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Assessment on the Decoupling Between Industrial Development and Energy Consumption in Beijing-Tianjin-Hebei Region

Dan Wu
School of Economics and Management
North China University of Technology
Beijing, China 100144

Siqi Cao
School of Economics and Management
North China University of Technology
Beijing, China 100144

***Abstract*—Based on the decoupling indicators of economic driving force, pressure of energy consumption and energy consumption efficiency, this paper constructs a system for evaluating the decoupling between industrial development and energy consumption in Beijing-Tianjin-Hebei region, and analyzes the decoupling situation of industrial development and energy consumption in Beijing-Tianjin-Hebei region from 1997 to 2016 by using elastic analysis method. Results show that: due to the superimposed effect of three regions, there is a change trend of "expansive negative decoupling – strong decoupling – weak decoupling" between the development of the primary industry and its energy consumption in Beijing-Tianjin-Hebei region; there is a change trend of "weak decoupling – expansive negative decoupling – weak decoupling – strong decoupling" between the development of the secondary industry and its energy consumption in Beijing-Tianjin-Hebei region; there is a change trend of "increasing connecting – weak decoupling" between the development of the tertiary industry and its energy consumption in Beijing-Tianjin-Hebei region.**

Keywords—Beijing-Tianjin-Hebei; industry; energy; decoupling; evaluation; model

I. INTRODUCTION

Eco-environmental protection and industrial upgrading and transfer are the key areas of coordinated development of Beijing-Tianjin-Hebei region. With the rapid advancement of integration of Beijing-Tianjin-Hebei region, energy consumption and environmental problems brought by it have aroused great concern. In the 1990s, decoupling theory was widely applied in foreign studies on the relationship between economy and resource environment, focusing on exploring economic growth and consumption of energy and resources [1]. As decoupling theory has been gradually perfected and matured, domestic research on it mainly includes two aspects: the first is a decoupling of resource consumption, such as the decoupling of economic industry and industry development from consumption of agricultural land, water recourse, coal, and energy [6], [7], [8], [9]. The second is a decoupling of environmental pollution, such as the decoupling of economic industry and industry development from carbon emissions of animal husbandry and construction industry, sewage discharge, and environment [10], [11], [12], [13], [14]. Fundamentally, economic development and energy consumption are affected by industrial structure. A reasonable industrial structure can effectively promote economic development and cut down energy consumption. At present, scholars rarely study the decoupling problem of economic development from energy consumption in Beijing-Tianjin-Hebei region from the perspective of industrial structure. In view of this, it is necessary to apply the decoupling theory to the industrial development and energy consumption in Beijing-Tianjin-Hebei region, and make an overall and systemic discussion on the situation of decoupling between industrial development and energy consumption in Beijing-Tianjin-Hebei region based on different periods of economic and social development in Beijing-Tianjin-Hebei region.

II. ASSESSMENT ON THE DECOUPLING BETWEEN INDUSTRIAL DEVELOPMENT AND INDUSTRIAL ENERGY CONSUMPTION IN BEIJING-TIANJIN-HEBEI REGION

The decoupling between industrial development and energy consumption in Beijing-Tianjin-Hebei region mainly refers to the gradual reduction of dependence on energy consumption in the course of industrial development in Beijing-Tianjin-Hebei region and an unrelated situation between the two in the end. Specifically, the industrial growth in Beijing-Tianjin-Hebei region is accompanied by "zero growth" or "negative growth" in energy consumption. By referring to the OECD decoupling index system and combining with views of Vehmas, Tapio and other scholars, the index of economic driving force, energy consumption pressure and energy consumption efficiency is introduced to construct an assessment system for decoupling state (see "Table I").

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TABLE I. AN ASSESSMENT SYSTEM FOR THE DECOUPLING BETWEEN INDUSTRIAL DEVELOPMENT AND ENERGY CONSUMPTION IN BEIJING-TIANJIN-HEBEI REGION

Decoupling Types	Economic Driving Force	State of Pressure	Efficiency of Energy Utilization	Decoupling Elastic Coefficients	Decoupling Evaluation
Decoupling	Growth	Decrease	Improvement	<0	Strong decoupling
	Growth	Increase	Improvement	（0,0.8）	Weak decoupling
	Recession	Decrease	Improvement	>1.2	Recessionary decoupling
Negative decoupling	Recession	Increase	Reduction	>0	Strong negative decoupling
	Recession	Decrease	Reduction	（0,0.8）	Weak negative decoupling
	Growth	Increase	Reduction	>1.2	Expansive negative decoupling
Connecting	Growth	Increase	——	（0.8,1.2）	Increasing connecting
	Recession	Decrease	——	（0.8,1.2）	Declining connecting

A. Assessment on the Decoupling Between the Development of Primary Industry and Its Energy Consumption in Beijing-Tianjin-Hebei Region

Different decoupling states represent different combinations of industrial development and energy consumption growth. Based on the development of the primary industry and energy consumption in Beijing, Tianjin and Hebei, it can be seen that Beijing has experienced a change trend of "strong decoupling – expansive negative decoupling – recessionary decoupling – weak negative decoupling". Finally, it presents an undesirable state that both increment of GDP and energy consumption is negative, and the decline rate of energy consumption is lower than that of GDP, and energy utilization efficiency decreases. Tianjin has experienced a change trend of "strong decoupling – weak decoupling – expansive negative decoupling". Ultimately, it also shows an undesirable state that both increment of GDP and energy consumption is positive, but the growth rate of energy consumption far exceeds that of GDP, and energy utilization efficiency decreases. Hebei has experienced a change trend of "expansive negative decoupling – strong decoupling – weak decoupling". In the end, it shows a more ideal state that both increment of GDP and energy consumption is positive, and energy consumption is growing at a slower rate than GDP, but the efficiency of energy utilization is improved. Due to the superimposed effect of three regions, there is a change trend of "expansive negative decoupling – strong decoupling – weak decoupling" between the development of the primary industry and its energy consumption (see "Table II") in Beijing-Tianjin-Hebei region.

TABLE II. ASSESSMENT ON THE DECOUPLING BETWEEN THE DEVELOPMENT OF THE PRIMARY INDUSTRY AND ITS ENERGY CONSUMPTION IN BEIJING-TIANJIN-HEBEI REGION FROM 1997 TO 2016

The Primary Industry	Year	Average Annual Growth Rate of Industrial Value	Average Annual Growth Rate of Industrial Energy Consumption	Variable Indexes of Energy Consumption Per Unit of Output Value	Decoupling Elastic Coefficients	Decoupling Evaluation
Beijing	1997-2000	2.47%	-1.382%	0.858	-0.5273	Strong decoupling
	2001-2005	0.61%	-4.011%	0.791	-6.0400	Strong decoupling
	2006-2010	1.46%	2.895%	1.073	2.0424	Expansive negative decoupling
	2011-2015	-0.89%	-2.997%	0.898	3.2354	Recessionary decoupling
	2016	-8.68%	-4.965%	1.041	0.5722	Weak negative decoupling
Tianjin	1997-2000	4.51%	-4.767%	0.689	-0.9196	Strong decoupling
	2001-2005	5.58%	1.540%	0.823	0.2548	Weak decoupling
	2006-2010	2.90%	4.485%	1.080	1.5982	Expansive negative decoupling
	2011-2015	3.19%	6.084%	1.148	2.0225	Expansive negative decoupling
	2016	3.00%	4.407%	1.014	1.4691	Expansive negative decoupling
Hebei	1997-2000	5.25%	32.088%	2.481	9.0037	Expansive negative decoupling
	2001-2005	5.94%	9.510%	1.180	1.7183	Expansive negative decoupling
	2006-2010	4.14%	4.773%	1.031	1.1683	Expansive negative decoupling
	2011-2015	3.56%	-1.341%	0.785	-0.3416	Strong decoupling
	2016	3.50%	0.935%	0.975	0.2670	Weak decoupling
Beijing-Tianjin-Hebei	1997-2000	4.95%	14.576%	1.420	3.3923	Expansive negative decoupling
	2001-2005	5.52%	6.368%	1.041	1.1730	Expansive negative decoupling
	2006-2010	3.88%	4.522%	1.031	1.1810	Expansive negative decoupling
	2011-2015	3.30%	-0.749%	0.819	-0.2094	Strong decoupling
	2016	2.90%	0.773%	0.979	0.2664	Weak decoupling

B. Assessment on the Decoupling Between the Development of the Secondary Industry and Its Energy Consumption in Beijing-Tianjin-Hebei Region

Different decoupling states indicate different growth trends of industrial development and energy consumption. According to the development of the secondary industry and energy consumption, there are different decoupling states in Beijing, Tianjin and Hebei. Except for weak decoupling from 2006 to 2010, Beijing has achieved a strong decoupling in other stages. Generally speaking, the development of the secondary industry in Beijing has basically got rid of its dependence on energy consumption. Apart from the strong decoupling in 1997-2000 and 2016, Tianjin has been in a weak decoupling state from 2001 to 2015. Hebei has experienced a trend of "weak decoupling – expansive negative decoupling – weak decoupling – strong decoupling". Due to the superimposed effect of three regions, there is a change trend of "weak decoupling – expansive negative decoupling – weak decoupling – strong decoupling" between the development of the secondary industry and its energy consumption (see "Table III") in Beijing-Tianjin-Hebei region.

TABLE III. ASSESSMENT ON THE DECOUPLING BETWEEN THE DEVELOPMENT OF THE SECONDARY INDUSTRY AND ITS ENERGY CONSUMPTION IN BEIJING-TIANJIN-HEBEI REGION FROM 1997 TO 2016

The Secondary Industry	Year	Average Annual Growth Rate of Industrial Value	Average Annual Growth Rate of Industrial Energy Consumption	Variable Index of Energy Consumption Per Unit of Output Value	Decoupling Elastic Coefficient	Decoupling Evaluation
Beijing	1997-2000	10.31%	-0.531%	0.661	-0.0439	Strong decoupling
	2001-2005	11.37%	-0.509%	0.569	-0.0353	Strong decoupling
	2006-2010	9.23%	0.003%	0.643	0.0003	Weak decoupling
	2011-2015	6.34%	-4.250%	0.592	-0.5429	Strong decoupling
	2016	6.33%	-1.677%	0.925	-0.2651	Strong decoupling
Tianjin	1997-2000	10.56%	-2.473%	0.605	-0.1929	Strong decoupling
	2001-2005	16.55%	8.741%	0.707	0.4523	Weak decoupling
	2006-2010	17.95%	12.118%	0.776	0.6014	Weak decoupling
	2011-2015	13.03%	6.231%	0.733	0.4174	Weak decoupling
	2016	8.40%	-2.776%	0.897	-0.3305	Strong decoupling
Hebei	1997-2000	11.93%	8.202%	0.873	0.6505	Weak decoupling
	2001-2005	12.66%	18.689%	1.298	1.6628	Expansive negative decoupling
	2006-2010	12.72%	4.966%	0.700	0.3343	Weak decoupling
	2011-2015	8.72%	2.012%	0.727	0.2016	Weak decoupling
	2016	4.90%	-0.689%	0.947	-0.1407	Strong decoupling
Beijing-Tianjin-Hebei	1997-2000	11.27%	4.146%	0.767	0.3310	Weak decoupling
	2001-2005	13.19%	13.972%	1.035	1.0755	Expansive negative decoupling
	2006-2010	13.34%	5.391%	0.695	0.3451	Weak decoupling
	2011-2015	9.61%	2.244%	0.706	0.2015	Weak decoupling
	2016	6.26%	-1.148%	0.930	-0.1834	Strong decoupling

C. Assessment on the Decoupling Between the Development of the Tertiary Industry and Its Energy Consumption in Beijing-Tianjin-Hebei Region

Different decoupling states reflect different growth combinations of industrial development and energy consumption. According to the development and energy consumption of the tertiary industry in Beijing, Tianjin and Hebei, it can be seen that three regions have been in a weak decoupling state since 2006, indicating that the development of the tertiary industry has not yet got rid of its dependence on energy consumption. With the development of the tertiary industry, energy consumption has been changing synchronously. However, the growth rate of energy consumption is always lower than that of the output value of the tertiary industry, and the efficiency of energy utilization is improved. This is an ideal state between economic development and energy consumption. Due to the superimposed effect of three regions, there is a change trend of "increasing connecting – weak decoupling" between the development of the tertiary industry and its energy consumption in Beijing-Tianjin-Hebei region (see "Table IV").

TABLE IV. ASSESSMENT ON THE DECOUPLING BETWEEN THE DEVELOPMENT OF THE TERTIARY INDUSTRY AND ITS ENERGY CONSUMPTION IN BEIJING-TIANJIN-HEBEI REGION FROM 1997 TO 2016

The Tertiary Industry	Year	Average Annual Growth Rate of Industrial Value	Average Annual Growth Rate of Industrial Energy Consumption	Variable Index of Energy Consumption Per Unit of Output Value	Decoupling Elastic Coefficient	Decoupling Evaluation
Beijing	1997-2000	11.84%	11.549%	0.990	0.9710	Increasing connecting
	2001-2005	13.03%	10.388%	0.888	0.7564	Weak decoupling
	2006-2010	12.25%	8.421%	0.841	0.6373	Weak decoupling
	2011-2015	8.10%	4.530%	0.845	0.5207	Weak decoupling
	2016	7.03%	3.073%	0.963	0.4375	Weak decoupling
Tianjin	1997-2000	11.44%	19.516%	1.323	1.9193	Expansive negative decoupling
	2001-2005	11.82%	-1.619%	0.527	-0.1047	Strong decoupling
	2006-2010	14.68%	8.537%	0.759	0.5148	Weak decoupling
	2011-2015	12.14%	7.018%	0.791	0.5219	Weak decoupling
	2016	10.00%	5.758%	0.961	0.5758	Weak decoupling
Hebei	1997-2000	10.62%	3.689%	0.772	0.3135	Weak decoupling
	2001-2005	11.40%	11.691%	1.013	1.0311	Increasing connecting
	2006-2010	12.83%	8.435%	0.820	0.6022	Weak decoupling
	2011-2015	9.67%	7.129%	0.889	0.5868	Weak decoupling
	2016	9.90%	10.795%	1.008	0.0990	Weak decoupling
Beijing-Tianjin-Hebei	1997-2000	11.25%	10.325%	0.967	0.9051	Increasing connecting
	2001-2005	12.15%	8.271%	0.839	0.6302	Weak decoupling
	2006-2010	12.92%	8.444%	0.817	0.5981	Weak decoupling
	2011-2015	9.53%	5.906%	0.845	0.5764	Weak decoupling
	2016	8.82%	6.514%	0.979	0.7389	Weak decoupling

III. CONCLUSION

The development of the primary industry has not yet "decoupled" from energy consumption in Beijing-Tianjin-Hebei region. There is a change trend of "expansive negative decoupling – strong decoupling – weak decoupling" between the development of the primary industry and its energy consumption in Beijing-Tianjin-Hebei region.

The development of the secondary industry has not yet "decoupled" from energy consumption in Beijing-Tianjin-Hebei region. There is a change trend of "weak decoupling – expansive negative decoupling – weak decoupling – strong decoupling" between the development of the secondary industry and its energy consumption in Beijing-Tianjin-Hebei region.

The development of the tertiary industry has not yet "decoupled" from energy consumption in Beijing-Tianjin-Hebei region. There is a change trend of "increasing connecting – weak decoupling" between the development of the tertiary industry and its energy consumption in Beijing-Tianjin-Hebei region.

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