Carbon Finance Solution in the Context of China's Dual-Control Energy Consumption Policy

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Abstract. The rapid economic development of China has resulted in a rise in energy consumption. China advocated dual-energy policy control in the hopes of balancing carbon emissions and supply chain supplies. While the dual management of energy policy may have a short-term negative impact on the energy market, this article emphasizes the potential to increase productivity, innovate the technology sector, lower production costs, and address the energy shortage problem in the long run. This article provides a systematic model for conducting carbon trading. The model successfully fills the gap in current China's carbon trading market on lack of size predicting and shares distribution for making carbon trading more accessible and sustainable in China in long run.

Keywords: China · Carbon Finance · Carbon Trading · Dual-Control Energy Consumption · Sustainable Energy · Corporate Social Responsibility

1 Introduction

1.1 Overview

The environment encompasses everything that surrounds humans, including the entire society, economics, and associated activities. The current energy industry, as well as the pace of world consumption, is highly concerning, since massive population expansion leads to a tremendous rise in electrical energy demand and imposes an unprecedented challenge to our ecosystem as well as environment. China's fast economic progress since its 1978 opening-up program has resulted in an increase in energy consumption. Therefore, the generation of electric power, one of the crucial components in energy industry, results a permanent negative impact on environment through gaseous emission: 63 percent sulfur dioxide caused acid rain, 22 percent the NO2 caused smog [10, 13].

To ameliorate the conflict between energy demand and environmental crisis, China proposed dual control of energy policy with the hope of maintaining a balance of carbon emission and supply chain supplies. In this article, we'll going to evaluate the current dual control of energy policy through microeconomics, macroeconomic and international economic perspective. Moreover, two alternative options – carbon taxes and trading - will be provided as a more flexible yet effective solution in meeting the huge energy consumption demand [1].

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1.2 Environmental Impact on Economics Development

While exploiting energy can support economics development in short-term, the cost of overconsumption is significantly higher in the long-term scale. IMF, international monetary fund, provides an in-depth analysis on the effect of climate change on macroeconomic and financial stability, as well as relevant suggestions on mitigation, adaption, and transition [4]. The *IMF Staff Climate Note* provides member nations and international community a general solution on addressing critical issues related to the environment and economic development.

The statistics data in *IMF Staff Climate Note* suggests that if these reductions are not made, warming will increase, necessitating even larger cutbacks of energy usage in the 2030s [7]. Global warming of 1.2 celcius is already having a broad variety of consequences: heat waves, droughts, floods, storms, sea level rise, and variations between climatic extremes. As the world continues to warm, it is projected that the frequency and intensity of these effects will grow – hindering the economic development in long-term [9].

2 Analysis on China's Dual Control of Energy Consumption Policy

2.1 Policy Overview

The Chinese government's "dual control" policy, which tries to reduce energy intensity while reducing total energy use, is vital for the nation to meet its energy and climate goals. During 13^{th}-14^{th} five-year-plan, the National Development and Reform Commission (NDRC) provided quarterly target performance assessments for the first time on 3 June and 12 August 2021, with provinces getting progress notices. Only a few days later, provinces on "progressive alert" started enforcing power regulation and production restrictions.

The explosion of COVID-19, on the other hand, has had a strong countervailing impact, undercutting this declining trend. To recover the economic development in a rapid way, China's government prioritized the industrial production and lightening the enforcement measures on regulation. The combination of solid industrial activity has tilted China's energy intensity balance toward the heavier end of the range, propelling the market's overall power consumption 17% rise in the first half of 2021.

2.2 Benefit-Cost Analysis on Dual-Control of Energy Policy

To begin with, dual control of energy policy could reduce the energy production cost in long-term and facilitates the restructuring within the energy production industry [6]. Generation cost involves with different components, including capital expenditure (depreciation, interest on equity and debt), fuel, carbon emission and standby generation. It's essential to notice that there exists a large uncertainty in estimation of future costs due

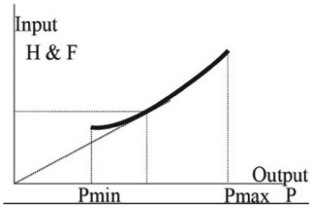

Fig. 1. Input & Production.

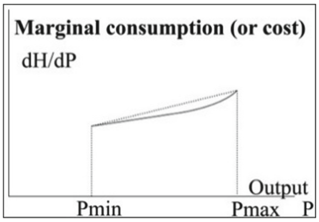

Fig. 2. Marginal Consumption.

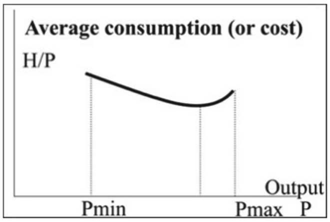

Fig. 3. Average Consumption (costs).

to the complexed factors, including minimum load requirements, start-up cost and non-linearity of production cost curves. Nevertheless, analyzing the cost function is also crucial. The notion in the energy production is as follows (Figs. 1, 2 and 3):

$$\begin{cases} H = \frac{kcal}{hour}, Consumption \\ F = \frac{T_c}{hour}, Cost \\ \frac{H}{P} = \frac{kcal}{MWh}, AverageConsumption \\ \frac{dH}{dP} = \frac{kcal}{MWh}, MariginalConsumption \end{cases}$$

In the graph, we could notice that although marginal consumption is an non-linear function, the slope is positive – meaning the any additional increase on output power will lead to an increase of production cost. Therefore, maintaining the production at an optimized point can effectively boost the production efficiency.

In addition, the dual control policy of energy may bring unprecedented technology innovation and advancement through updating the supply chain. Global renewable energy capacity increased significantly over the last two years, reaching approximately

280 gigawatts (GW) in 2020, about 45% more than in 2019, according to the International Energy Agency. Companies, which adapting renewable energy, can gain competitive edge on the market [11]. In other word, companies need to come up with innovation solutions in utilizing renewable energy, which could accelerate the technology advancement.

Nevertheless, in the meanwhile, restricting the carbon emission may hinder the industrial production by limiting the production at inefficient output level. In other word, the marginal cost is below the marginal revenue – making the revenue under the normal performance. If we examine this policy through examining long-run scale, the LRAC (long run average costs) may remain the same given that the carbon consumption quota is within a reasonable range.

In addition, the aggregated supply (AS) may decrease, causing the price level and unemployment rate goes up while making real GDP output decreases. Nevertheless, the long run self-adjustment in the AD-AS model can address the challenge here. The increase in unemployment will lead to lower wages as firms do not need to compete labor for higher salary. As a result, a decrease in the price of the production will ultimately lead an increase in SRAS. Therefore, the aggregate output will return to the normal level.

Nevertheless, the temporary shortage of supply may cause decrease in export – there is relatively less demand for China's currency, it will depreciate and loses value in short run. Also, multinational cooperation are motivated to outsource its production in other countries which without a quota on energy consumption – leading the outflow to domestic capital. The good news is, however, the international trade will remain the same in the long run. Simply because as China's currency depreciates, the price of goods became cheaper, which compensate the increase caused by the energy consumption restriction.

Therefore, the dual control of energy policy boosts the productivity, innovate the tech field, reduce the production cost, and alleviate the energy shortage issue in long-term. In the meanwhile, it also inevitable causes the increase in average fixed cost for industrial production, outflow of domestic capital, and harm China's position in international trade in short-term. Considering all the long-term benefits and short-term costs, we may draw the conclusion that dual control of energy policy certainly make a step on solving the environmental issues – but it's too radical and lack of a well-designed transition stage. Therefore, the carbon trading, a alternative solution, could be a promising strategy on reducing the short-term cost.

3 Carbon Trading

Carbon trading is the process of pricing carbon for the purpose of saving energy and reducing emissions by setting a basic allocation of carbon emissions to a region [14]. In a carbon trading market, companies and factories can trade ownership of carbon emissions to balance production. Through Allowance Trading and Credit Trading, the government allocates carbon emissions to companies and factories. According to Coase's theorem, as long as property rights are clearly defined and transaction costs are zero or small, the end result of market equilibrium is efficient, thus achieving optimal resource allocation and internalizing externalities. However, China is still at the stage of weak efficiency in carbon trading.

3.1 Current Issue of Carbon Trading in China

At present, the meso-talking trading system is still in its initial stage, and the market suffers from low participation and deficiencies in pricing, regulation, reward and punishment mechanisms [3]. Liu, L. et al. (2014) proposed that China's carbon market has the status quo of market segmentation, low participation, and imbalanced pricing mechanism, which affects the unified trading benchmark of the market. Huang et al. (2014) compared the development of the talk market in Europe and China, and pointed out that the incentive mechanism of the Chinese talk trading market is unclear and the market is seriously fragmented. Zhou Wenbo et al. (2011) [5]. Due to the uneven distribution of the market geographically and the decentralization of carbon exchanges in China, there are large differences in carbon allocation for each industrial sector. This discrepancy will make it difficult for participants to form reasonable expectations and lead to irrational investments in the market [12].

In the short term, whether it is the carbon tax levied on Shanghai enterprises since 2013 of up to 30,000 RMB or the carbon penalty levied on Beijing enterprises in 2014 of 3–5 times the market price for carbon emissions exceeding the carbon quota standard, the existence of carbon trading has achieved the market's ability to self absorb carbon emissions in the short term [8]. There is value in carbon trading to boost the market value of new energy companies and stabilize the development of other companies. But in the long term, geographically differentiated penalty mechanisms and unclear carbon allowance standards will make the carbon trading market inefficient in the long term and lead irrational investments.

This paper will develop a carbon capture scheme for an Allowance Trading-based carbon market through the TOPSIS algorithm and gradually reduce the total market value of carbon emissions by emphasizing Corporate Social Responsibility (CSR) as a prediction of the total market value of Carbon Emission. The two approaches are combined to achieve a long-term sustainable market transformation.

4 TOPSIS in Allocating Carbon Emission RiTOPSIS in Allocating Carbon Emission Rights and CSR for Market's Transition

4.1 Improved TOPSIS

Generating the initial evaluating matrix:

Assume there are N of conditions that have to be analyzed when allocating carbon emission ownership to a company or factory, each condition has M of evaluations $M = (M_1, M_2, \ldots, M_m)$. The matrix is generated below:

$$X = \{X_{ij}\}_{n\times m} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nn} \end{bmatrix}$$

Data Dimensionless:

Standardize the data at the initial conditions to eliminate the effects of differences in units and magnitudes.

Positive Indicators: $x_{ij}^{'} = \frac{x_{ij} - min(x_j)}{max(x_j) - min(x_j)}$

Negative Indicators: $x_{ij}' = \frac{max(x_j) - x_{ij}}{max(x_j) - min(x_j)}$

$min(x_j)$ is the minimum value of the jth indicator, while $min(x_j)$ is the maximum value of the jth indicator.

Generating Weighted Matrux:

Based on the combined equilibrium weights of the hierarchical analysis method combined with thecoefficient of variation method, the calculated original decision matrix E is multiplied with the weights of each indicator to obtain the weighted decision moments.

$$Y = \{Y_{ij}\}_{n \times m} = \begin{bmatrix} x_{11} * W_i{}^* \cdots x_{1m} * W_n{}^* \\ \vdots \quad \ddots \quad \vdots \\ x_{n1} * W_i{}^* \cdots x_{nm} * W_n{}^* \end{bmatrix}$$

Calculating positive and negative ideal output:

$D_i = \sum_i^n Y^- \times (Y_{ij} - Y^+)$

D_i indicates the level of idealness. D_i is smaller, then the evaluation is more positive, and vice versa.

4.2 Matching the Conditions of Carbon Emission to TOPSIS Scheme

For TOPSIS, it is sufficient to fill all the related indicators to carbon emission regardless the units. Here is an example of a TOPSIS calculation using raw materials, carbon emissions of products, company revenues and the state of the environment in the neighborhood as indicators. After filling in all the indicators TOPSIS can produce a carbon allowance weight for all companies and factories in a city/province. The weights are multiplied by the total carbon emission standards to obtain the initial carbon allowances for all plants and companies.

Example:

Benefit Type: Types of raw materials used; Carbon emissions from products; Economic benefit in carbon emission (production); Proximity ecological benefits.

For each type, several related conditions is required to evaluate. The more the conditions are, the more accurate it is.

4.3 Quantifying the Market' Value of CSR to Reasonably Forecast Carbon

Since the dual effect of carbon trading and carbon pricing can drive sustainable transitions to occur, when the scale of sustainable transitions grows, the market becomes less tolerant of non-sustainable businesses. Therefore, by estimating the ability of CSR to influence the market, the total carbon quota can be judged so that the total carbon quota can be reasonably reduced each year.

Comparing the stock prices of profit-maximizing and socially responsible companies is a way to determine if a company's value may be increased by implementing CSR [2].

Assume that in order to carry out CSR, the industry is required to invest in socially responsible events that cost C. The revenue of the industry is R. As a result, an industry's net earnings are R-C. Because the industry that does not use CSR has no C, the net earnings are R.

As follows:

$$B_{sc} = \frac{\mu F(R - C)}{\varnothing N}$$

The overall advantages of socially aware investors are represented by B_sc. Assuming that each investor buys the same number of shares, the total benefits will be equal to the entire profit divided by the total number of socially aware investors. Benefits of wealth-maximum investors are referred to as: B_{wm}

$$B_{wm} = \frac{(1 - \mu)FR}{(1 - \varnothing)N}$$

The supply and demand for these distinct sorts of stocks in the market are used to determine the stock price for socially responsible and traditional profit-maximizing corporations. The entire supply of shares of stock in socially responsible enterprises is:

$$S_{SR} = \mu Fs$$

The entire supply of shares for companies that are not socially responsible is:

$$S_{SR} = (1-)\mu Fs$$

And for the price of stock in wealth-maximizing industries is P_{wm}:

$$P_{wm} = \frac{(1 - \mu)Ne}{(1 - \varnothing)Fs}$$

By comparing the indicator of P_{wm}, the influence of CSR on market can be identified. Thus, the total Carbon Emission trend can be identified. Therefore, the market could be expected.

5 Conclusion

The dual control of energy policy can improve the field of innovative technologies, reduce production costs, increase productivity and alleviate energy shortages in the long term. However, it causes an increase in average fixed costs, an outflow of Chinese capital, and in the short-term damages China's position in international trade. Carbon trading appropriately mitigates the problem as an internal cost-absorbing scheme for carbon emissions. This paper identifies the missing carbon allowance link and unpredictable market in China's existing carbon trading. With the TOPSIS algorithm for rational carbon allowance distribution and the CSR model to handle the iteration of the carbon trading market, the ideas in this paper make it possible to move from a weakly efficient to a highly efficient carbon trading market in China.

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The IPE database gives all the data that researchers need to use. From the most basic carbon emission distribution to the action index of each province and city on Carbon Peaking and Carbon Neutrality, and even the development of carbon trading, there are detailed records. The benefits of having a large amount of data analysis in a non-profit organization are appreciated.

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