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Emission reduction policy: A regional economic analysis for China☆

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ABSTRACT

China is under considerable pressure to reduce its CO_2 emissions and has given a public commitment to substantial cuts by 2020. Policy makers are acutely aware of the possible adverse economic consequences of such cuts, and an important part of this issue is the regional dimension—will policy to reduce emissions exacerbate the already large inter-regional disparities in China, and if so, will some policies be better than others? These issues have received relatively little attention in the literature. We contribute to a better understanding of these issues by exploring the regional economic effects of two sets of policies by which emissions might be reduced: a reduction in the number of permits under a tradable permit system and a subsidy to pollution abatement. We do this in a small two-region theoretical model designed to capture some of the salient features of the Chinese economy and the Chinese tax/expenditure system. We show that there are important regional implications of a national pollution reduction policy and that the preferred policy depends on how disparities are measured, on how the revenue from the sale of permits is spent and on how a subsidy is financed.

1. Introduction

China's high growth rate in the past 35 years has brought great benefits to the country but these have been accompanied by serious problems. Two such problems will be the focus of this paper, *viz*., pollution and widening regional disparities. We will argue that these problems are not independent and that, in particular, policies to control emissions may have adverse consequences for regional inequality, consequences that need to be taken into account in the evaluation of alternative policy instruments.

The seriousness of the two problems is widely acknowledged. The rapid growth of carbon emissions is claimed to be one important factor, which has contributed to national environmental degradation and which has also spilled over to the global environment. China's carbon dioxide (CO_2) emissions have grown at an average annual rate of 5.8% during the period since reforms began in 1978. In 2008, China overtook the US as the largest single emitter of CO_2 and now accounts for over 25% of world emissions. Moreover, given China's continuing high growth rate, it is safe to predict that its contribution to world emissions will grow for some time.

Environmental concerns have stimulated a number of potential policy responses in China, including a proposal to cap CO_2 emissions for each province, establishing industrial energy efficiency audits, setting targets for the deployment of renewable electricity generation, introducing a carbon tax, developing markets for trading carbon emission permits and providing financial subsidies for carbon reduction. Recently, a number of pilot emission trading schemes were introduced as part of its policy to develop a comprehensive carbon trading system.[1]

The problem of inter-regional disparities is a long-standing one in China's economic policy concerns. Disparities are large by world standards and have been the subject of a variety of policy measures since the inception of the People's Republic. Over the past decade, GDP per head in the wealthier coastal region has been about twice that in the inland region, and at the provincial level, the differences are greater: for example, the ratio of per capita GDP in the wealthiest province, Jiangsu, to that in the poorest, Guizhou, was more than 3 in 2013. Disparities of this order have persisted for most of the history of modern China and

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[1] For recent discussion of emission reduction policy in China, with a focus on emission-trading schemes, see Zhang et al. (2014) and Jiang et al. (2014). For an evaluation of three of the recently-announced pilot schemes, see Munnings et al. (2014).

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show few signs of sustained narrowing, despite the application of a range of policies over six decades.[2]

In this paper, we examine the interaction between pollution reduction policies and regional disparities. We focus on two of the more popular pollution reduction instruments: a subsidy for abatement activity and a system of emission caps and tradable permits—a cap-and-trade scheme (CTS) in which the central government sets a limit on emissions, permits for which are freely tradable. The main rationale for both policies is that they will shift economic activity from high-emission-intensity to low-emission-intensity production and, in doing so, can be expected to result in widespread industrial reallocation within the economy. Given the substantial differences in industrial structure across the regions, this industrial reallocation may be expected to lead to regional reallocation and so to influence inter-regional disparities. We argue that the choice of emission control policies should be undertaken with an eye to their regional effects.

In our analysis of the interaction between the two selected emission reduction policies and inter-regional disparities, we pay particular attention to the financing implications of the pollution reduction policies—in the case of a subsidy: how this is financed by the regional governments and in the case of permit sales: who gets the revenue and how it is disposed of. The need to specify the way in which the permit revenue is disposed of allows us to link the CTS policy to the clean development mechanism (CDM) established under the Kyoto Protocol by the UN Framework Convention on Climate Change (see UNFCCC, 2014). This mechanism is an international policy designed to allow developed countries to meet part of their emission reduction targets by financing emission abatement activity in developing countries. We will interpret one of our policy shocks in terms of a CDM applied to regions in China.

The framework we use to analyse these questions is that of a small two-region theoretical model. While the model is quite a general two-region one, it is set up so as to capture some of the features of the Chinese economy, including two levels of government with explicit budget constraints. Furthermore, while it is a theoretical model, it is solved numerically, after calibrating using Chinese regional data. While, in some sense, this makes our model a computable general equilibrium (CGE) model, it is not one in the traditional sense of that term (see Bao et al., 2013) for a standard (large) CGE model, which is used to analyse the sectoral effects of an emission tax in China. Our model is similar in size to that of Li and Lin (2013), although their model does not have any regional disaggregation.

To anticipate the outcomes of our simulations, we find that regions matter in that policies have differential regional effects and different policies interact differently with measures of regional disparities. Moreover, this interaction also depends on the way in which disparities are measured, whether in terms of income, per capita output or welfare. Further, assumptions about the way in which the government budgets are balanced matter. In the case of a CTS-based policy, it matters who gets the additional revenue from permit sales and what they spend it on. In the case of a subsidy, it matters how the government finances the subsidy.

If we assume that the government focuses on conventional measures of disparities such as income and per capita output to assess the policy outcomes, then a CTS-based cut in the cap with the revenue allocated to the regional governments for infrastructure spending (the CDM-motivated policy) is a clear winner—it increases output in both regions, it generally increases profits, incomes and private consumption and reduces the inter-regional disparities whether measured by income or output per capita. However, ironically, this policy reduces welfare for the households in the poorer region, so hurting the very people the government sets out to help.

If we assume, on the other hand, that the government targets the utility or welfare gap (utility is, after all, what households maximise), then a CTS-based policy with the revenue being spent on government consumption dominates the other policies; besides, this is the only policy of the ones considered in which the utility of the interior households actually increases. However, at the same time, wages, profits, income and private consumption all fall in both regions which might lead to considerable resistance to such a policy, despite the welfare gain to the poorer region.

The choice between the two subsidy-based policies also depends importantly on the assumptions made about the government budget constraint. Both policies result in a fall in welfare in both regions. If the subsidy is paid for by a reduction in government consumption, the welfare gap narrows, but only because welfare falls by more in the coast than it does in the interior. The subsidy increases profits, incomes and private consumption, but the beneficial effects of this are more than offset by a fall in government consumption. If, on the other hand, the subsidy is one financed by a reduction in infrastructure expenditure, the output and income gaps narrow, but in this case, the welfare gap widens and welfare falls in both regions.

Thus, in designing a policy to reduce pollution, the regional dimension is important, although the preferred approach will depend on the details—the details of the government's regional objectives and the details of the way in which the policy is financed.

The structure of the paper is as follows. In Section 2, we provide some background information on the two problems, which are the focus of this paper before going on. In Section 3, we give a brief review of the literature and an explanation of how we contribute to the literature. This is followed in Section 4 by a description of the model we use. In Section 5, we explain the simulations we carry out and report results of these simulations in Section 6. We present conclusions in Section 7.

2. Background information

In Table 1, we provide some summary information on China's emission levels for representative years over the past decade, and to put them into context, we provide comparable data for the US. We restrict the information to CO_2 emissions since it is these that we will have in mind when we set up our model.

A decade ago, China's emissions were about half of those of the US, a situation that was almost reversed by 2012. China's emissions eclipsed those of the US in 2008 when US emission levels fell, under the influence of the Global Financial Crisis, while China's continued to rise. The table shows that while China has a considerably lower level of emissions per capita, this is solely because of China's lower level of economic development; indeed, China's emissions per unit of GDP are about twice those of the US. If China were to achieve current US per capita GDP

Table 1
Comparison of China and US in CO_2 emissions.

Year	CO_2		CO_2 share of the world		CO_2 per capita		CO_2/GDP	
	(million tons)		(%)		(tons per person)		(million tons per billion yuan)	
	China	US	China	US	China	US	China	US
2000	3429.91	6377.05	13.51	25.12	2.71	22.59	1.14	0.62
2005	5573.91	6493.73	18.92	22.05	4.26	21.93	1.04	0.50
2010	7945.19	6130.36	24.19	18.67	5.93	19.79	0.79	0.41
2012	9208.05	5786.13	26.72	16.79	6.80	18.42	0.75	0.36

Notes: GDP data are based on purchasing-power-parity (PPP) valuation, which come from *World Economic Outlook Database* (IMF, 2013), and CO_2 data come from *Statistical Review of World Energy 2013* (BP, 2013).

[2] For recent discussion of regional disparities and policies, see Chen and Groenewold (2013), Herrerias and Monfort (2015), Lin et al. (2013) and Rizov and Zhang (2014). Chen and Groenewold (2014) analyses the effectiveness of various policies in the mitigation of regional disparities.