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The prospects of China's long-term economic development and CO_2 emissions under fossil fuel supply constraints

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ABSTRACT

This paper presents an energy-environment-economy model that described technology-specific information and integrated resource depletion to simulate China's long-term CO_2 emissions and economic development under fossil fuel supply constraints towards 2050. The modeling approach and findings not only support the theoretical of relationship between physical resources depletion and economic growth to some extent, but also provide practical significance for policy making that can be shared with other developing countries. The results indicate that energy supply constraints will play a crucial role in China's future economic development, causing a 7.9% decrease in GDP compared to the 2050 baseline and a peak of CO_2 emissions at 11.2 Gt around 2034 under a resource constraint scenario, which can be considered as a new baseline considering fossil fuel depletion. Moreover, under a low carbon scenario considering low carbon measures, economic growth is less dependent on fossil fuel consumption, and CO_2 emissions will peak earlier in 2030, and the negative impact on GDP from finite fossil fuel supply can be alleviated by 5.5% by 2050. The low carbon scenario is a good way to achieve both CO_2 mitigation and low-carbon growth, which may lead to a complete restructuring of the China's energy-economic system. To achieve the economic restructure towards low carbon economy, Chinese government should take into account the crucial role of fossil fuels supply constraints, set reasonable and moderate future GDP growth targets, and strictly implement the low carbon measures including accelerating technical progress, non-fossil fuel development, energy structure improvement and the upgrading of industrial structure and household consumption patterns.

1. Introduction

China's rapid economic growth has been driven by the massive consumption of high-carbon (fossil fuel) energy for a long time and has caused large CO_2 emissions. In 2013, the country created 12.3% of the world's total GDP, consumed approximately 22.4% of the world's primary energy and contributed 27.1% of the world's carbon emissions (NBSC, 2014; BP, 2014). Now, China is the world's largest CO_2 emitter and its current emission-intensive growth poses a serious threat to the success of global mitigation efforts (Steckel et al., 2011). Although the Chinese government proposes to reduce its 2005 carbon intensity level by 40–45% by 2020 (NDRC, 2014), the pressure for post-2020 action on climate change is increasing. In 2014, China and the United States unveiled a negotiated deal to reduce their greenhouse gas emissions. China promised a peak in CO_2 emissions by around 2030 and to make best efforts to peak earlier, intending to increase its share of non-fossil fuels in primary energy consumption to around 20%—by 2030 (China-US Joint Announcement on Climate Change, 2014). However, this will not be easy to achieve because, as a developing country in the process of industrialization and urbanization, China still needs to produce energy to support the development of its economy and raise living standards. Therefore, the question of the prospects of China's long-term economic growth and CO_2 emissions attract broad attention.

To examine the prospects of China's long-term economic growth and CO_2 emissions, there are two kind of important factors which

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should be taken into account. One is the measures of energy saving and carbon emission reduction proposed by China's government towards a low carbon economy, which will cause a decrease in carbon emissions and affect economic growth. The other one is fossil fuel supply constraint. Domestic fossil fuel supply has become more and more stressful. According to the energy production levels and estimated reserves in 2010, the mining of coal, oil and natural gas in China will be possible for only a further 50, 15 and 40 years respectively (Ministry of Land and Resources of China, 2011). Many studies also showed that the supply of coal, oil and natural gas for China will peak before 2050 (Imam et al., 2004; Lin and Liu, 2010). Besides, international fossil fuel supply seems not to increase significantly, because issues such as geopolitics and other factors can affect international imports available to China. The increasing pressure of fossil fuel supply constraints will play an important role in the future energy supply system, which will further affect China's future economic growth and CO_2 emissions. Therefore, if it is not considered, China's future economic growth potential and CO_2 emissions may be overestimated, and potential measures for promoting the transition to a low carbon economy might not be accurately evaluated.

In this paper, the prospects of long-term economic growth and CO_2 emissions considering fossil fuel supply constraints will be examined based on a Chinese energy-environment-economy CGE model and a few questions will be made clear: (1) what are the projections of economic growth and CO_2 emissions in China towards 2050 under the fossil fuel supply constraints? (2) If low carbon measures are further considered, how will these projections change? (3) Can China achieve the target of achieving the peak of CO_2 in 2030 as well as low-carbon growth? (4) what policy suggestions and predictions can be obtained for China's government towards low carbon economy?

2. Literature review

Previous studies relating to China's medium or long-term CO_2 emission and energy consumption trends focus on the analysis under different social and economic assumptions and scenarios mainly using bottom-up energy technology models (UNDP, 2010; IEA, 2010; Rout et al., 2011; Zhou et al., 2013), top-down economic models (Wang et al., 2009; Shi et al., 2014) and integrated bottom-up and top-down models (Jiang et al., 2009; Dai et al., 2011). Most researchers consider that China's demand for energy and carbon emissions will still continue to increase as the scale of non-fossil energy use expands, after which carbon emissions will eventually begin to decrease even if energy demand continues growing (Liang et al., 2004; Wang et al., 2010; Li, 2010). Polices options on reducing CO_2 emissions and energy saving and in China have been discussed a lot in the previous literature. The development of renewable energy, deployment of innovative energy technologies and mitigation technologies induced by climate policies are analyzed by some scholars and are regarded as key determinants for reducing China's CO_2 emissions efficiently (Zhou et al., 2012; Duan et al., 2013; Zhang et al., 2014; Wen et al., 2014). Other scholars addressed the cost effectiveness of market mechanisms such as carbon emission trading and carbon tax, and investigated their effects on China's CO_2 emission (Cui et al., 2014; Guo et al., 2014; Wang et al., 2015; Zou et al., 2016). Furthermore, under the low-carbon development scenario, if other measures such as the improvement of energy efficiency, adjustment of the structure of the energy industry and the adoption of a low carbon lifestyle are implemented, it is very likely that both China's energy demand and emissions will drop substantially in the future (Jiang et al., 2008, 2009; Wei et al., 2008; IEA, 2010; Fan, 2011; Liu et al., 2016). Some researchers predict that the summit of China's carbon emissions will appear between 2025 and 2030 under the low-carbon development scenario (Jiang et al., 2009; CECERG, 2009; CAE, 2011; Yuan et al., 2014). In order to study China's long-term economic development prospects, top-down models such as Computable General Equilibrium (CGE) models tailored for specifying the behaviors of economic agents as they interact across markets, are commonly used to simulate the operation of market economy and analyze government policies' effect on CO_2 mitigation and the resulting economic growth (Li, 2010; Zhou, 2012). Some studies indicate

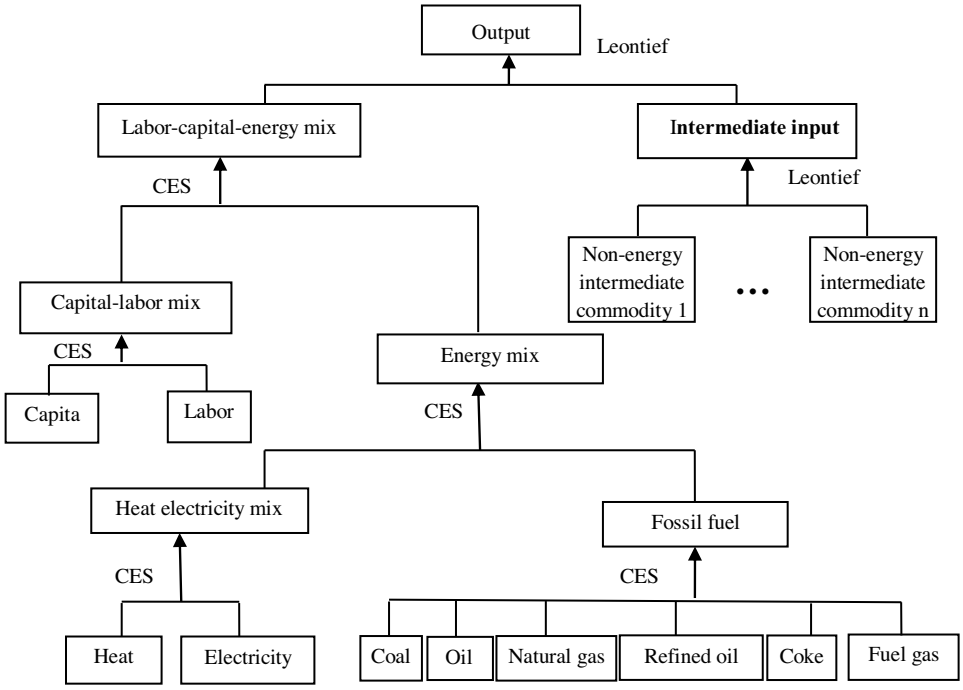

Fig. 1. Structure of production module except for resource mining sectors. Note: Coal, raw oil, as well as natural gas are intermediate inputs (not production factors) for Coking and Coal-fired power generation, Refined petroleum and Oil-fired power generation, as well as Natural gas power generation, respectively.