Climate Change Research: Evaluation and Policy Implications
S. Zwerver, R.S.A.R. van Rompaey, M.T.J. Kok and M.M. Berk, (Eds.)

MACROECONOMIC ANALYSIS OF CO_2 EMISSION LIMITS FOR CHINA

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Abstract

Using a newly developed time-recursive dynamic CGE model for energy and environmental policy analysis of the Chinese economy, a business-as-usual scenario is first developed assuming no specific policy intervention to limit the growth rate of CO_2 emissions. Counterfactual policy simulation is then carried out to compute the macroeconomic implications of a carbon tax to limit the Chinese energy-related CO_2 emissions.

1. INTRODUCTION

As a developing country, China is currently undergoing significant transformation. This has led to spectacular growth of the Chinese economy, with an annual growth rate of about 9% for GNP during the period 1980-90. In the meantime, energy consumption rose from 602.75 Mtce (million tons of coal equivalent) in 1980 to 987.03 Mtce in 1990. The corresponding CO_2 emissions grow from 358.60 MtC (million tons of carbon) to 586.87 MtC during the same period (Zhang, 1994a). This means that China ranks second in global CO_2 emissions when Soviet emissions are split among the newly independent republics. Assuming a business-as-usual scenario, China's contribution to global CO_2 emissions is estimated to rise from 11% in 1990 to 28% in 2100 (Manne, 1992). Thus, advocates of controlling CO_2 emissions call for substantial efforts in China. Indeed, given China as the world's most populous country and largest coal producer and consumer, her coal-dominated energy structure and her energy-and-carbon-intensive economy, her economic development and her efforts to limit CO_2 emissions are of great influence on future global CO_2 emissions.

This study aims to explore the evolution of the Chinese energy-related CO_2 emissions in the absence of a carbon limit and to analyze the economy-wide impacts if a carbon tax is imposed to achieve the predefined carbon limits. In doing so, we have chosen a computable general equilibrium (CGE) approach. This choice has been motivated by the wide recognition of CGE approach as an appropriate tool for such a purpose (Zhang, 1994b).

2. GENERAL FEATURES OF THE CGE MODEL OF THE CHINESE ECONOMY

The CGE model for energy and environmental policy of the Chinese economy is of a time-recursive dynamic structure. It operates by simulating the operation of markets for factors, products and foreign exchange, with equations specifying supply and demand behaviour across all markets. Moreover, since focus is placed on quant-

model pays particular attention to modelling the energy sector and its linkages to the rest of the economy. In our CGE model, energy use is disaggregated into coal, oil, natural gas and electricity. Along with capital, labor and intermediate inputs, the four energy inputs are viewed as the basic inputs into the nested constant elasticity of substitution-Leontief production function for each producing sector.

Our model includes ten producing sectors and four types of agents (producers, households, the government, and foreigners). It is made up of the following blocks: production and factors, prices, income, expenditures, investment and capital accumulation, foreign trade, energy and environment, welfare measures, and market clearing conditions and macroeconomic balances. The model allows endogenous substitution among energy inputs and alternative allocation of resources as well as endogenous determination of foreign trade and household consumption in the Chinese economy for coping with the environmental restrictions. Thus, the CGE model makes it possible to analyze the Chinese economy-energy-environment system interactions simultaneously, both at the sectoral level and at the macroeconomic level. The equilibrium solution for a given year produces a wealth of detailed information, including market clearing prices, GNP, productivity levels by industry, investment by industry, final consumption levels by commodity, employment by industry, imports and exports by commodity, energy consumption in physical terms, and CO_2 emissions. See Zhang (1995) for a detailed description of the model.

3. THE BUSINESS-AS-USUAL (BaU) SCENARIO[1]

The BaU scenario assumes no policy intervention to limit the rate of CO_2 emissions, but does allow for anticipated changes in demographic, economic, industrial and technological developments and environmental policies not directly aimed at carbon abatement.

To develop the BaU scenario using the time-recursive dynamic CGE model involves two steps. The first step is to make a set of underlying baseline assumptions about how the exogenous variables in the model would evolve over the period till 2010. This involves updating time-dependent variables and revising certain parameters over time to reflect the world and Chinese economic development as well as the changes in tastes or technology. The second step is to use these assumptions to construct the BaU projections about the endogenous variables mentioned earlier.

Table 1 shows some selected results, while a detailed representation of the CGE simulation results for China will appear in Zhang (1995).

Table 1
Selected CGE simulation results for China (abbreviations are explained in text)

	1990	2010	
		BaU	CAS
GNP (Billion Yuan in 1990 prices)	13763	61946.7	61301.0
Population (millions)	1093	1413	1413
Energy consumption (Mtce)	987.0	2515.6	2047.1
Elasticity of energy consumption	0.56	0.61	0.48
Elasticity of electricity consumption	0.84	1.01	0.93
Annual rate of energy conservation (%)	3.6	2.8	3.7
CO_2 emissions (MtC)	586.9	1527.5	1242.6
CO_2 emissions per capita (tC)	0.51	1.08	0.88

4. CARBON ABATEMENT: COUNTERFACTUAL POLICY SIMULATION

It has been argued that a carbon tax is an effective means of providing economic incentives for limiting CO_2 emissions (Zhang, 1994c). For this reason, our CGE model incorporates a carbon tax as an economic instrument to serve such a purpose.

In counterfactual policy simulation, we impose a carbon tax of 300 Yuan per ton of carbon to achieve 20% cut in CO_2 emissions in 2010 relative to the BaU scenario. The carbon tax is equivalent to 25 in 2010 US$. Table 1 gives some selected results (in absolute values) of the carbon abatement simulation labelled as the CAS, while Table 2 reports main economic effects of the carbon tax relative to the BaU. For a representation of alternative CGE policy simulation results of sectoral detail for China, see Zhang (1995).

Table 2
Main macroeconomic indexes in 2010

	Percentage derivations relative to BaU (-: declines)
GNP	- 1.042
Exports	- 2.778
Imports	- 0.675
Private consumption	- 0.858
Energy consumption	-18.624
CO_2 emissions	-18.746

The results in Table 2 can be briefly explained as follows. The unilateral imposition of the carbon tax to cut the Chinese energy consumption and hence CO_2 emissions will reduce the international competitiveness of the Chinese products. As a result, China will face a decline of export volumes. Such a decline also means a loss of GNP, given that the increasing exports are one of the driving forces behind China's booming economy. Moreover, the combination of a decline in export volume plus a rise in export prices makes import volumes fall somewhat less than exports. With private consumption constituting part of the final demand (GNP), this will therefore lead to that private consumption needs not to fall as much as GNP.

5. CONCLUDING REMARKS

From the preceding analysis we draw the following main conclusions. First, driven by the threat of further degradation of the environment and the harmful economic effects of energy shortages, China has made and will continue to make great efforts directed at energy conservation and enhanced energy efficiency whether or not the global climate change issue requires special action on China's part. This can be reflected by the fact that, with an annual energy saving rate of 2.8% during the period 1990-2010, China would achieve an annual economic growth rate of 7.8%, at the same time the Chinese CO_2 emissions per capita in 2010 are still controlled below the current world average (1.14 tC in 1990) under the BaU path. Moreover, it is conceivable that the Chinese government is to take a broad range of measures to further slow down the growth of her per capita emissions when curbing global CO_2 emissions requires special action on China's part.

Second, compared with some global studies that treat China as a separate region, we analyze the impacts of a less restrictive carbon emission scenario in which

China's CO_2 emissions in 2010 are allowed to be 110% higher than her 1990 level. Even in this case, China would face a GNP lose of 1% relative to the BaU. This supports the general findings that China would be one of the regions hardest hit by carbon constraint (Manne, 1992).

Finally, in our calculations, the imposition of a carbon tax (25 in 2010 US$) would cut CO_2 emissions by 285 MtC in 2010. This tax is much smaller than those reported for the industrialized countries to achieve the same amount of carbon cutback. This suggests that international action should consider, among others, *joint implementation* as an useful means of reducing global CO_2 emissions effectively. This mechanism will not only help China alleviate the suffering from the future possible carbon limits, also act to reduce the pressure put on the industrialized countries for yet stringent measures to stabilize global CO_2 emissions.

6. NOTE

[1] The results reported here are only preliminary and are subject to changes. This also applies to the results of counterfactual policy simulation. For a detailed representation of the final results, see Zhang (1995).

7. REFERENCES

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