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Optimal carbon taxes for China and implications for power generation, welfare, and the environment

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ABSTRACT

China is expected to constitute about half of the world's emissions between 2010 and 2040. As concerns about climate change intensify, the Chinese government is poised to commit to a low carbon economy. These conditions make China a suitable case in which to study how emission policies impact on energy supply, welfare, and the environment. To achieve this purpose, we incorporate abatement technologies into the GTAP computable general equilibrium model and show that optimal taxes range between 0.03% for services and 2.02% for manufacturing. In most cases, simulated tax rates are by far higher than pollution taxes stipulated in the new Chinese environmental tax law. Furthermore, despite a decline in output of many sectors including the electricity sector, overall welfare gains exist from introducing carbon taxes. Moreover, these taxes reduce environmental pollution by approximately 62.5%. In general, carbon taxes are insufficient for mitigation in China, and due to a coal-dominant energy structure, implementing these taxes leads to a decline in power generation. Hence, the Chinese aggressive investment strategy for renewable electricity technologies as stipulated in its 13th Five-Year Plan is understandable.

1. Introduction

China accounts for the world's largest carbon emissions driven primarily by the country's huge reliance of coal and other fossil energy. According to NEAA (2015), China, at present, constitutes approximately 30% of the world's carbon emissions. Besides, China compared with many other countries, accounts for a very high growth rate and it is expected to constitute approximately half of the world's projected emissions between 2010 and 2040 (Carson et al., 2014).

The above conditions make China a suitable case in which to study the manner in which emission policies would influence Chinese power supply, welfare, and the environment.

As the global clamor to reduce carbon emissions persists, the Chinese government is taking serious care to design energy policies for the future and the issues of economic growth driven by a limited use of carbon and fossil fuels would foundation these policies. In the 12th Five-Year Plan of the Chinese government, there is an ambitious commitment to reduce carbon emissions. As compared to the carbon emissions level in 2005, a 40–45% cut per unit output has been proposed by the year 2020 (Lin and Wesseh, 2013a; Wesseh and Lin, 2016a). The recent Paris Conference on climate change in 2015 prompted the Chinese government to further raise this target from 40% to 45% to between 60% and 65% and to peak emissions by the year 2030. As a means of achieving these goals and promoting energy supply security, Chinese central planners and academicians have demonstrated enormous interest in environmental taxes and the expansion of clean energy and its potential replacement for fossil-related energy sources. For instance, the Chinese new environmental tax law which is due to come into effect in January 2018 stipulates the taxing of air and water pollutants at rates beginning at $ 0.17 and $ 0.20 per unit, respectively. A monthly tax ranging from $ 50 to $ 1612 has also been stipulated for noise pollution.

The objectives of this paper are therefore threefold. First, an attempt is made to calculate optimal[1] emissions taxes for China. Second, the model is readjusted to test the economy-wide and environmental consequences of implementing the calculated taxes in China. Finally, the results are combined to discuss their implications for clean energy expansion in China.

As may be noticed from the review of studies presented in the next section and to the authors' best knowledge, this paper happens to be the first-of-its-kind approach to the application of real and more appropriate data for carbon policy design for China. In other words, our study

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[1] Optimal taxes in this study refer to the minimum tax rates that fully internalize environmental damages.

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is the first one which utilizes more recent Chinese-specific sectoral abatement data to design and study optimal carbon fees and to explain their implications for clean energy development in China. Our modeling technique also adds value to the literature by incorporating abatement technologies into economic modeling.

The rest of the study proceeds in the following manner: The literature and how it addresses the problem is presented in Section 2. Sources and descriptions of the applied data are documented in Section 3. Section 4 describes the methodology employed in our research and explains their applications. Section 5 summarizes results obtained. Relevant discussions of the results and implications for Chinese clean energy policy are presented in Section 6. Section 7 draws the conclusions.

2. Relevant literature

Carbon taxes and the development of clean energy technologies have been instituted in many parts of the world for the purpose of limiting and controlling carbon dioxide emissions. From a global perspective, the carbon tax literature is diverse. From comparing the manner in which carbon taxes perform in relations with other mechanisms for abatement to comparing trends in emissions fees, from economic impacts of carbon taxes to environmental considerations, the literature seems broad.

The first strand of studies is the one that compare the performances of various options for mitigation. The general conclusion from these studies is that a carbon tax is a superior mechanism for abatement. Notable examples of these studies include: Weitzman (1974), Pizer (2002), Dasgupta and Heal (1979), Nordhaus (2006), and Zakeri et al. (2015).

The trends in carbon taxes have also been the focus of several researchers. Sinclair (1992) asserts a decline in the rate of carbon taxes. Ulph and Ulph (1994), however, questioned the reliability of Sinclair's findings and argue a rise in carbon taxes in some cases. Following similar research direction, Hoel and Kverndokk (1996) produced the same conclusions as Ulph and Ulph (1994). Few other studies (e.g. Farzin and Tahvonen, 1996; Van der Zwaan et al., 2002; and Bosetti et al., 2011) have produced mixed conclusions between Sinclair (1992) and Ulph and Ulph (1994).

There are studies that also highlight the designing to optimal carbon taxes including but not limited to Farzin and Tahvonen (1996), Perroni and Wigle (1997), Alton et al. (2014), and Duan et al. (2014).

Finally, the aspect of the literature that constitutes the vast majority of studies is the part that considers the consequences of introducing a carbon tax. Findings from these studies are mixed with conclusions suggesting that carbon taxes could reduce emissions in some cases and fail in other cases. Also, welfare implications of carbon taxes are also mixed in the literature, and hence, an appropriate execution of carbon tax recycling is recommended. The most recent publications supporting these conclusions include: Liang and Wei (2012); Fang et al. (2013); Dissou and Siddiqui (2014); Marie (2014); Liu and Lu (2015); Chen et al. (2015); Li and Lu (2015); and Wesseh and Lin (2016b). For a more detailed review of this literature, interested readers are referred to Wesseh and Lin (2016b).

For China in particular, the impacts of implementing carbon taxes have been assessed recently by few authors. Duan et al. (2014) constructs a model of Chinese energy economy and environment in order to evaluate optimal trend in carbon taxes. The authors find that the optimal carbon tax rates for China demonstrate evidence of an increasing monotonic function. Li and Lu (2015) use TIMES model to project Chinese cement demand and study how carbon taxes influence China's cement industry. The authors find that, in the short-run, the implementation of carbon taxes does not influence technology choices. However, a high carbon tax appears to increase the application of production with CCS or waste heat recovery in the long-run. Chen and Nie (2016) apply an optimal welfare model to study the effects of a carbon tax on social welfare in China. The authors find that carbon taxes raise social welfare from a production perspective and lower social welfare from the consumption and redistribution perspectives. Wesseh and Lin (2016b) compute optimal emissions taxes from a global perspective including China and found that carbon taxes reduce environmental damages by nearly 50% on average. Dong et al., 2015 employ CGE model to evaluate the impact of a carbon tax on Chinese carbon dioxide reduction and the economy in general. Their results point to evidence of significant reductions in carbon dioxide but report economic losses under all scenarios.

From the review of studies described above, one would realize that the literature in general has produced mixed results. Some studies point to economic and environmental gains from implementing carbon taxes while other studies argue on the contrary. In terms of China in particular, the literature has mainly employed theoretical wisdom to simulate optimal trends in carbon taxes on an aggregate basis. In other words, these studies have failed to use actual abatement data disaggregated by polluting sectors. These limitations undermine the effectiveness and optimality of the kind of taxes that have been simulated in the literature, especially for studies focusing on China. A notable exception, however, is found in Wesseh and Lin (2016b) who use actual abatement data to address the problem. Notwithstanding, despite the contribution of their study especially for results reported for the United States, it is worth mentioning also that they use US industrial data as a proxy for other countries and regions. The assumption that US abatement technologies could represent the situation in other countries is somehow strong and could be misleading in some respect. In addition, be it the United States itself or other countries, the data used appear to be somehow outdated given that they were collected for the year 1993.

Against this backdrop, a study of this nature which utilizes a more recent and actual Chinese abatement data in combination with other macroeconomic variables (see Section 3) is not only necessary for Chinese energy and environmental policy designs, but could as well add value to the somehow inconsistent literature on carbon pricing and their general impacts. This should not be taken for granted especially when such inconsistency is attributable, in part, to the applied data and modeling techniques.

3. The data

In order to derive optimal carbon taxes for carbon-constrained China, this study collects and employs environmental damages and abatement data for various polluting sectors of China. Damages and abatement data for China are collected from Labriet and Loulou (2003). In addition, data on output per sector, sectorial government spending, and sectorial private sector spending, are included to provide for a more complete analysis. These data are taken from the version 8 database[2] of the Global Trade Analysis Project (GTAP). This version of GTAP consists of 129 regions and 57 sectors and has a base year of 2007. In order to make the computation of emissions taxes possible for China, we aggregate the database into 2 regions and 11 sectors. From Labriet and Loulou (2003), damages and abatement data are converted and apportioned accordingly to our 2-region, 11-sector aggregation of the GTAP database. The original GTAP regions are grouped into two new regions. The first region is China and all other regions are grouped as rest of the world. All sectors in GTAP have been grouped as services, electricity, transportation, manufacturing, mining & extraction, agriculture, food processing, construction & utilities, and textiles & clothing.

[2] For details on the GTAP version 8 database, interested readers are referred to the following link: https://www.gtap.agecon.purdue.edu/databases/v8/.