Impact of China’s Domestic Carbon Emission Trading Scheme

Shantong Li

Jianwu He

Development Research Center, of the State, China

Abstract:

In December 2009, as a participant in the Copenhagen Accord, China pledged to carry out a domestically binding target to reduce its economy‘s carbon intensity by 40 to 45 percent by 2020 compared to 2005 levels. To achieve this target, Chinese government is planning to utilize more market-based means and will begin domestic carbon trading programs during the period of 12th Five-Year Plan. By now, literature review shows that there is no study focusing on economic effect of China’s domestic carbon trading. With different provincial economic structure and growth, there exists substantial difference for energy consumption and carbon emission between provinces in China. In 2008, the highest provincial carbon emission per GDP is about six times of the lowest provincial carbon intensity. Therefore, it is expected different carbon emission trading scheme will result in different effect on different provinces, and the there will some impact on income disparities between the provinces. In this paper two domestic carbon emission trading schemes are designed: one is the emission quota based on provincial carbon emission per capita, and another is the emission quota based on accumulation of provincial carbon emission. We utilized China’s multi-regional（30 provinces）computable general equilibrium (DRC-CGE) model developed by the Development Research Center of the State Council of China . This model is recursive dynamic. The model is calibrated to the 2002 provincial Social Accounting Matrix (SAM) developed from the 2002 provincial input/output tables. The paper will address macroeconomic impacts of domestic carbon emission trading schemes in China and also the impacts on provincial economic development as well as income disparity between provinces.

Draft, do not quote

Contents

Draft, do not quote

Introduction

In December 2009, as a participant in the Copenhagen Accord, China pledged to carry out a domestically binding target to reduce its economy's carbon intensity by 40 to 45 percent by 2020 compared to 2005 levels. In 12th Five Year Plan, currently published by China's government, announced several new carbon and energy targets from 2010 levels, namely reducing carbon dioxide emissions per unit of GDP by 17 per cent from 2010 levels by 2015. Therefore China's government will carry out new policies to reduce carbon in the near future and this has become hot topic for researchers.

After the groundbreaking work of Coase in the 1960s, scholars quickly began to point out the instrument's usefulness for air pollution control. Tradable emission permits have been successfully used in the US since 1995 to tackle the problem of acid rain by reducing sulphur dioxide and nitrous oxide emissions. In 12th Five Year Plan, China's government also announced to establish carbon emission trading markets step by step. The emission trading will be one of policy choices for carbon reduction in the future. This paper will analyze the potential impact of different emission trading policy on each province based on multi-provincial China's CGE model.

This paper is organized as follows. In section II, a multi-provincial China's CGE model is introduced, which is the instrument for our assessment of emission trading. In section III, the paper describes different emission trading scenarios. In section III, we present the results of our quantitative simulations of each of the scenarios. In last part, the paper provides a concluding assessment of the implications of our result.

China's Multi-regional Computable General Equilibrium Model

The model in this paper belongs to a family of DRC-CGE-models used extensively over the past two decades to analyze environmental policy and other policy reforms, and maintained at the Development Research Center of the State Council in China. In

Draft, do not quote

China the model is used in regional development planning and macroeconomic planning for the State Council, including the Five Year plans.

The model has 30 region and 23 sectors (including 1 agricultural sectors, 3 mining sectors, 7 manufacturing sectors, 8 utility sector, and 4 services sectors). There are 4 production factors: land, resource, labor, and capital. Labor is disaggregated into 3 types by occupation. There are 2 representative households by area.

In DRC-CGE model, five types of energy are included, namely coal, crude oil and natural gas, petroleum products, gas and electricity. The electricity activity is divided into different sub-sector by source (Thermal-, hydro-, nuclear and renewable power generation). Emissions in DRC-CGE-model have three drivers. Most are generated through intermediate consumption of fossil fuels. Some are driven by final demand on fossil fuels. And the remainder is generated by aggregate output—for example emissions from cement production. The amount of a given polluting emission takes the following form:

$$E = \sum_i \sum_j \alpha_{i,j} XAp_{i,j} + \sum_i \beta_i XP_i \quad + \sum_j \gamma_j XAf_j$$

Where, E is the emission level of a given polluting emission, $\alpha_{i,j}$ is the emission volume associated with one unit consumption of commodity i used by sector j, and XAp refers to intermediate input; β_j the emission volume associated with one unit production of sector j, and XP refers to sectoral output; γ_j the emission volume associated with one unit consumption of product j in final consumption, and XAf refers to finial demand. Thus, the first two elements of the right-hand side expression represent supply-related emissions, the third one final-demand-related emissions.

DRC-CGE model has a flexible system of carbon mitigation policies. The simplest is a provincial specific carbon tax—that also allows for exemptions for designated sectors or households. An alternative is to provide a cap on emissions at either provincial or national level. The model will then produce the shadow price of carbon, i.e. the carbon tax, as a model outcome. If a national cap is imposed, a single uniform tax will be calculated. This type of regime assumes no trading. A final option is to have a provincial or national cap with trading and assigned quotas. Similar to the

Draft, do not quote

previous regime, a uniform carbon tax will be calculated (and would be nearly identical to the no-trade carbon tax), but emissions trading would occur depending on the initial quotas and the shape of the individual marginal abatement curves for each member of the trading regime.

The model is calibrated to DRC multi-regional Social Accounting Matrix with a 2002 base year[1]. For a detailed description see Appendix 2.

Carbon dioxide emissions trading scenario design

Draft, do not quote

Allowance allocation is a contended issue in virtually every cap-and-trade programme as it critically determines the policy's distribution impact (Steffen Brunner, 2008). From regional point of view, the key question is which province can receive scarcity rent created by capping emissions.

In general, there are many principles for permits allocation, namely grandfather principle, per capita principle, accumulated per capita principle etc. As for grandfather principle, the total permits are distributed in proportion to past emissions. Unlike grandfather principle, per capita principle means that total permits are distributed in proportion to population, i.e, every people has equal emission permits. There two principles are widely recognized. This paper designs two scenarios according to these two principles to illustrate the impact of different principle for permits allocation.

Table 1 describes two different emissions trading scenarios. For these two scenarios, the total permits are same, 80% of the historical emission, i.e total emission will be reduced by 20%. But the principles for permit allocation are different. In the first scenario, called as ETS1, total permits are distributed to each province by historical emission, i.e province with higher historical emission will get more permits. In second scenario, namely ETS2, total permits are allocated to each province by population, i.e the larger the population, the more the permits.

Table 1 Scenarios of inter-provincial carbon emissions trading

[1] The latest published regional Input-Output tables are 2002 tables.

Scenario	Description
ETS1 (graderfather principle)	**Objectives**: Cutting the overall regional emissions of carbon dioxide by 20% **Permits Allocation**: total emission permits(80% of current emission) are distributed among provinces in proportion to current provincial emissions
ETS2 (per capita principles)	**Objectives**: Cutting the overall regional emissions of carbon dioxide by 20% **Permits Allocation**: total emission permits(80% of current emission) are distributed among provinces in proportion to current provincial population

Result of Emissions trading simulation

The impact of emission trading on regional welfare and regional disparity is analyzed as follow.

1. ETS1 Scenario (graderfather principle)

Given that historical emissions are the criterion using for allocation of permits, it is necessary to analyze the regional historical emission. Figure 1 shows the provincial carbon emission before reduction and its per capita GDP levels. It can be seen that the developed provinces in coastal area hare large amount of carbon emission, such as Shandong, Guangdong, Jiangsu and other coastal provinces. Carbon emission in Shandong Province is the largest among all provinces, about 7.6% of national carbon emission. On the contrary, carbon emission in backward western provinces is relatively small. In general, the more developed the economy, the larger the carbon emission. Based on historical principles, the larger the historical emissions, the greater the emission rights available, and therefore developed provinces will also receive more carbon emissions in ETS1 scenario.

Draft, do not quote

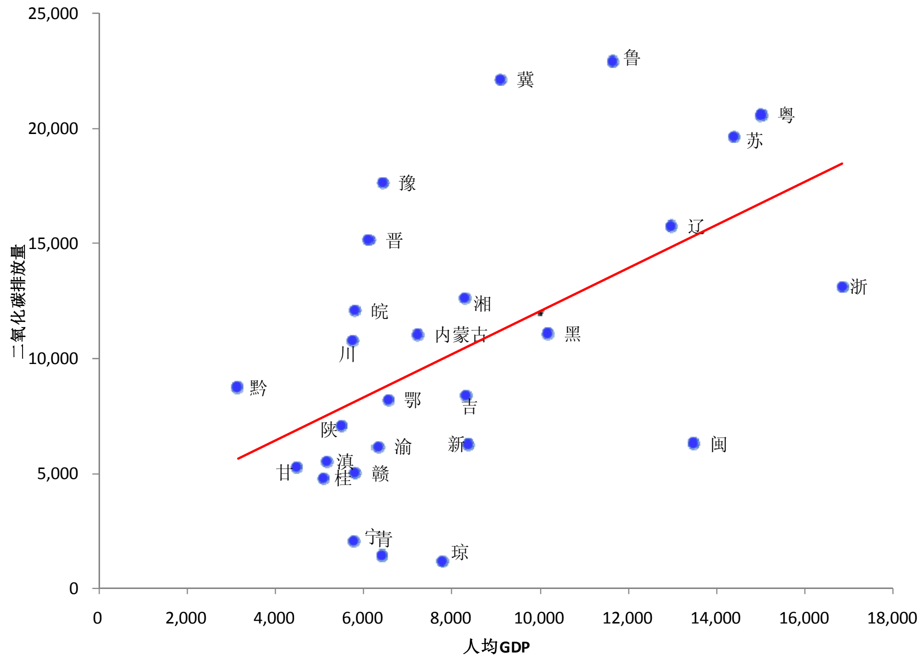

Fig 1 Carbon emission and GDP per capita

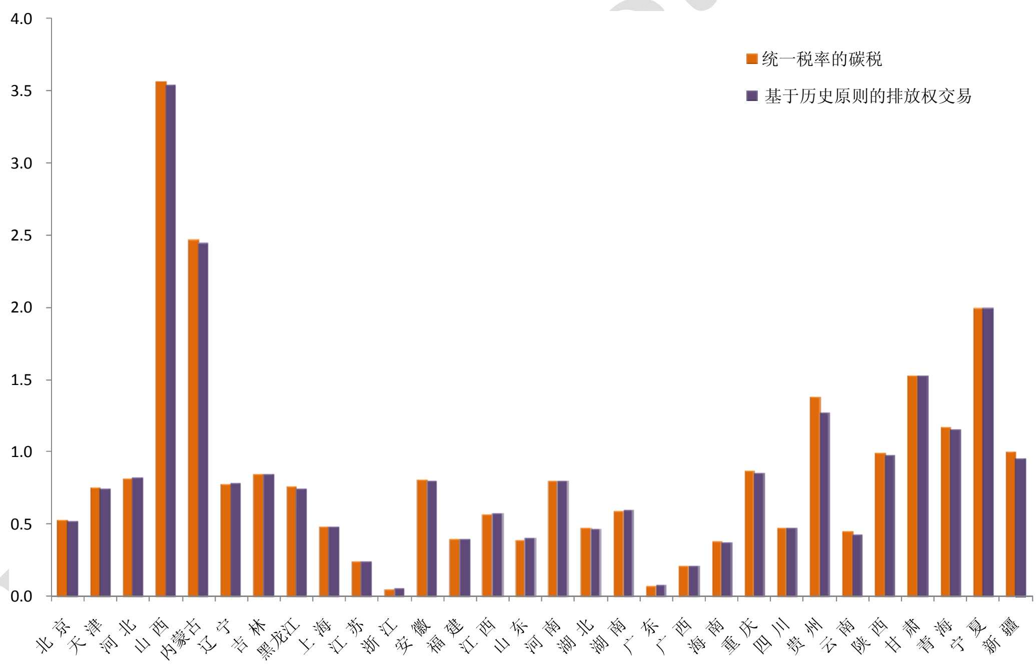

Fig 2 Welfare losses for each province in historical principle scenario

Figure 2 shows the welfare change of each province in the historical principle scenario, relative to no carbon reduction scenario. Based on the simulation result, we can find that resource-intensive provinces in western area, such as Shanxi, Inner Mongolia, Guizhou, Gansu, Xinjiang, Qinghai and Ningxia provinces, will bear the brunt of carbon emission trading in historical principle. The welfare losses for these provinces are close to or more than 1% of GDP, of which the losses for Inner Mongolia and Shanxi loss are more than 2%. But for those developed provinces, such as Guangdong, Jiangsu, Zhejiang and so on, the welfare losses are very small, of which Jiangsu has smallest loss, slightly more than 0.05%. Furthermore, it also can be found that the provinces with very small emission and small emission intensity will face small welfare losses due to emission trading in historical principle scenario, such as Guangxi, Hainan, Yunnan.

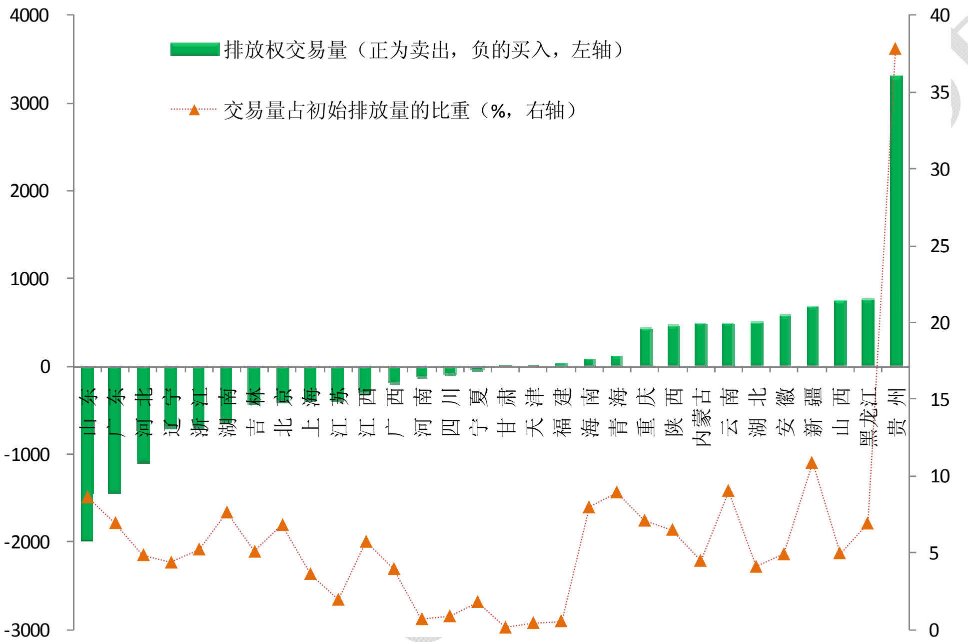

Figure 3 Emission trading in historical principle scenario

Figure 3 denotes the volume of emission trading and the proportion of emission trading to initial emission with trading. According to the simulation result, the proportion of emission trading to initial emission with trading is lower than 10% for all provinces except Guizhou and Xinjiang. Why is the amount of emission trading in historical principle scenario so small? The reason for this is that the permits for each province in historical principle are close to the optimal emission reduction path of each province. The detail reasons for this are discussed as follow: In general, given the same cost of emission reduction, the demand on emission permits for the province with high carbon intensity will be higher than that of province with low carbon intensity; In historical principle scenario, the developed provinces with high initial emission will get more emission permits than backward provinces with low initial emission. Therefore, the allocation of emission permit is consistent with the demand on emission permit and the amount of emission trading in historical principle is very small.

Based on the simulation result, given the same initial emission levels, the province with high carbon intensity will get benefit from the historical principle, relative to province with low carbon intensity; Given the same carbon intensity, the province with high initial carbon emission will get benefit from historical principle, compared with province with low initial carbon emission.

From regional disparity's point of view, the historical principle lacks of fairness. This paper also calculates the change of regional disparity in historical principle, relative to no trading scenario. The result shows that GINI coefficient of regional per capita income is 0.02% higher than that in no trading scenario.

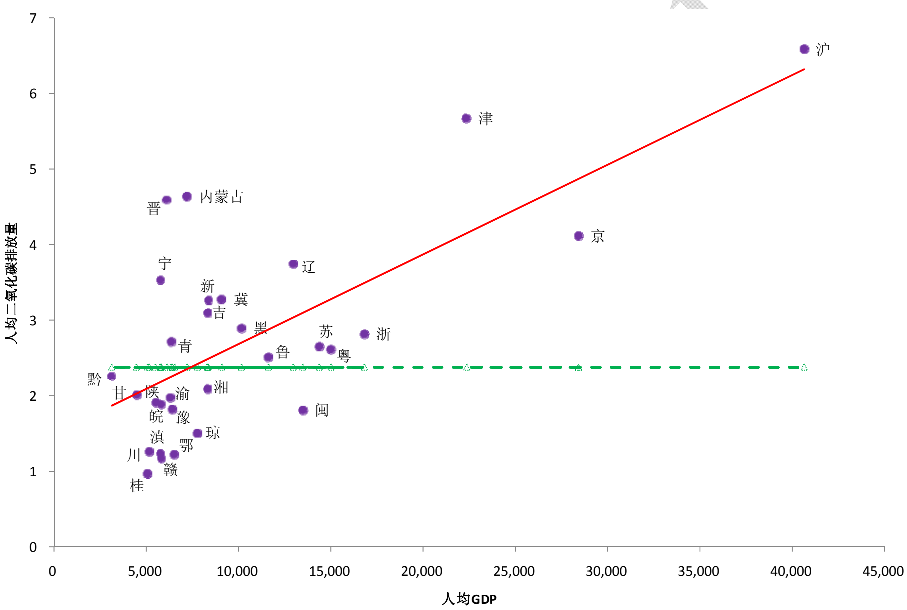

Figure 4 Regional carbon emission per capita and GDP per capita

2. ETS2 scenario (per capita principle)

In this scenario, population is the criterion using for allocation of permits. To begin with analysis this scenario, it is necessary to analyze the regional historical emission per capita. Figure 4 shows the provincial initial carbon emission per capita and its per capita GDP levels. It can be seen that the developed provinces in coastal area hare large amount of carbon emission, such as Shandong, Guangdong, Jiangsu and other coastal provinces. Carbon emission in Shandong Province is the largest among all provinces, about 7.6% of national carbon emission. On the contrary, carbon emission in backward western provinces is relatively small. In general, the more developed the economy, the larger the carbon emission. Based on historical principles, the larger the historical emissions, the greater the emission rights available, and therefore developed provinces will also receive more carbon emissions in ETS1 scenario.

In general, according to the data in Figure 4, the higher per capita GDP, the larger carbon emission per capita. Of all provinces, Shanghai has highest per capita carbon emission, about 6.6 tons and 3 times of national average level. On the contrary, Guangxi has lowest per capita carbon emission, less than 1 ton and lower than half of national average level. As for all coastal province except Fujian, their per capita carbon emissions are all higher than national average level. In addition, those provinces with high energy resource endowment, has higher per capital carbon emission than national average.

In per capita principle scenario, emission permits are allocated based on regional population and the province with large population will get more emission permit than that of province with small population. The provinces, which per capita carbon emission is higher than national average level, are more likely to become the buyer of emission permits. On the contrary, the provinces with low per capita will become seller of emission permits. In general, the provinces with very low per capita carbon emission will benefit from per capita principle scenario. Of course, there is another very import factor affecting the distribution impact, namely regional marginal abatement cost.

Draft, do not quote

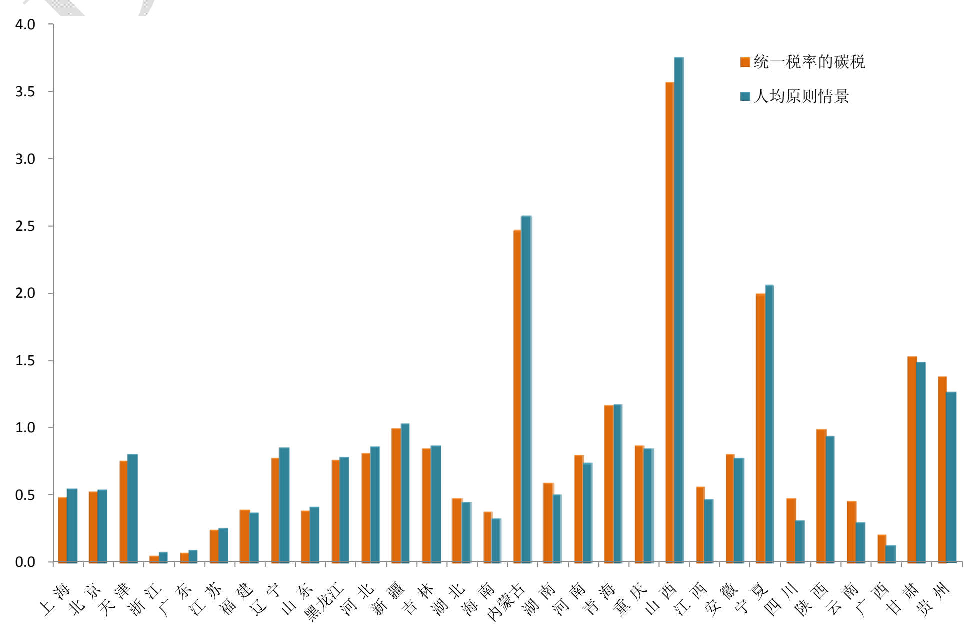

Figure 5 Welfare losses for each province in per capita principle scenario

Figure 5 shows welfare losses for each region in per capita scenario. According to simulation results, the general impact of emission trading in per capita scenario is similar to that in historical scenario. Compared with historical scenario, we can also find that resource-intensive provinces in western area, such as Shanxi, Inner Mongolia, Guizhou, Gansu, Xinjiang, Qinghai and Ningxia provinces, will bear the brunt of carbon emission trading in historical principle. In addition, the losses for developed provinces with high carbon emission and high emission intensity are relatively small. There are three reasons for this: firstly, the disparity of per capita emission is very low, except several provinces; secondly, the energy resource in China is very concentrated in several western provinces; the target of emission reduction in this paper is relatively small, so that total amount of emission trade is small.

Although the overall impact of two scenarios is close, the impacts on regions are very different. According to simulation result, the impact on backward provinces is relatively smaller than that in historical scenario due to very low per capita carbon emission. On the contrary, the welfare losses of coastal developed provinces are larger than that in historical scenario. The paper also calculates the GINI coefficient of per capita income in per capita scenario. The regional disparity in per capita scenario is 0.07% lower than that in historical scenario. From regional disparity's point of view, the per capita scenario is fairer than historical scenario.

Conclusions

This paper sets up two emission trading scenarios according to different principle for emission permits allocation, namely historical principle scenario and per capita principle scenario. A multi-provincial CGE model is used to simulate these two emission trading scenario. According to the simulation result, this paper can make following conclusions:

1. From the perspective of equity, two scenarios will both increasing the regional

Draft, do not quote

disparity, relative to no emission trading scenario. But the per capita principle scenario is fairer than historical principle scenario.

2. The western provinces with rich energy resource will face largest welfare losses in both historical principle scenario and per capita scenario, compared with other provinces. On the contrary the developed provinces, with high emission and low emission intensity, will suffer small welfare losses.
3. The amount of emission trading in per capita principle scenario is much larger than that in historical principle scenario.

Reference

I.Juergens et.al, EU ETS and competitiveness: dealing with carbon leakage, http://www.ccap.org/docs/resources/904/EU%20ETS%20and%20competitiveness_%20dealing%20with%20carbon%20leakage.pdf

Graichen, V., K. Schumacher, F. C. Matthes, L. Mohr, V. Duscha, J. Schleich and J. Diekmann, 2008. Impacts of the EU Emissions Trading Scheme on the industrial competitiveness in Germany, Research Report 3707 41 501, UBA-FB 001177, UmweltBundesamt, http://www.umweltdaten.de/publikationen/fpdf-l/3625.pdf

Stephanie Monjon and Philippe Quirion, 2009 Addressing leakage in the EU ETS: results from the CASE II model， Climate Strategies Working Paper，March 16，2009, http://www.webmeets.com/WCERE/2010/Prog/getpdf.asp?pid=732&pdf=/files/papers/WCERE/2010/732/Monjon_Quirion_CASE2_2010_WCERE.PDF

Grubb, M., Brewer, T., Sato, M., Heilmayr, R., Fazekas, D. 2009. Climate Policy and Industrial Competitiveness: Ten Insights from Europe on the EU Emissions Trading System. German Marshall Fund Report. http://www.gmfus.org/publications/article.cfm?parent_type=P&id=640

Carbon Trust (2008a). Cutting Carbon in Europe: The 2020 Plans. London: Carbon Trust.

Carbon Trust (2008b). EU ETS Impacts on Profitability and Trade: A sector-by-sector analysis. London: Carbon Trust.

Misato Sato, Michael J. Grubb, James Cust, Katie Chan, Anna Korppoo and Pablo

Draft, do not quote

Ceppi，2007, Differentiation and dynamics of competitiveness impacts from the EU ETS, Cambridge Working Papers in Economics from Faculty of Economics, University of Cambridge

Böhringer, C. and A. Lange (2005), Economic Implications of Alternative Allocation Schemes for Emission Allowances, Scandinavian Journal of Economics 107, 563-581.

Bovenberg, A.L. (1995), Environmental Taxation and Employment, De Economist 143, 111- 140.

Bovenberg, A.L. and F. van der Ploeg (1996), Optimal Taxation, Public Goods and Environmental Policy with Involuntary Unemployment, Journal of Public Economics 62, 59-83.

Capros, P. and Mantzos, L. (2000), The economic effects of EU-wide industry level emissions trading to reduce greenhouse gases. Results from PRIME Energy-Systems Model, Athen.

Carbon Trust (2004), The European Emissions Trading Scheme, London.

Centre for Economic Studies, Fundacion Tomillo (2000), Industrial Benefits and Costs of Greenhouse Gas Abatement Strategies: Applications of E3ME, E3ME-Project Working Paper for Task 9: GHG Abatement Benefits and Costs, Cambridge.

CEPA Environmental Registry (2005), "Notice of intent to regulate greenhouse gas emissions by Large Final Emitters", Canada Gazette Part I, Vol. 139 No. 29.

ERM (Environmental Resources Management), Euroelectric (Union of the Electricity Industry) (2002), GETS 3 –Greenhouse Gas and Energy Trading Simulation, Final Report, Environmental Resources Management, March 2002.

Fankhauser, Samuel (1995), Valuing Climate Change - The Economics of the Greenhouse. Earthscan, London.

Goulder, L.H. (1995), Environmental Taxation and the Double Dividend: A Reader's Guide, International Tax and Public Finance 2, 157-183.

Hoel, M. (1991), Global environmental problems: The effects of unilateral actions taken by one country, Journal of Environmental Economics and Management 20, 55-70.

Institute for Prospektive Technological Studies (IPTS) (2000), Preliminary Analysis of the Implementation of an EU-Wide Permit Trading Scheme on CO Emissions Abatement Costs. Results from the POLES model, Sevilla.

IPCC Working Group III (1995), Summary for Policymakers: Economic and Social Dimensions of Climate Change. IPCC Secretariat, Geneva.

Jansen, H. and G. Klaassen (2000), Economic Impacts of the 1997 EU Energy Tax:

Draft, do not quote

Simulations with Three EU-Wide Models, Environmental and Resource Economics 15, 179 – 197.

Jensen, J., and T.N. Rasmussen (2000), Allocation of CO2 Emissions Permits: A General Equilibrium Analysis of Policy Instruments, Journal of Environmental Economics and Management 40, 111-136.

Kemfert, C., M. Kohlhaas, T. Truong, and A. Protsenko (2005), The Environmental and Economic Effects of European Emissions Trading, DIW Discussions Papers 533, Berlin.

Klepper, G. and Peterson, S. (2004), The EU Emissions Trading Scheme, Allowance Prices, Trade Flows, Competitiveness Effects, Kiel Working Paper No. 1195, Kiel Institute for World Economics, Kiel.

Koskela, E. and R. Schöb (1999), Alleviating Unemployment: The Case for Green Tax Reforms, European Economic Review 43, 1723-1746. 52

Kruger, J. A. and W.A. Pizer (2004), Greenhouse Gas Trading in Europe - The New Grand Policy Experiment, Environment 46, 8-23.

Martinez, K. K. and Neuhoff, K. (2004), Allocation of Carbon Emission Certificates in the Power Sector: How Generators Profit from Grandfathered Rights, Cambridge Working Paper in Economics 444.

Morgenstern, R.D., W.A. Pizer, and J.-S. Shih (2002), Jobs versus the Environment: An Industry-level Perspective, Journal of Environmental Economics and Management 43, 412-436.

Parry, I.W. (2002), Are Tradable Emissions Permits a Good Idea?, Resources for the Future Issues Brief 02-33, Washington D.C.

Reinaud, J. (2005), Industrial Competitiveness under the European Union Emissions Trading Scheme, IEA Information Paper, Paris.

Rennings, K. and T. Zwick (2002), Employment Impact of Cleaner Production on the Firm Level: Empirical Evidence from a Survey in Five European Countries, International Journal of Innovation Management 6, 319-342.