International Conference on Applied Energy 2019
Aug 12-15, 2019, Västerås, Sweden
Paper ID: 0037

IMPACT OF BEIJING CARBON EMISSIONS TRADING MECHANISM ON INDUSTRIAL COMPETITIVENESS

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ABSTRACT

Competitiveness change after the establishment of carbon emissions trading mechanism is explored on the basis of Beijing industry energy consumption and carbon emissions price data. It is demonstrated that additional costs incurred by carbon trading mechanism have less effect on the industrial competitiveness. Scenario analysis is also conducted to discuss changes under different price.

Keywords: carbon emissions trading mechanism, carbon emissions price, carbon emissions cost, industrial competitiveness

NONMENCLATURE

Abbreviations	
APEN	Applied Energy
Symbols	
n	Year

1. INTRODUCTION

Beijing started carbon emissions trading mechanism at the end of 2013, carbon market rules and regulations have become more and more perfect and carbon trading volume has been continuously increased over the past five years. Carbon trading mechanism is playing an important role in promoting enterprises to reduce carbon emissions consciously. In the light of energy saving and coping strategy to climate change in the Beijing "Thirteenth Five-Year Plan", Beijing plans to control energy consumption, quantity and intensity of carbon dioxide emissions, and per unit GDP of carbon dioxide emissions falls 20.5% on the base of 2015 by 2020. In order to achieve these binding targets, it is vital to magnify the key role of carbon emissions trading mechanism in energy saving and emissions reduction.

Although carbon emissions trading mechanism is an important market instrument to effectively mitigate climate change and control greenhouse gas emissions, many scholars hold that carbon market has a great impact on economic development, especially in energy related industries, for instance, electricity power industry. Cong R and Wei Y [1] found that China carbon emissions trading system(CETS) push up carbon emissions price by 12%, fluctuation in carbon market increases volatility of electricity market by 4%. In European carbon emissions trading system(EU ETS), Kirat D and Ahamada I [2] raised that EU ETS contributed much to French electricity distribution price. There was a long-term cointegration relationship between carbon emissions price of EU ETS, electricity price and energy price, the relation between carbon emissions price and electricity price was really weak(Freitas and Silva [3]).

After aviation industry was incorporated into EU ETS, it had little impact on the output of air transport. When carbon emissions price was changing, the research results of airlines were still stable(Anger A [4]). Impact of EU ETS on American airlines was also small, throughput of air operations will continue to grow(Malina R et al. [5]). Meleo L, Nava C, Pozzi C [6] showed that EU ETS increased limited direct cost for Italian airlines. Cui Q, Wei Y, Li Y [7] documented that although airlines had a longer buffer period, they could adapt themselves to requirements of the EU ETS in the long run.

Some literatures focus on the impact of carbon market on the social and economic development(Rogge K, Schneider M, Hoffmann V [8]; Cheng B et al. [9]; Dirix

Selection and peer-review under responsibility of the scientific committee of the 11th Int. Conf. on Applied Energy (ICAE2019).

J, Peeters W, Sterckx S [10]; Liu Y, Guo J, Fan Y [11]; Choi Y, Liu Y, Lee H [12]).

Lots of articles have studied the impact of carbon emissions trading mechanism and obtained rich results which provides an important reference for this paper. However, it can be found from the above papers that topics about the impact of carbon emissions trading mechanism on industrial competitiveness is very rare. The improvement of industrial competitiveness is particularly important in the process of implementing new capital strategy, transforming and upgrading industrial structure in Beijing.

Observed that industry was firstly involved in carbon market at the beginning, this study try to analyze impact of Beijing carbon emissions trading mechanism on industrial competitiveness. The paper is organized as follows: Section 2 presents basic procedure and data sources. Section 3 details the empirical results and discusses the findings. Some implications about market design are addressed in the end.

2. METHODOLOGY

2.1 Industrial competitiveness assessment method

In order to empirically explore how Beijing carbon emissions trading mechanism impacts industrial competitiveness, we choose the competitiveness evaluation model approach. Unlike previous researches, we limit our study to the increase of additional cost caused by carbon emissions trading mechanism, analyze the impact of carbon emissions trading mechanism on industry from the perspective of cost. Its main idea is to calculate carbon emissions cost during production process and find out whether or not industry is affected according to the proportion of the additional cost in added value. This cost is obtained by multiplying carbon emissions of energy by carbon emissions trading price to obtain this cost. Obviously, the impact on industrial competitiveness becomes more significant when the carbon emissions cost of per unit added value increases.

In this paper, carbon emissions cost is decomposed into two parts: direct carbon emissions cost and indirect cost. Direct cost is incurred by the direct carbon dioxide emissions due to consumption of basic fossil energy, while indirect cost is from heat and electricity power consumption in industry.

On the basis of above analysis, the ratio of carbon emissions cost to industrial added value is defined as:

$$RV = \frac{(DCO_2 + IDCO_2) \times BEA}{IAV} \tag{1}$$

where DCO_2 and $IDCO_2$ is direct and indirect carbon emissions, *BEA* refers to trading price in Beijing carbon market, *IAV* is industrial added value, then $DCO_2 \times BEA$ and $IDCO_2 \times BEA$ represents direct and indirect carbon emissions cost in industry, *RDV* and *RIDV* is the ratio of direct and indirect carbon emissions cost to industrial added value.

2.2 Data sources

All the Industrial added value data are from China Statistical Yearbook(2017), We hand collect carbon emissions price data from Beijing Environment Exchange daily trading price, eliminate the zero turnover trading day and calculate the average price. The price is 54.89 yuan/ton in 2014, 47.72 yuan/ton in 2015 and 48.66 yuan/ton in 2016.

In order to estimate industrial direct CO_2 emissions of Beijing, this paper conduct and improve the method introduced in Intergovernmental Panel Climate Change(IPCC) Guidelines for National Greenhouse Gas Inventories(2006), which is written as follows:

$$DCO_2 = E \times NCV \times CEF \times COF \times \frac{44}{12}$$

E is the total consumption of basic energy, which can be obtained from China Energy Statistical Yearbook(2012-2017). NCV is net average calorific value in the China Energy Statistical Yearbook(2017). CEF is carbon emissions coefficient presented by IPCC, and COF is carbon oxidation factor in Provincial Greenhouse Gas List Guidelines(2011) issued by National Development and Reform Commission(NDRC). 44 and 12 is the molecular weight of CO2 and C. Carbon emission coefficient of coal is not directly provided by IPCC, so we replace it with weighted average of anthracite(0.2) and bituminous coal(0.8). The reason is proportion of different types in Chinese coal production hasn’t changed for many years, 75-80% is bituminous coal. The carbon oxidation factor of coal is also calculated by this method. All the energy related parameters are summarized in Table 1.

Table 1 Energy parameters

Energy	NCV(KJ/kg,M3)	CEF(kgC/GJ)	COF
Raw coal	20908	26.36	0.93
Cleaned coal	26344	29.5	0.93
Coke	28435	29.2	0.93
Crude oil	41816	20	0.98
Gasoline	43070	18.9	0.98
Kerosene	43070	19.6	0.98
Diesel oil	42652	20.2	0.98
Fuel oil	41816	21.1	0.98
LPG	50179	17.2	0.98

Refinery gas	45998	18.2	0.98
Natural gas	38931	15.3	0.99
Coke oven gas	17353	12.1	0.93

As to the estimation of indirect carbon dioxide emissions from the consumption of heat and electricity power in industry, we use the method as follows:

$$IDCO_2 = Activity\ level \times CEF$$

which is documented in Shanghai Greenhouse Gas Emission Accounting and Reporting Guidelines(2012) issued by Shanghai DRC. The activity level is the heat and electricity power consumption of industry in Beijing, which is also from China Energy Statistical Yearbook(2012-2017). The indirect carbon dioxide emission factors of heat and electricity power are shown in Table 2.

Table 2 Carbon emission factor of heat and electricity

Category	CEF
Heat emission factor	0.11 t CO2/GJ
Electricity emission factor	7.88 t CO2/ 104kWh

According to the above formulas, the direct carbon dioxide emissions generated by the use of 12 types of energy and indirect carbon dioxide emissions from the use of heat and electricity in industry of Beijing from 2011 to 2016 are displayed in Table 3. TCO_2 refers to the total carbon dioxide emissions in Beijing industries.

Table 3 Beijing industry CO2(million ton)

Year	DCO2	IDCO2	TCO2
2011	15.38	24.56	39.94
2012	15.32	24.77	40.09
2013	10.75	23.07	33.82
2014	9.31	23.02	32.33
2015	8.94	22.18	31.12
2016	7.85	22.87	30.72

3. EMPIRICAL RESULTS

Industrial carbon emission intensity is carbon dioxide emissions of per unit industrial added value, it is a comprehensive index to assess the carbon emissions reduction policy. In order to visually reflect the effect of carbon emissions trading, this paper first presents the industrial carbon emission intensity(CI), direct and indirect carbon emission intensity(DCI, IDCI) , and depicts them in Fig.1, where $CI=CO_2/IAV$, $DCI=DCO_2/IAV$, and $IDCI = IDCO_2/IAV$.

As shown in Fig.1, the overall trend of industrial carbon intensity in Beijing decline gradually from 2011 to 2016, with a big drop in 2013, when Beijing started its carbon market at the end of that year. Carbon intensity in 2012 was 1.22 ton per ten thousand yuan, whereas it was 0.76 ton per ten thousand yuan in 2016, reduced by 37% in four years. The effect of carbon emissions trading mechanism on industrial carbon intensity is apparently. After detailing the trends, this paper finds that direct carbon intensity decrease faster than indirect one. It demonstrates that there were definite improvements in direct carbon emissions reduction.

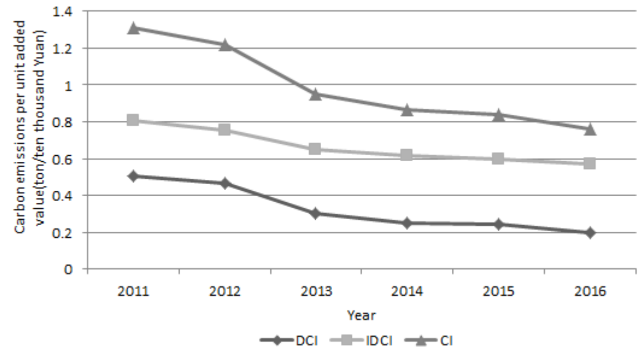

Fig.1. Industrial carbon intensity in Beijing

Therefore, the following sections conduct further quantitative analysis to find whether or not carbon emissions trading mechanism affects industrial competitiveness.

3.1 *Impact on industrial competitiveness*

Based on the carbon emissions price and direct and indirect CO_2 in Table 3, we use (1) and get the ratios of direct and indirect carbon emission cost to industrial added value. All the additional costs that carbon emissions trading mechanism recurred during 2014-2016 are shown in Table 4.

Table 4 Beijing industrial carbon emission cost(million Yuan)

Year	Direct cost	Indirect cost	Total cost
2014	510.88	1263.50	1774.38
2015	426.42	1058.29	1484.71
2016	381.96	1112.63	1494.59

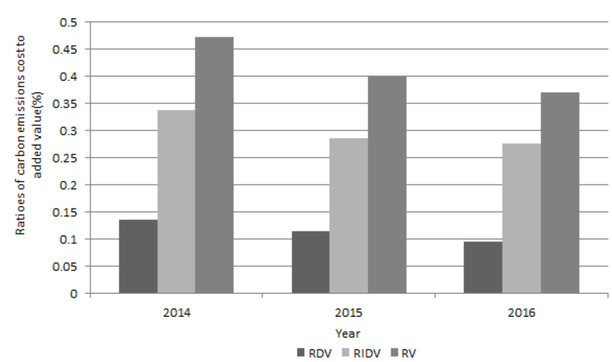

Fig.2.Impact on industrial competitiveness(2014-2016)

Fig.2 displays impact of the carbon market on industrial competitiveness. In 2014, when the carbon emissions price was 54.89 yuan/ton, ratio of additional direct and indirect cost to industry added value is 0.14%

and 0.34%. Carbon emissions price in 2015 was 47.72 yuan/ton, and the ratio was 0.11% and 0.29%, it was 0.09% and 0.28% in 2016. As a whole, the three ratios decrease year by year, which means that impact of carbon emissions trading mechanism on industrial competitiveness is getting smaller and smaller. Although Beijing industry contributes a lot in its gross domestic production(the industrial added value of GDP is 17.6%, 16.1% and 15.7% in 2014, 2015 and 2016), the additional cost caused by carbon market is only 0.48%, 0.4% and 0.37%. The impact of carbon market on industrial competitiveness is very tiny. In their research report, Germany federal environment agency take 5% as a alert level in European developed country. If the ratio is above 5%, the impact on competitiveness is significant. Under this standard, impact of Beijing carbon emissions trading mechanism on industrial competitiveness can be eliminated, even not all the energy consumptions are included in calculation. However, proportion of indirect carbon emissions cost in all the cost is very high.

3.2 Scenario analysis under different carbon price

Given the target of Paris agreement, World Bank [13] estimated that by 2020 reasonable interval of global carbon emissions price should be 40-80 dollar/ton(about 250-500 yuan/ton). On the basis of average carbon emissions and industrial added values in 2012-2016, we find that impact of carbon emissions trading on Beijing industrial competitiveness is about 2.29% at price 250 yuan/ton, and 4.58% at price 500 yuan/ton. Although the ratio is all under the alert level, 4.58% is very close to the critical value. Therefore, Beijing industry could not bear too high carbon emissions price. Moreover, each industry has its own circumstance, excessively high price may not only hurt industry but beat other industries in Beijing.

In the next step, we will unveil how impact changes concomitant to the different carbon emissions price. Considering price in 2016 is 48.66 yuan/ton, we take 50 yuan/ton as the basis, and also use average carbon emissions and industrial added values in five years to compute the ratio of carbon emission cost to industrial added value at each ten yuan increase. Results are displayed in Fig.3.

With the increasing in carbon emissions price, impact of carbon emissions trading mechanism on industrial competitiveness is also expanding gradually, showing a obvious linear upward trend. Compared with direct carbon emission cost, indirect carbon emission cost increases rapidly, accordingly, marginal indirect carbon cost is pretty high. As seen from Fig.3, slope of the first straight line is rather steep, which indicates that influence of carbon emissions trading mechanism on total carbon emission cost is more pronounced. Furthermore, every ten yuan increase in carbon emissions price will raise the impact on industrial competitiveness by 0.09. Therefore, reasonable carbon emissions price is beneficial to the economic development in the long run.

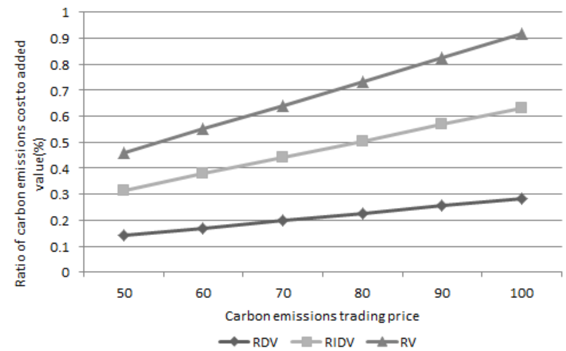

Fig.3.Ratio change under different carbon price

Against 5% alert level in European country, this paper estimates the maximum carbon emissions price in Beijing. Other things being equal, the acceptable maximum is about 546 yuan/ton under this circumstance. As long as carbon emissions price isn't higher than the maximum, impact of carbon emissions trading mechanism on industrial competitiveness is in allowable range. However, such price is obviously too high for China's carbon market in its early stage. 75% of the global carbon market price is less than 10 dollar/ton [14], this paper thus adopts 60yuan/ton to calculate carbon emission cost, and finds that the impact is only 0.55%, far below the 5% alert level. As a consequence, carbon emissions price in China should refer to the standards of vast majority countries in the world.

4. CONCLUSIONS

This paper conducts research on the impact of Beijing carbon emissions trading mechanism on industrial competitiveness. We confirm industrial carbon emission cost incurred by carbon emissions trading mechanism and explore the cost change under different carbon emissions price.

We argue that in order to improve the industrial competitiveness, carbon emissions trading mechanism need to combine with other energy-related policies to achieve the optima effects. Fossil energy in energy consumption structure of Beijing industry is still relatively high, which leads to the high direct carbon emission cost. Carbon market instruments should unite with energy regulations and industrial structure policies [15]-[16].

We also conclude that bearing capacity of different industries and regions should be taken into account when setting carbon emissions price. There are great difference in regional economic development and carbon emissions in China, therefore, carbon market should be constructed in accordance with local conditions. Data show that average price of China's pilot regional carbon markets ranges from 12.69 yuan / ton (Tianjin) to 50.81 yuan/ton (Beijing) in 2017, and the price difference is very large. From our point of view, the existence of such a difference is reasonable. A one-size-fits-all carbon emissions price will, on the contrary, weaken the competitiveness of industry. Therefore, carbon emissions trading price should not be too high in the initial stage of China carbon market.

Finally, China should adhere to the principles of common but differentiated to set carbon emissions price. On the one hand, if we adopt world bank suggested price, the impact on industrial competitiveness may be 2.29%-4.58%, which is near to alert level. On the other hand, when we adopt 5% alert level in developed country, carbon emissions price rush to excessively high. Consequently, like most countries in the world, less than 60yuan/ton is the best choice of carbon emissions trading price in China current carbon market, and the impact on industrial competitiveness is under 0.55%.

ACKNOWLEDGEMENT

This work was financially supported by the Priority Academic Program Development of Jiangsu Higher Education Institutions (PAPD), the Philosophy and Social Science Foundation of Jiangsu Province (No.16GLB013).

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