The Economic Implications of Domestic Carbon Dioxide Emission Trading: A Computable General Equilibrium Model for Ukraine

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The purpose of the paper is to assess the economic effect of implementing a domestic CO_2 Emissions Trading Scheme (ETS) in the Ukraine and to analyse how it may help the country to promote sustainable economic growth based on energy-efficiency and environmentally benign structural changes.

Ukraine is a resource-based economy, which industrial production is characterized by high material and energy intensity (0.5 teo/thd $, whereas this indicator equals 0.15 for the OECD countries, and 0.2 is the world average), obsolete capital stock developed during the Soviet period, a significant share of coal in the energy balance and a high probability that coal will remain major domestic energy source.

Abnormally low energy prices have been the main factor behind the rapid growth of Ukrainian energy-intensive industries such as steel, heavy machinery and chemicals. These industries are also among Ukraine's most important export earners. At the same time they are heavily depended on imported energy (the total Ukrainian import energy dependence is about 60%). Their competitiveness is threatened by energy inefficiency in an era of rising energy prices.

Ukraine is ranked 11th in the world for GHG (green house gases) emissions and has been identified as a major source of trans-boundary air pollution for the eastern Mediterranean region. Nevertheless, the GhG emissions in the country have never been regulated.

Ukraine has no obligations for the emission reduction during the first commitment period (2008-2012) of the Kyoto Protocol, but has 1.7 billion tone of CO_2–e headroom compared to its 1990 emission level and the tremendous potential for cheap emissions reduction (around 750 Mt of CO_2 could be reduced at the cost below 8 $/t), that can be sold on the international emission market through the flexible mechanisms of the Kyoto Protocol.

However country faces an urgent need to ensure the sustainability of the economic growth, tracking industrial energy efficiency, GHG emissions and the consolidation of market reforms which are critical if the country is to fulfil its stated aspirations with regard to increasing integration with the EU and WTO. Most likely that under the EU-Ukraine Free Trade Agreement, Ukraine might be asked to apply the EU environmental *acquis* to comply with all the EU's main environmental standards, notably its water and air pollution directives.

Emission trading has proved to be the most cost-effective instrument for the control of GHG emissions. However, the economic impact largely depends on the emission trading system design, particularly on permits allocation option (e.g. distributional and competitiveness impacts, possible substantial increase in production cost in some industries).

In order to provide an evaluation of possible design issues of the Ukrainian domestic ETS and to determine the optimal method (in terms of environmental efficiency, welfare loss minimization and thus political acceptability) of permits allocation, a comparatively-static computable general equilibrium model of Ukrainian economy is employed.

Three basic allocation schemes are examined: (1) **Output based grandfathering:** each sector receives permits for free according to its benchmark market share in total production; (2) **Emissions-based grandfathering:** permits are allocated proportionally to the sector's emissions share in total emissions for a base year, also for free; (3) **Auctioning**: energy-intensive sectors buy permits from the government.

These allocation schemes are tested for the two general options of ETS design: First, when the scheme is open to international emissions trading markets with fully elastic supply and demand; Second, when it is restricted to the domestic emission market. Then results of all the model scenarios are compared with an emission taxation scenario where industrial emissions are taxed at

the rate sufficient to achieve the 10% emission reduction with no implementation of emissions regulation measures.

Carbon dioxide is the major emissions source in Ukraine; it is responsible for 76% of national GHG emissions, thus, other greenhouse gases are not considered in this model.

The most energy intensive sectors (EIS), which are petroleum refining, electric power, metallurgy, coke products, chemical products, machinery and equipment, mineral products and the pulp and paper participate in the ETS, with the goal to reach 10% emission reduction. The emissions of the less energy intensive industries (Non EIS), namely a rest of industries aggregate, coal and hydrocarbon production and the transport sector, are taxed to achieve the same 10% reduction goal.

The simulation results show that the emission tax scenario produces the largest structural changes with a move towards the non-energy intensive industries. The aggregate output of the energy-intensive industries is reduced by 6.2% of the BaU (business as usual) benchmark. The aggregate output of non energy-intensive sectors expands by 1.12%. The aggregate Marginal Abatement Cost (MAC) is $ 0.98 /t CO_2.

Due to the absence of any implicit subsidies, auctioning of emissions permits ensures the optimal reduction in the production levels of emission trading industrial sectors, which leads to the lowest among all the trading scenarios marginal abatement costs for them. When the ETS is restricted to the domestic market only, output reduction in the EIS is about 4.15%; their MAC is $ 0.55/t CO_2. The non- trading sectors whose emissions are taxed to reach the 10% CO_2 reduction target face reduction in their output by -4.52% and a rather high MAC due to the rigidity of emission taxation which is command and control instrument of emission abatement: $10.85 /t CO_2.

Output-based grandfathering of emission permits which act as an output subsidy drastically reduces the adverse impacts on energy-intensive production. In the closed ETS the output of the trading sectors falls by 3.86%; but higher than optimal production levels lead to higher permit prices ($0.73/t CO_2) as output subsidization reduces incentives for emission reduction by output contraction. Also, in this case, more emission reduction is required from the Non ETS sectors that lead to bigger decline in their output (by 4.58%) and high MAC ($10.49/t CO_2).

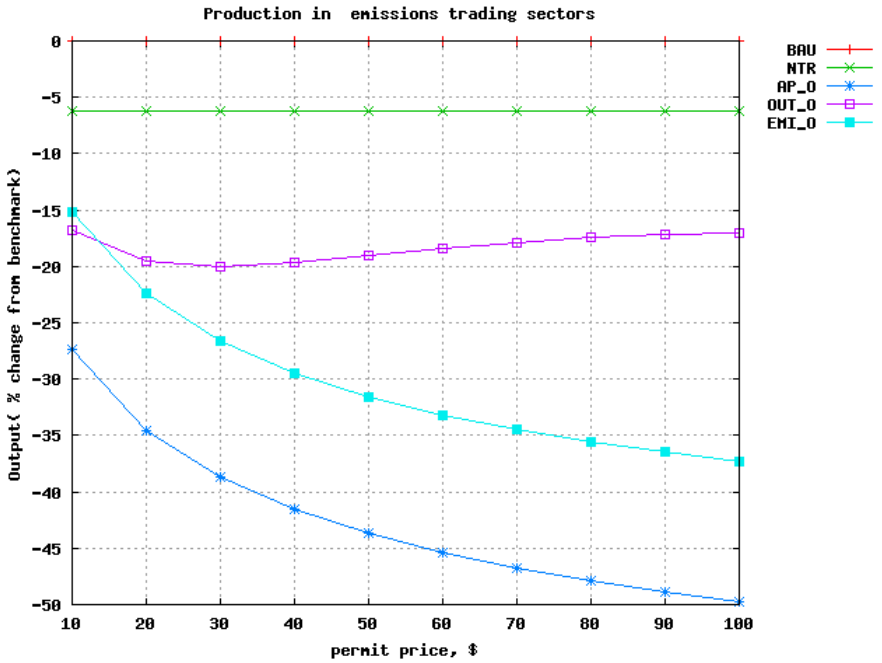
Model simulations indicate that emission-based grandfathering performs worst. Under this permit allocation option, energy consumption in the trading sectors is subsidized, rewarding production with CO_2 intensive technologies, increasing emissions and MAC and reducing the incentives to substitute away from the consumption of energy-intensive inputs and improve the energy efficiency of trading sectors. Thus, compliance with the rigid emissions limit results in strong output reduction of EIS by 4.11% and highest prices for the emission permits for EIS among all the scenarios ($5.11 /t CO_2). Output of the non trading sectors drops by 4.53%, and their MAC would be $9.91 /t CO_2.

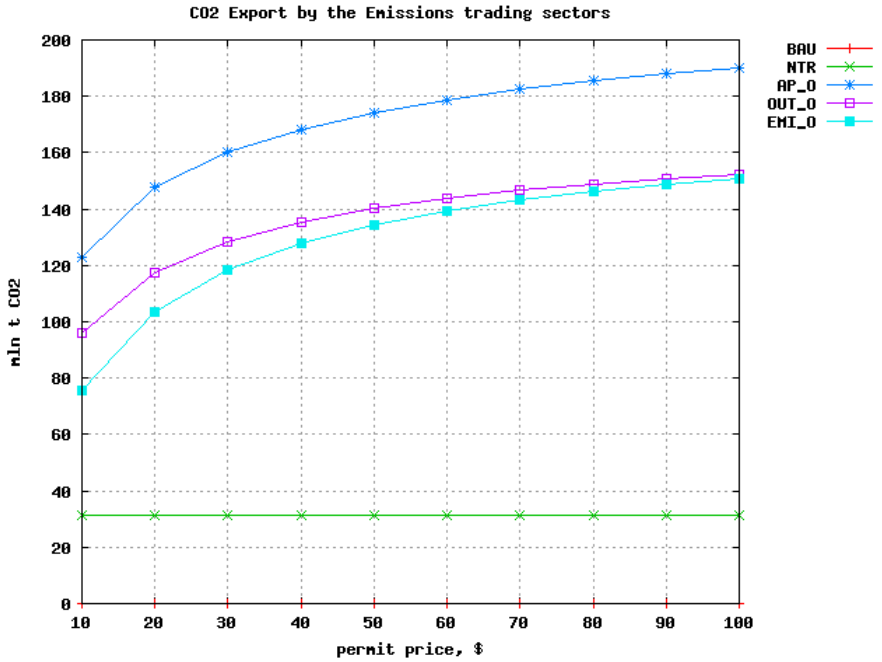
Model results reveal that for all the closed ETS scenarios and taxation the country GDP will actually remain the same due to the structural changes in favour of the less energy intensive industries.

In open emissions trading systems the trade-off between the environmental efficiency and subsidization increases in severity with increases in the international permit price. From efficiency considerations it is profitable to gradually decrease energy-intensive production towards high permit prices in order to gain from permit export (see diagrams below). Under the auctioning scenario (AP_O), reductions in production levels of the emissions trading sectors as well as CO_2 export levels are the largest. The efficiency costs for ameliorating adverse production and output effects in energy-intensive industries through output-based (OUT_O) or emission-based (EMI_O) allocation becomes more costly the higher the international permit price is. The costs reflect foregone gains from permit trade because permit exports would be smaller then the efficient volumes under auctioned permit systems.

Although, the projected international market prices for emission permits are in the range of $10-100/t$CO_2$, the estimated Ukrainian revenues from permit sale for small permit prices as $10/t$CO_2$, would vary from $800 mln (EMI_O) to $1.2 mln (AP_O), being in the middle of this

range for the OUT_O scenario: $980 mln. The emission reduction of trading sectors for the permit price of $10/t$CO_2$ would vary from -26% (EMI_O),-34% (OUT_O), till -44% (Auctioning).





In any case there are should be no doubts regarding the feasibility of an ETS implementation as a cost-effective mechanism of emission reduction. There is just the choice between the politically acceptable scheme of emission reduction which is output-based grandfathering and the environmentally effective option which is auctioning. Functioning of the emissions trading system open for the international emission market with fully elastic supply and demand would ensure the most flexible emissions reduction.

Taking into account the existing considerable subsidization of the energy-intensive industries, their strategic role in Ukrainian GDP and export formation, and significant industrial lobby that influence governmental decisions, 100% auctioning of the emission permits seems to be impossible, primarily in the short run. However, it could be reasonable to follow the hybrid allocation pattern of the European emission trading scheme: to auction about 5% of permits, grandfathering the rest of them; and to gradually increase the share of auctioned permits during the next emissions trading periods.