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The Economic impact of different carbon tax revenue recycling schemes in China: A model-based scenario analysis ☆

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HIGHLIGHTS

- Three alternative carbon tax revenue recycling schemes are analyzed and compared.
- Deducting consumption tax gives the highest absolute emissions cut.
- Deducting production tax has largely relieves the total and average mitigation cost.
- Different schemes also have different effects on industry level and time dynamics.

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ABSTRACT

As an important policy instrument for climate mitigation, the carbon tax policy design and its consequent social-economic impact calls for more research. In this paper, a dynamic Computable General Equilibrium (CGE) model – CASIPM-GE model is applied to explore the impact of a carbon tax and different tax revenue recycling schemes on China's economy. Simulation results show that the carbon tax is effective to reduce carbon emissions with mild impact on China's macro economy. In particular, a production tax deduction can be used to recycle the carbon tax revenue if the government wants to reduce the cost of a carbon tax; however, a consumption tax deduction may help the economy to restructure and may benefit the long-run emissions reduction. In terms of industrial output, most industries are negatively affected; sectors with large share of exports are subjected to negative shocks if there is consumption tax deduction financed by the carbon tax revenue. The study suggests that carbon revenue recycling scheme is important in designing the carbon tax policy: a well-designed scheme can help reduce the cost of a carbon tax.

1. Introduction

China has been very active in coping with the climate change issue in recent years. Being the largest single carbon emitter in the world, the mitigation pressure for China is both from the global community and from the domestic environmental and resource constraints on economic development. The major economic approach to carbon emissions mitigation is to put a price on carbon, either through a carbon tax or a cap-and-trade scheme. While China launched its "pilot emission trading scheme" in seven provinces and cities in 2013, theoretical research suggests that a carbon tax is preferable to an emission trading scheme [1,2] and there is also a group of advocates of carbon tax policy in China. In the Third Plenary Meeting of the 18th Session of Communist Party of China (CPC) held in Beijing in November 2013, the issue of carbon tax and environmental tax was formally addressed. Therefore, as an alternative and complementary policy of carbon mitigation other than emission trading policy, it is important to provide policy makers with the economic assessment on a carbon tax policy and its impact on the Chinese economy. While a cap-and-trade scheme requires a solid carbon market to be established, a carbon tax policy will involve a sound fiscal reform.

The design of a carbon tax policy involves: tax base, tax rate and revenue distribution [3]. In a recent theoretical review by Goulder [4] on fiscal interactions and climate policy, he pointed out that there are two major fiscal interaction effects in terms of the distribution of carbon tax revenue. One is the revenue-recycling effect

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which will gain efficiency improvement from cutting existing distortionary tax rates. The other effect is termed as the tax-interaction effect which will cause additional efficiency loss as the carbon tax (or environmental tax) will lower the real prices of factors, e.g. real wage and real capital return [4]. Therefore, to achieve "double dividend", the revenue-recycling effect should exceed the tax-interaction effect and primary cost. This implies the importance of exploiting the revenue-recycling effect, and thus, the importance of policy design. Similar conclusion is also made by Parry [5], Sumner et al. [3] and Pezzey and Jotzo [6].

In practice, there are extensive model-based studies on the tax base and tax rate (e.g. [7–9]). However, such research on revenue distribution, especially for China, calls for more efforts and this is where this paper can contribute.

There are several studies exploring the impact of different carbon tax revenue recycling schemes by using Computable General Equilibrium (CGE) models for different economies. McKibbin et al. [10] used G-Cubed model, an inter-temporary global CGE model, to explore the impact of a carbon tax and different uses of tax revenue on the economy-wide mitigation cost and fiscal position for the US. They found that using a carbon tax to reduce capital taxes would expand the overall economy and short-run employment. On the other hand, such tax reform will significantly reduce carbon emissions. In terms of improving the budget deficit, McKibbin et al. [10] found that a carbon tax scheme as such well-designed can reduce the budget deficit as well as achieve the emission targets at a minimal cost to the economy. Rausch and Reilly [11] also found that a carbon tax would provide a "Win–Win–Win" solution to US: first, cutting existing distortionary taxes, such as corporate tax and income tax, improves the social welfare; second, this will encourage employment, investment and consumption, thus expanding the overall economy; third, the carbon emissions will be reduced and so will the oil imports. Some most recent studies, e.g. Beck and Wigle [12] and Böhringer and Müller [13] also support that the impact of a carbon tax can be largely reduced if the tax revenue can be used to reduce corporate or income taxes.

Callan et al. [14] applies SWITCH model to Ireland to study the effects of carbon tax and revenue recycling across the income distribution. They found that if the carbon tax revenue is returned to private sectors as a means of social benefits and tax credits, households, no matter what income level, can be better off. Furthermore, there still can be some "surplus" in the carbon tax revenue with such welfare improvement.

Timilsina [15]'s study used a static multi-sector CGE model of Thailand and found that using carbon tax to reduce emissions will exert less welfare loss than the other environmental and non-environmental taxes across all the tax revenue recycling schemes considered in the study. In particular, the welfare loss is the smallest when carbon tax revenue is used to reduce existing indirect tax rates of non-energy goods.

There are also a few studies on tax revenue recycling for China. Brenner et al. [16] considered a revenue recycling option, "sky trust", which is to return the carbon tax revenue as lump-sum redistribution to all households on an equal per capita basis. They found that such a scheme would not only reduce fossil fuel consumption but also lower income inequality. Liang and Wei [17] adopted a recursive dynamic CGE model of China to explore the impact of a carbon tax on the urban–rural gap and living standard. They found that a carbon tax under the current social welfare system in China would further increase the income gap between urban and rural households. Therefore, they argued that carbon tax policy should be accompanied with indirect tax rate cuts financed by carbon tax revenue, and a biased government transfer toward rural households. More recently, Zhang and Zhang [18] explored in a CGE model whether carbon tax will yield employment double dividend for China under two revenue recycling schemes: one is that all of the carbon tax revenue is used to subsidize the residents, the other is that all such revenue is used to reduce corporate income tax rate. Their results showed that if carbon tax is supported by reducing corporate income tax, there will be "double dividend" on employment.

These studies, although considering the revenue recycling schemes in the policy analysis, have different specific aims and do not particularly compare the overall economic impact across different recycling schemes. Furthermore, the analysis on the industry level and the dynamic effect of such policy is not well addressed in the previous studies. Therefore, this paper contributes to the literature in two folds: first, by imposing the same carbon tax we control the effect of the carbon tax shock and assess the economic impact of three carbon tax revenue recycling schemes both in the initial year and across time; second, we have an updated database and detailed industry classification for China in the model such that we can analyze the results on both macro-economic level and industry level. In particular, such detailed industry classification allows us to explore the impact of a carbon tax on the production chains, which is important for policy makers on industry policies.

The rest of the paper is organized as follows: Section 2 provides a brief description of the CASIPM-GE model used in this study; Section 3 illustrates the policy scenarios; Section 4 presents the results on both macro-economic level and industry level; Section 5 discusses the policy implications and concludes.

2. The CASIPM-GE model and the baseline

The CASIPM-GE (Institute of Policy and Management, Chinese Academy of Sciences General Equilibrium) model is a dynamic Computable General Equilibrium model of China based on the MONASH dynamic CGE model (Dixon et al., 1982) [29], which is developed by the Institute of Policy and Management, Chinese Academy of Sciences and the CoPS (Center of Policy Studies) of Monash University in Australia.[1] The Social Accounting Matrix (SAM) is based on the 2007 Input–Output Table of China. The CASIPM-GE model covers 137 industries, 3 input factors (Labor, Capital and Land), and 6 economic entities (producers, investors, households, government, inventories and the rest of the world). There are 8 commodities that can be used as margins: water transport, air transport, rail transport, road transport, pipeline transport, insurance services, wholesale and retail trade and storage and warehouse services. Imports are not used as margin services [19]. The CASIPM-GE model also incorporates some recent development in long-term forecasting and empirical test [20]. The model is recursive dynamic and solved in 5-year intervals. In this study, we use a long-run closure which allows the capital stock to vary according to the change of capital price rather than fixed.

Fig. 1 provides the production structure of the model. There are 6 layers of production and most of which are nested in Constant Elasticity of Substitution (CES) functional form, except for the top tier where the primary factors and intermediate inputs are nested as Leontief production. The dynamics of the capital accumulation is briefly described in Appendix A. The sector aggregation is provided in Appendix B.

To analyze environmental policies, we establish a set of equations (see Eqs. (1)–(3)) for emission accounting in the model.

$$\mathrm{Em}(\mathrm{ee},r) = \mathrm{AE}(\mathrm{ee}) * H(\mathrm{ee}) * Q(\mathrm{ee},r), \tag{1}$$

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[1] The model is coded in GEMPack software. It is available to the readers for replication upon request. Please contact Yu LIU via liuyu@casipm.ac.cn.