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Evaluating the economic impacts and feasibility of China's energy cap: Based on an Analytic General Equilibrium Model

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ABSTRACT

China has introduced the energy cap policy to slow down its rapid growth in energy consumption, release the increasing pressure on its energy security and control greenhouse gas emissions. Based on an Analytic General Equilibrium Model (AGEM), this study simulates the impacts of Gradually Strengthened Energy Cap (GSEC) on China's production sectors, households and price system. The results show that, firstly, GSEC can lead to "contractionary effect" and "crowding-out effect" in the fossil fuel production sector, which transfers part of labor and energy inputs from fossil fuel production sector to non-fossil-fuel production sector. Secondly, if the growth rates of total capital and labor inputs in the whole economy can be maintained above certain levels, the non-fossil-fuel production sector will keep growing under the GSEC. Thirdly, energy cap policy will not reduce residential consumption. Fourthly, the prices of labor, energy and intermediate inputs will rapidly grow along with the GSEC. Fifthly, policymakers should improve the investment- and employment-related policies to reduce the constraint of energy cap on China's economy. In conclusion, collaborated with investment and employment policies, energy cap policy will not hinder the economic development or harm the consumption in residential sector.

1. Introduction

Since 1978s economic reform, China has grown its economy from a low-income country to the second largest economy in the world in a hard and fast industrialization period. The economy is fuelled by abundant fossil fuel. However, its obsession with economic growth results in the highest carbon dioxide emission and severe environmental complication that any other country is facing (Liu and Mu, 2016). The task to decouple energy demand from economic growth then becomes a priority for the Chinese government.

Various measures have been introduced every five years in the National Plans. The 11th Five-year Plan (2006–2010) focused on improving energy efficiency – setting energy intensity target, and successfully lowered China's energy consumption per GDP (index of energy intensity) by 19.19% (NDRC and NBSC, 2011). Despite this improvement, the total absolute volume of energy consumption and carbon emission increased due to the "open end" energy consumption pattern.[1] The 12th Five-year Plan (2011–2015) then adjusted the strategy to include both intensity targets – reducing energy intensity and carbon intensity by 16% and 17%, respectively– and the appropriate energy cap target (PRC, 2011). Although the 12th Plan announced to implement the energy cap policy, China did not clarify the specific target for the energy cap, and the policymakers were still exploring and preparing for the implementation. Not until June 2014, in the Action Plan on Energy Development Strategy (APEDS) (2014–2020), for the first time, China stated the energy cap target of primary energy consumption around 4.8 billion tons standard coal equivalent (tce) and coal consumption around 4.2 billion tons[2] by 2020. The two energy cap targets were then adjusted to 5 billion tons tce for primary energy consumption and 4.1 billion tons for coal consumption in the 13th Five-Year Plan (2016–2020) since the target of the primary energy cap was a little too ambitious and the coal cap target was a bit conservative in the APEDS (2014–2020).

Energy cap policy sets a target on total primary energy consumption for a year based on analysis of economic growth, energy demand and resource capacity. This targeted volume is then allocated to provinces

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[1] "open-end" energy consumption pattern refers to the energy allocation pattern, in which policymakers do not interfere, only demand-supply relationship in the market allocates energy among market participants. China used to adopt this pattern in its energy economic system.

[2] 1ton coal = 0.7143 t standard coal equivalent.

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and cities, and puts a cap on how much weight each local government can put on pushing further growth and use of fossil fuels. It then incentivizes local governments to seek and promote energy efficiency, including getting rid of outdated machineries, encouraging investment in less energy-intensive industries and R & D into clean technology alternatives. Sustainable economic development can be more smoothly transitioned to from this current point as argued by Wang et al. (2014a) and Chen (2012).

Different versions of energy cap policies were seen in the US and EU. Since 1980s, the US has gradually implemented the Cap-and-Trade policy in the fields of reducing leaded gasoline, SO_2 and NO_X emissions, and in allocating water and fishery resources, by first controlling the total amount of pollutant emissions and resource utilization and then allocating them based on trade schemes (Colby, 2000; Schmalensee and Stavins, 2015). The US did not control its total energy consumption directly. However, both the Regional Greenhouse Gas Initiative (RGGI) which has been implemented in nine states[3] in northeastern US since 2009 (RGGI Inc, 2013) and the Climate Action Plan which has been in place in California since 2013 take the Cap-and-Trade policy (Air Resources Board, 2016), thus indirectly constrain the energy consumption in these regions. After 2006, there have been continuously debates nation-wide on whether the Cap-and-Trade policy should be applied in carbon emission reduction (McClain and Meier, 2013).

Various literatures analyzed the potential impacts of carbon Cap-and-Trade policy on renewable energy market (Bird et al., 2008), power generation market (Rocha et al., 2015), families with different levels of income (Shammin and Bullard, 2009; Kunkel and Kammen, 2011), local agriculture (Jiang and Koo, 2014), economic structure readjustment (Jorgenson et al., 2009; Goettle and Fawcett, 2009) and the macroeconomy (Paltsev et al., 2007; Goulder et al., 2010; Jorgenson et al., 2011) in the United States.

Bird et al. (2008) claims that the passing path and economic influence of the Cap-and-Trade policy follows the following rules: Because the Cap-and-Trade programmes can raise the power generation cost in fossil fuel power plants and improve the cost-effectiveness of power generation in renewable energy sector. It can further encourage more future development of renewable energy power generation and impact the total carbon dioxide emissions in the United States.

Rocha et al. (2015) shows that the CO2Cap-and-Tradeprogrammecan impact the power generation market from two perspectives, firstly on the investment strategy of power generators in the long-run, and then on the supply bidding strategy of power generators in the real-time electricity market when they consider the CO2 subsidy cost. By analyzing the expense models in different families, Shammin and Bullard (2009) claims that the Cap-and-Trade policy is regressive, as it levies proportionally higher emission reduction cost on low-income families. However, proves that the Cap-and-Trade policy is progressive, because most families can gain positive revenues even though government retains half of the income from selling the carbon emission allowances.

Jiang and Koo (2014) provides a quantitative analysis on the impacts of Cap-and-Trade policy on the production cost, production value and revenues in agriculture industry in the United States. Even though the Cap-and-Trade policy can impact the prices of energy input and energy-related input in agriculture industry, producers are able to adjust their strategy under the different policies. For example, when energy price is at relatively low level, producers can improve the production efficiency to lighten the higher cost caused by higher oil price; when energy price is at high level, they can use organics to replace the chemical fertilizer to address the cost issue caused by high natural gas price. Goettle and Fawcett (2009) analyzes the economic influences of increasingly strict Cap-and-Trade regimes in the United States by an Inter-temporal General Equilibrium Model. Their study shows that the market-based incentive mechanism introduced by the Cap-and-Trade regime has three passing paths, namely production reduction, input and production re-structuring, and inductive technical change. Furthermore, their results show that not only the energy sector, but also the agricultural, chemical engineering, high-tech manufacturing and trade industries will suffer some losses under this policy. Goulder et al. (2010) use the numeric general equilibrium model to examine the impacts of different emission allowance allocation plans on the profits in different industries, as well as on the whole economy. They claim that how the allowance is allocated – by audition or free allocation, can decide the different passing paths of the profits in different industries. For example, in the audition system, all the producers must purchase their allowance, therefore transfer the potential rents from firms to government; while in the free allocation system, as the firms can obtain the allowance by free, they can reserve the rent themselves.

From lessons and experiences in the US, EU has initiated the EU Emission Trading System (EU ETS) since 2005 to target on carbon emission reduction and realize the first stage reduction target of Kyoto Protocol (European Commission, 2013). EU ETS achieved significant reduction of greenhouse gas emission in the EU, and was considered as a cost-effective and economically efficient way to reduce greenhouse gas emissions (Laing et al., 2013; Bel and Joseph, 2015). Many studies examined the impacts of EU ETS, for example, on Germany's power industry (Hoffmann, 2007; Rogge and Hoffmann, 2010; Rogge et al., 2011), Italian electricity market (Bonenti et al., 2013), energy intensive industries in Europe (Bleischwitz et al., 2007), corporate innovation activities (Schmidt et al., 2012), bio-mass resource utilization (Kautto et al., 2012), large heat and electricity co-generation plants (Westner and Madlener, 2012), value of power companies in Europe (Mo et al., 2012) and aviation and freight transport business (Derigs and Illing, 2013).

Rogge and Hoffmann (2010) analyzes the impacts of EU ETS on the four building blocks in Germany's power generation technology innovation system, namely know-how and skills, actors and networks, institutions and generation technology demand. The study shows that EU ETS influences the changing speed and trend of generation technology through these four blocks. Based on the data from power sectors in seven countries in EU, Schmidt et al. (2012) evaluated the impacts of the EU ETS on power companies' innovation speed and trend. The result shows that, although the impacts are limited (or even controversial), the long-term emission reduction target is still a key trigger for technology innovation and research, development and demonstration (RD & D) – both demand- and technology-driven policy instruments influence the low-carbon technology substantially, and they can compensate the limitation of the ETS policies.

Bonenti et al. (2013) examines the impacts of EU ETS on investment, price and profit in Italy's electricity market, and shows that the investment of power generators is higher in perfectly competitive market than in oligopoly market, yet the investment focuses on the fossil-fuel-fired power plants in two market configurations. Kautto et al. (2012) analyzes the interaction among EU ETS and other climate policy instruments in EU countries, and evaluates the influence of these policies on the biomass energy. The results show that, these climate policies have comprehensive impacts, including strengthening the competitiveness of obtaining the biomass resources, changing the fossil fuel energy structure and pushing the wood price to increase. Targeting at the change of EU ETS rules at the third stage, Westner and Madlener (2012) studies its economic impacts on the large-scale co-generation power plants in Germany. The modified emission allowance allocation mechanism has significantly decreased the expected net present value of the technologies as well as the attraction to investors of these co-generation plants. Mo et al. (2012) calculates the impacts of the change

[3] The nine States are Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont.