractions, and enrich its tourism products and services. Cities in Hebei should take up the spillover effect from Beijing and Tianjin in a rational and orderly manner and use high-quality tourism destinations and differentiated services to provide an important bearing space for the integrated, coordinated, and high-quality development of the BTHR.

This study has the following limitations: first, a relatively conservative conversion relationship of 1:1 between tourism revenue (TR) and TDGDP was used; second, the number of high-speed railway lines and the number of taxis were used instead of passenger volume data; and third, the passenger volume data did not distinguish between tourists and non-tourists. In addition, the specific impact and mechanism of the coronavirus pandemic on tourism, transportation, and the economy are still unclear. This study only covers data for one year after the pandemic outbreak, which limits the usefulness of the results.

6. Outlook

It is difficult to apply the Tourism Satellite Account methodology proposed by the United Nations to the local situation in China because of the different statistical calibers used in different regions and the low degree of internationalization, as well as the lack of statistical data on new industries in the existing statistical yearbooks. Therefore, there is an urgent need to establish a new statistical system for the cultural tourism industry that is in line with internationalization and can be adapted for local application. The tourism SDGs proposed by the United Nations involve multiple dimensions of the environment, economy, and society, and the trade-off and synergy relationships among them are complex and diverse. There is an urgent need to strengthen research on sustainable development in tourism from the cross-perspective of multiple SDG indicators. There is an urgent need to continue to promote data sharing, particularly visitor flow tracking data, through legislative safeguards and international cooperation. Future research should attempt to strengthen theoretical exploration and methodological research in the field of sustainable development in tourism and further integrate multifaceted methods such as social network analysis, artificial intelligence, and machine learning to achieve accurate simulation and prediction of the spatial spillover effects of tourist transportation.

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Appendix A

Table A1. Global Moran's I text from 2010 to 2020.

Year	Obs.	Correlation Coefficient of *ln tr*	Correlation Coefficient of *ln itr*	Correlation Coefficient of *ln dtr*	Correlation Coefficient of *ln nt*	Correlation Coefficient of *ln nita*	Correlation Coefficient of *ln ndt*
2010	143	0.121 **	0.127 **	0.120 **	0.068	0.084 *	0.017
2011	143	0.118 *	0.122 *	0.116 *	0.067	0.084 *	0.066
2012	143	0.115 *	0.118 *	0.114 *	0.065	0.090 *	0.064
2013	143	0.109 *	0.129 **	0.109 *	0.059	0.088 *	0.058
2014	143	0.096 *	0.115 *	0.093 *	0.049	0.086 *	0.048
2015	143	0.063	0.123 *	0.061	0.035	0.089 *	0.034
2016	143	0.057	0.120 *	0.053	0.031	0.099 *	0.030

Table A1. *Cont.*

Year	Obs.	Correlation Coefficient of *ln tr*	Correlation Coefficient of *ln itr*	Correlation Coefficient of *ln dtr*	Correlation Coefficient of *ln nt*	Correlation Coefficient of *ln nita*	Correlation Coefficient of *ln ndt*
2017	143	0.044	0.128 *	0.039	0.021	0.096 *	0.020
2018	143	0.028	0.096 *	0.025	0.002	0.077	0.001
2019	143	0.013	0.100 *	0.010	−0.009	0.076	−0.010
2020	143	0.078	0.089 *	0.076	0.084	0.002	0.083

Note: ** at the 0.05 level, and * at the 0.10 level.

Table A2. Descriptive statistics of the variables from 2010 to 2020.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.	VIF
ln tr	143	15.0649	1.3097	12.0910	17.9465	
ln itr	143	10.3523	2.2417	3.9120	15.1102	
ln dtr	143	15.0446	1.2966	12.0813	17.8873	
ln nt	143	8.2279	1.0191	5.8522	10.3800	
ln nita	143	2.4162	1.8851	−4.6052	6.2546	
ln ndt	143	8.2383	1.0179	5.8493	10.3683	
ln hpv	143	8.4884	1.2096	5.4889	11.7931	5.11
ln wpv	143	0.4729	1.2466	0.0000	4.9488	1.45
ln capv	143	2.7207	3.0076	0.0000	9.1314	4.27
ln rtpv	143	1.9901	4.2886	0.0000	12.8898	5.62
ln nc	143	8.7310	1.0027	7.1884	11.2236	8.07
nhrl	143	1.5385	1.5326	0.0000	9.0000	2.52
ln ntd	143	4.3083	0.6895	1.3863	5.3982	3.95
ln aufdi	143	13.1609	1.3876	9.9844	16.6148	6.07
ln gdp_per capital	143	10.6984	0.5045	9.7438	12.0133	4.17

Appendix B

Table A3. Abbreviations for the variables.

Variable Name	Variable Abbreviation
Tourism Revenue	TR
Inbound Tourism Revenue	ITR
Domestic Tourism Revenue	DTR
Number of Tourists	NT
Number of International Tourist Arrivals	NITA
Number of Domestic Tourists	NDT
Tourism direct GDP as a proportion of total GDP	P-TDGDP
Highway Passenger Volume	HPV
Waterway Passenger Volume	WPV
Civil Aviation Passenger Volume	CAPV
Rail Transportation Passenger Volume	RTPV
Bus (Electric) Vehicle Passenger Volume	BVPV
Number of Cabs	NC
Number of High-Speed Railway Lines	NHRL
Number of Tourism Destinations	NTD
Actually Utilized Foreign Direct Investment	AUFDI
Gross Domestic Product	GDP
Permanent Resident Population	PRP
Gross Domestic Product Per Capital	GDP-per capital
Corona Virus Disease 2019	COVID-19

Table A4. Global Moran's I text from 2010 to 2019.

Year	Obs.	Correlation Coefficient of *ln tr*	Correlation Coefficient of *ln itr*	Correlation Coefficient of *ln dtr*	Correlation Coefficient of *ln nt*	Correlation Coefficient of *ln nita*	Correlation Coefficient of *ln ndt*
2010	130	0.168 **	0.174 **	0.166 **	0.107 *	0.129 **	0.039
2011	130	0.163 **	0.170 **	0.161 **	0.103 *	0.129 **	0.102 *
2012	130	0.160 **	0.168 **	0.158 **	0.098 *	0.135 **	0.097 *
2013	130	0.153 **	0.180 **	0.151 **	0.090 *	0.134 **	0.089 *
2014	130	0.137 **	0.162 **	0.133 **	0.078 *	0.132 **	0.077 *
2015	130	0.100 *	0.171 **	0.097 *	0.064	0.135 **	0.062
2016	130	0.093 *	0.170 **	0.088 *	0.058	0.136 **	0.057
2017	130	0.079 *	0.175 **	0.073	0.047	0.142 **	0.045
2018	130	0.061	0.140 **	0.058	0.026	0.123 **	0.025
2019	130	0.045	0.144 **	0.041	0.014	0.121 **	0.012

Note: ** at the 0.05 level, and * at the 0.10 level.

Table A5. Descriptive statistics of the variables from 2010 to 2019.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.	VIF
ln tr	130	15.0569	1.3430	12.0910	17.9465	
ln itr	130	10.6097	2.0567	7.344719	15.11016	
ln dtr	130	15.0349	1.3289	12.0813	17.8873	
ln nt	130	8.2230	1.0419	5.8522	10.3800	
ln nita	130	2.6888	1.6405	−0.0619	6.2546	
ln ndt	130	8.2346	1.0406	5.8493	10.3683	
ln hpv	130	8.6329	1.0993	6.6438	11.7931	5.67
ln wpv	130	0.4918	1.2685	0.0000	4.9488	1.53
ln capv	130	2.6778	3.0151	0.0000	9.1314	4.11
ln rtpv	130	1.9457	4.2644	0.0000	12.8898	5.58
ln nc	130	8.7513	0.9935	7.1884	11.1777	7.71
nhrl	130	1.4000	1.3329	0.0000	6.0000	2.94
ln ntd	130	4.4062	0.5839	2.0794	5.3982	3.64
ln aufdi	130	13.1167	1.4085	9.9844	16.6148	6.67
ln gdp_per capital	130	10.6777	0.5032	9.7438	11.9923	4.28

Table A6. Estimation results of the SDM for the panel data from 2010 to 2020.

Variables	Model 1 *ln tr*	Model 2 *ln itr*	Model 3 *ln dtr*	Model 4 *ln nt*	Model 5 *ln nita*	Model 6 *ln ndt*
ln hpv	−0.0738 (−0.0584)	0.2576 ** (−0.1132)	−0.0719 (−0.0569)	−0.0032 (−0.0422)	0.1944 * (−0.1042)	0.0660 (−0.0753)
ln wpv	0.0156 (−0.0327)	0.0088 (−0.0634)	0.0128 (−0.0319)	0.0046 (−0.0236)	0.0229 (−0.0584)	0.0068 (−0.0421)
ln capv	0.0804 *** (−0.0253)	0.1149 ** (−0.0488)	0.0812 *** (−0.0247)	0.0508 *** (−0.0183)	0.0778 * (−0.0450)	0.0418 (−0.0324)
ln rtpv	−0.0009 (−0.0162)	0.0233 (−0.0315)	−0.0009 (−0.0158)	−0.0060 (−0.0117)	0.0197 (−0.0289)	−0.0220 (−0.0209)
ln nc	−0.0573 (−0.0689)	0.0109 (−0.1334)	−0.0629 (−0.0672)	−0.0773 (−0.0498)	0.0597 (−0.1228)	0.0844 (−0.0888)
nhrl	−0.0078 (−0.0260)	0.0862 * (−0.0506)	−0.0048 (−0.0254)	−0.0115 (−0.0189)	0.1176 ** (−0.0467)	0.0490 (−0.0336)
ln ntd	−0.3478 *** (−0.0833)	0.3524 ** (−0.1625)	−0.3323 *** (−0.0813)	−0.3004 *** (−0.0604)	0.1924 (−0.1491)	−0.3454 *** (−0.1073)
ln aufdi	0.1913 *** (−0.0461)	0.3239 *** (−0.0889)	0.1803 *** (−0.0450)	0.1129 *** (−0.0335)	0.2882 *** (−0.0820)	0.2386 *** (−0.0588)
ln gdp_per capital	−0.0261 (−0.2427)	−0.7625 (−0.4687)	−0.0430 (−0.2367)	0.0027 (−0.1752)	−0.4256 (−0.4316)	−0.2136 (−0.3122)
W × *ln hpv*	−0.0851 (−0.1967)	1.1053 *** (−0.3806)	−0.0714 (−0.1919)	−0.0595 (−0.1429)	1.2273 *** (−0.3534)	−0.0352 (−0.2533)
W × *ln wpv*	0.0983 (−0.1072)	0.2023 (−0.2069)	0.0936 (−0.1046)	0.0333 (−0.0776)	0.4444** (−0.1906)	−0.0458 (−0.1378)

Table A6. *Cont.*

Variables	Model 1 *ln tr*	Model 2 *ln itr*	Model 3 *ln dtr*	Model 4 *ln nt*	Model 5 *ln nita*	Model 6 *ln ndt*
W × *ln capv*	0.1820 * (−0.1049)	0.1507 (−0.2020)	0.1680 (−0.1025)	0.0681 (−0.0757)	0.3354 * (−0.1858)	0.0973 (−0.1343)
W × *ln rtpv*	−0.1219 *** (−0.0469)	0.2220 ** (−0.0909)	−0.1180 *** (−0.0457)	−0.0840 ** (−0.0339)	0.0395 (−0.0839)	−0.0932 (−0.0604)
W × *ln nc*	−0.0655 (−0.1689)	−0.1069 (−0.3281)	−0.0751 (−0.1648)	−0.0079 (−0.1224)	−0.1181 (−0.3021)	−0.0422 (−0.2176)
W × *nhrl*	0.0040 (−0.0870)	0.1353 (−0.1701)	0.0050 (−0.0848)	0.0883 (−0.0630)	0.1937 (−0.1577)	0.1595 (−0.1120)
W × *ln ntd*	0.1017 (−0.2484)	1.6162 *** (−0.4834)	0.1111 (−0.2422)	0.1930 (−0.1788)	1.6434 *** (−0.4442)	0.2336 (−0.3177)
W × *ln aufdi*	0.1451 (−0.1888)	1.0409 *** (−0.3587)	0.1428 (−0.1840)	0.2168 (−0.1364)	1.1577 *** (−0.3284)	0.2802 (−0.2391)
W × *ln gdp_per capital*	2.1049 ** (−0.8722)	0.5910 (−1.6792)	1.9701 ** (−0.8507)	1.3098 ** (−0.6306)	1.6881 (−1.5529)	2.5158 ** (−1.1174)
N	143	143	143	143	143	143
R-sq	0.470	0.497	0.477	0.366	0.549	0.494
AIC	301.2281	482.4044	299.6868	235.2062	464.8931	251.7102
BIC	330.8565	512.0328	329.3153	264.8347	494.5215	281.3386
Hausman test	40.30 ***	−109.99	41.52 ***	191.66 ***	2.06	−53.46

Note: *** denotes significance at the 0.01 level, ** at the 0.05 level, and * at the 0.10 level.

Table A7. Spatial effect decomposition from 2010 to 2020.

Variables	Model 1 *ln tr*	Model 2 *ln itr*	Model 3 *ln dtr*	Model 4 *ln nt*	Model 5 *ln nita*	Model 6 *ln ndt*
Direct effects						
ln hpv	−0.0813 (−0.0702)	0.3240 ** (−0.1321)	−0.0780 (−0.0682)	−0.0054 (−0.0480)	0.2626 ** (−0.1229)	0.0696 (−0.0771)
ln wpv	0.0230 (−0.0367)	0.0167 (−0.0663)	0.0195 (−0.0356)	0.0054 (−0.0251)	0.0426 (−0.0619)	0.0065 (−0.0403)
ln capv	0.1022 *** (−0.0292)	0.1308 ** (−0.0511)	0.1012 *** (−0.0282)	0.0581 *** (−0.0194)	0.1008 ** (−0.0470)	0.0423 (−0.0308)
ln rtpv	−0.0121 (−0.0185)	0.0343 (−0.0331)	−0.0116 (−0.0180)	−0.0116 (−0.0126)	0.0213 (−0.0298)	−0.0195 (−0.0200)
ln nc	−0.0649 (−0.0771)	0.0038 (−0.1400)	−0.0713 (−0.0749)	−0.0792 (−0.0529)	0.0532 (−0.1278)	0.0858 (−0.0834)
nhrl	−0.0056 (−0.0309)	0.0980 * (−0.0555)	−0.0025 (−0.0300)	−0.0048 (−0.0210)	0.1317 *** (−0.0505)	0.0477 (−0.0328)
ln ntd	−0.3553 *** (−0.0992)	0.4336 ** (−0.1854)	−0.3381 *** (−0.0963)	−0.2973 *** (−0.0681)	0.2680 (−0.1697)	−0.3597 *** (−0.1096)
ln aufdi	0.2105 *** (−0.0544)	0.3823 *** (−0.1006)	0.1984 *** (−0.0527)	0.1280 *** (−0.0367)	0.3483 *** (−0.0924)	0.2305*** (−0.0560)
ln gdp_per capital	0.1783 (−0.2900)	−0.6984 (−0.5017)	0.1445 (−0.2807)	0.0977 (−0.1954)	−0.3112 (−0.4596)	−0.2615 (−0.3058)
Indirect effects						
ln hpv	−0.1575 (−0.3235)	1.5276 ** (−0.5998)	−0.1343 (−0.3117)	−0.0731 (−0.2011)	1.6378 *** (−0.5765)	−0.0289 (−0.2260)
ln wpv	0.1515 (−0.1654)	0.2546 (−0.2661)	0.1416 (−0.1594)	0.0419 (−0.1025)	0.5617 ** (−0.2583)	−0.0463 (−0.1187)
ln capv	0.3340 * (−0.1784)	0.2540 (−0.2805)	0.3086 * (−0.1708)	0.1180 (−0.1074)	0.4669 * (−0.2594)	0.0921 (−0.1250)
ln rtpv	−0.1917 ** (−0.0870)	0.2822 ** (−0.1343)	−0.1838 ** (−0.0838)	−0.1185 ** (−0.0535)	0.0481 (−0.1129)	−0.0858 (−0.0570)
ln nc	−0.1205 (−0.2895)	−0.1267 (−0.4650)	−0.1367 (−0.2797)	−0.0316 (−0.1799)	−0.1253 (−0.4162)	−0.0402 (−0.1996)
nhrl	0.0006 (−0.1357)	0.1944 (−0.2148)	0.0038 (−0.1309)	0.1135 (−0.0868)	0.2723 (−0.1937)	0.1364 (−0.0982)
ln ntd	−0.0535 (−0.4176)	2.1659 *** (−0.7258)	−0.0263 (−0.4009)	0.1404 (−0.2541)	2.1156 *** (−0.6415)	0.2580 (−0.2840)
ln aufdi	0.3504 (−0.3155)	1.4789 *** (−0.5639)	0.3352 (−0.3042)	0.3474 * (−0.2022)	1.5841 *** (−0.5197)	0.2444 (−0.2316)
ln gdp_per capital	3.1701 ** (−1.4667)	0.5180 (−2.2190)	2.9277 ** (−1.4052)	1.7452 * (−0.8977)	1.9793 (−2.0010)	2.2971 ** (−1.0138)

Table A7. *Cont.*

Variables	Model 1 *ln tr*	Model 2 *ln itr*	Model 3 *ln dtr*	Model 4 *ln nt*	Model 5 *ln nita*	Model 6 *ln ndt*
Total effects						
ln hpv	−0.2388 (−0.3704)	1.8516 *** (−0.6823)	−0.2123 (−0.3570)	−0.0785 (−0.2300)	1.9005 *** (−0.6545)	0.0407 (−0.2497)
ln wpv	0.1745 (−0.1901)	0.2713 (−0.3054)	0.1612 (−0.1832)	0.0474 (−0.1179)	0.6043 ** (−0.2958)	−0.0398 (−0.1317)
ln capv	0.4362 ** (−0.1979)	0.3848 (−0.3087)	0.4098 ** (−0.1895)	0.1761 (−0.1186)	0.5677 ** (−0.2853)	0.1344 (−0.1311)
ln rtpv	−0.2039 ** (−0.0998)	0.3165 ** (−0.1544)	−0.1954 ** (−0.0961)	−0.1300 ** (−0.0616)	0.0694 (−0.1302)	−0.1053 (−0.0641)
ln nc	−0.1854 (−0.3486)	−0.1228 (−0.5647)	−0.2080 (−0.3368)	−0.1108 (−0.2183)	−0.0721 (−0.5063)	0.0456 (−0.2435)
nhrl	−0.0049 (−0.1586)	0.2924 (−0.2519)	0.0012 (−0.1529)	0.1088 (−0.1010)	0.4040 * (−0.2268)	0.1841 (−0.1126)
ln ntd	−0.4089 (−0.4864)	2.5996 *** (−0.8460)	−0.3644 (−0.4673)	−0.1568 (−0.2979)	2.3836 *** (−0.7513)	−0.1017 (−0.3257)
ln aufdi	0.5609 (−0.3536)	1.8612 *** (−0.6300)	0.5336 (−0.3410)	0.4753 ** (−0.2256)	1.9324 *** (−0.5802)	0.4748 * (−0.2480)
ln gdp_per capital	3.3484 ** (−1.6802)	−0.1804 (−2.5371)	3.0722 * (−1.6102)	1.8429 * (−1.0303)	1.6681 (−2.2905)	2.0357 * (−1.1368)

Note: *** denotes significance at the 0.01 level, ** at the 0.05 level, and * at the 0.10 level.

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