The Timing of China's Carbon Peaking under an Uncertain Future

By Hongbo Duan, Jianlei Mo, Ying Fan and Shouyang Wang

INTRODUCTION

According to the Sino-US joint statement on climate change in 2014, China is committed to peaking its carbon emissions in 2030, at which time the share of non-fossil energy in China will account for over 20%; China's Intended Nationally Determined Contributions (INDC) plan, which was submitted to the United Nations in 2015, reaffirms this commitment. Although plenty of work has been done to prove the rationality and feasibility of these targets for economic development, energy consumption as well as for energy restructuring, there remain different opinions on the commitments at home and abroad. Some argue that these targets are pretty ambitious, and that China has to deal with very daunting challenges, while the others believe that the goals committed to may not be so difficult to reach, costing less than expected. It is likely that the multiple uncertainties embedded in the process of carbon mitigation are largely responsible for this divergence. There remain around 15 years for China to deliver on its commitments, during which time a great many uncertainties involving economic growth, energy efficiency enhancement and low-carbon transition, etc., will comingle and significantly affect the feasibility, policy options and costs of fulfilling the goals; these uncertainties mainly manifest themselves as uncertainties regarding labor productivity, substitutions among different production factors, energy efficiency improvement, and learning about the effect of renewables, all of which complicate judgments about future carbon emission trajectories and energy transition trends.

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On this basis, it is of great importance to investigate China's energy restructuring and economy decarbonizing issues under multiple uncertainties. Specifically, we try to answer these questions: How challenging will it be for China to reach the carbon-peaking target it has committed to? What is the likelihood that China will reach its targets under different policy scenarios? What will be the corresponding peak values? To have a high probability of reaching the targets, what policy measures should be taken? What is the relationship between the carbon-peaking target and the energy-restructuring target, and how will the influences of carbon tax and subsidy policy on achieving these two targets differ?

MODELLING APPROACH

The proposed stochastic 3E-integrated model in this work is essentially based on the prior 3E system model, CE3METL, a Chinese version of the E3METL model. Characterized by its core technology diffusion mechanism, i.e., multi-logistic curves instead of conventional constant elasticity substitution (CES) method, the E3METL model consists of macro economy, energy technology and climate sub-modules, which is consistent with the typical frameworks of 3E-integrated models. The E3METL and CE3METL models have been employed to conduct climate-relevant research since they were built in 2013. By incorporating multiple uncertainties and employing Monte-Carlo simulation methods, we have extended the framework of the CE3METL model and developed a stochastic 3E-integrated model.

MAIN RESULTS

Based on the current policy and the outlook for future policy development, three sets of policy scenarios have been formulated: the single carbon pricing policy, the single subsidy policy for renewable energy, and the policy combination of carbon pricing and renewable energy subsidies. For each of these three policy scenarios, we set different levels of the carbon price and subsidy. Specifically, the subsidy rate levels are set as 0, 20% and 40%, respectively, and the carbon price levels are set ad valorem as 0, 200 USD/tC, 400 $/tC, 600 USD/tC, and 800 USD/tC, respectively, based on which we can obtain 15 policy scenarios.

With carbon mitigation efforts made by the Chinese government in the baseline scenario, the probability for carbon emissions to peak before 2030 is very low, only about 11.5%, and it does not reach 50% until 2040. This means that it is almost impossible for China to realize its carbon peaking target in 2030 without making further efforts. With the carbon tax and subsidy increasing, the distribution of the

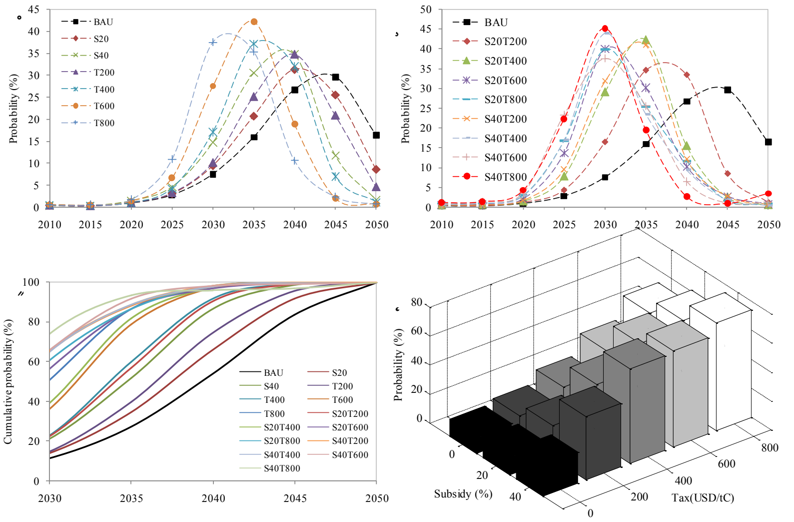

Figure 1. Probability and cumulative probability distribution of optimal time for CO_2 emissions to peak. a and b show the results under single policy scenarios and the policy mix scenarios; c and d denote the cumulative probability distribution of CO_2 emission peaking time and the probability of CO_2 emissions peaking before 2030, respectively.

time for carbon emissions to peak moves to the left, and the peaking time becomes earlier. Specifically, with a subsidy of 40% being introduced, carbon emissions mainly peak between 2035 and 2040, and the probabilities are 30.5% and 34.8%, respectively. While with a carbon tax of 800 USD/tC being introduced, the carbon emissions mainly peak between 2030 and 2035, and the probabilities are 37.6% and 35.4%, respectively (Figure 1). It followed that the carbon tax policy has a more significant effect on carbon emissions than does the subsidy policy; on the other hand, these results show that the single carbon tax and subsidy policy cannot guarantee with a high probability that carbon emissions will peak, and that a policy mix is needed. For the policy mix scenarios, several curves overlap with each other, and the curves become thinner and the time to peak becomes more concentrated; when further increasing the carbon tax and subsidy, the curves however do not move to the left significantly, which implies that the marginal effect of policy would diminish. Under the most stringent policy mix scenario (S40T800), carbon emissions would peak before 2030 with a cumulative probability of 73.9%. Thus, carbon emission management and policy-making should be implemented from the perspective of risk management, and policy makers can take corresponding policy measures based on the degree of confidence required; if they hope to realize the target with a higher degree of confidence or a higher probability, increased efforts should be made.

It is almost impossible for China to realize the non-fossil energy deployment target in 2030 under the current policy environment; and the contribution of the single subsidy policy to achieving the 20% non-fossil energy target is also quite limited (Figure 2). As for the single carbon tax policy, only when the carbon tax is high enough does the effect start to emerge and become remarkable, for example, as the carbon tax level increases from 200 to 800 USD/tC, the probabilities will expand from 1.42% to 82.2%, respectively. It should be noted that the policy mix has a more significant effect on energy transformation and decarbonization. To be specific, with the subsidy of 40% and the carbon tax of 200 USD/tC being implemented, the probability reaches 48.29%, when doubling the policy efforts, the corresponding probability will approach 100% (Figure 2). Therefore, one single subsidy policy is insufficient to ensure achievement of the 20% non-fossil energy target, and a policy mix is necessary. In addition, the synergistic effect of carbon tax on non-fossil energy development is also significant and should not be neglected; especially when a high carbon tax is implemented, the non-fossil energy target can be realized as a side effect of the carbon tax.

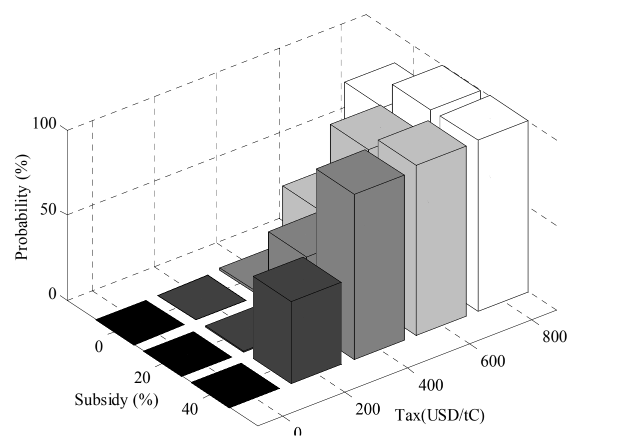

Figure 2. Probability to realize the 20% non-fossil energy target in 2030.

CONCLUDING REMARKS

Without taking any further policy measures, it is almost impossible for China to peak its carbon emissions in 2030, and the probability of carbon emissions peaking does not reach 50% until 2040. The effect of the single subsidy policy for renewables on carbon emissions is rather limited, and the probability of carbon emissions peaking before 2030 is only 21.3% in the presence of a 40% subsidy. While the carbon tax policy has more remarkable effect on carbon emissions, and the probability of peaking reaches 51.1% with a carbon tax of 800 USD/tC being implemented. The policy mix of carbon tax and renewable energy subsidy has a more significant effect on carbon emissions, and with a carbon tax of 800 USD/tC and a subsidy of 40% being introduced simultaneously, the target-realizing probability before 2030 reaches up to 73.9%.

Also, the simulation results reveal that carbon tax policy and renewable subsidies have a more significant effect on the energy mix change than on carbon emission evolution. Specifically, with a carbon tax of 800 USD/tC being introduced, the probability of realizing the non-fossil energy target is 82.5%, which is much higher than the probability of realizing the target of carbon emission peaking, i.e., 51.1%. Additionally, with a policy mix of 800 USD/tC and a 40% subsidy being implemented, the probability of realizing the non-fossil energy target would approach 100%, 26.1% higher than the probability for carbon emissions to peak. It can be inferred that it is easier to realize the non-fossil energy target, and some additional efforts and measures are needed to peak China's carbon emissions.

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