Technological Forecasting & Social Change xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Assessment of carbon leakage through the industry channel: The EU perspective

Leonidas Paroussos, Panagiotis Fragkos, Pantelis Capros *, Kostas Fragkiadakis

National Technical University of Athens, Department of Electrical and Computer Engineering, 9 Iroon Politechniou Street, 15773 Zografou Campus, Athens, Greece

ARTICLE INFO

Article history:
Received 31 January 2013
Received in revised form 7 February 2014
Accepted 10 February 2014
Available online xxxx

JEL classification:
D58
Q54
Q43

Keywords:
Carbon leakage
General equilibrium
Climate policy
GEM-E3
Industry relocation

ABSTRACT

Lack of consensus on an international agreement for reducing Greenhouse Gas Emissions (GHG) emissions eventually leads to asymmetric climate policies which not only increase the cost of reducing emissions but also decrease the effectiveness of the climate policy, through carbon leakage. We calculate the carbon leakage rate when EU undertakes a unilateral climate policy and we assess the importance of the competitiveness channel on carbon leakage. Our analysis is global and mirrors energy and climate policies and commitments that are currently announced at country level. The effectiveness of possible measures to mitigate carbon leakage is also evaluated and the results emphasize on the importance of the size of the group of countries participating in the GHG mitigation effort. The analysis is based on the results obtained using the GEM-E3 model, a global multi-sector and multi-country computable general equilibrium model. It is found that total carbon leakage is around 28%, over the 2015–2050 period, when the EU acts alone with moderate Armington trade substitution elasticity values; leakage rates are found to increase when assuming higher trade elasticities. The size and composition, in terms of GHG and energy intensities, of the group of regions undertaking emission reductions matter for carbon leakage. The paper finds that the leakage is significantly reduced when China joins the mitigation effort. If the USA joins the EU effort, the leakage rate drops only to 25% and if alternatively China joins the EU the leakage rate drops to 3% over the 2015–2050 period. This is attributed to both the market size of China and to the energy intensity features of its production. Chemicals and metals are industries prone to higher leakage rates.

1. Introduction

In the 15th UNFCCC[1] conference of parties held in 2009 in Copenhagen participating countries made different pledges to reduce their Greenhouse Gas (GHG) emissions by 2020. The emission reductions implied by these pledges are not enough to stabilize emission concentrations at safe[2] levels. Failure to reach a wide international agreement to reduce GHG emissions globally, eventually leads to asymmetric climate policies which not only increase the cost of reducing emissions but also decrease the effectiveness of the climate policy, because of carbon leakage [1].

Carbon leakage is defined as "The part of emissions reductions in abating countries that may be offset by an increase of the emissions in the non-abating countries" [2] and depends on: the magnitude of unilaterally performed GHG emission reductions, the exposure of the abating economies to foreign competition, the eventual measures[3] to counterbalance the adverse effects on industrial competitiveness, the technology

* Corresponding author. Tel.: +30 210 772 3629; fax: +30 210 772 3630.
E-mail address: kapros@central.ntua.gr (P. Capros).

[1] United Nations Framework Convention on Climate Change.

[2] According to the Intergovernmental Panel on Climate Change (IPCC) (Fourth Assessment Report) global GHG emissions in 2050 should be reduced by at least 50% from 1990 levels.

[3] Different measures have been proposed (but not always adopted) to protect the competitiveness of these industries including preferential allocation of grandfathered allowances to energy-intensive manufacturing, output based rebating (OBR) or border carbon adjustments (BCA).

http://dx.doi.org/10.1016/j.techfore.2014.02.011
0040-1625/

spillovers and the size, both in terms of GHG emissions and GDP, of the countries involved in the abatement effort.

Optimal (least cost) climate change mitigation at a global scale implies exploiting the cheapest emission reduction options across all regions and all sectors at the margin. As international climate negotiations made very slow progress in recent years, increasing skepticism prevails about the actual prospects of global concerted action against climate change. Consequently, the research has shifted towards regional climate action and the impacts of unilateral emission reduction policies. So carbon leakage can occur and effectively reduce emission reduction achieved in the carbon abating countries.

The channels through which carbon leakage occurs are: i) the energy channel (increase of energy consumption in non-abating countries induced by lower international fossil fuel prices due to emission reduction, hence lower fuel consumption, in the abating regions) and ii) the industry channel (due to different relative costs, energy intensive production partly shifts from countries applying emission reduction policies to countries that do not).

Carbon leakage raises concerns for climate policy especially in the EU which has decided to pursue ambitious targets for reducing GHG emissions [3,4]. The EU can be considered as a first mover in global GHG mitigation. The EU has established the worlds' largest emissions trading system (EU ETS), has already implemented a series of emission reduction, energy efficiency and RES deployment policies, and has confirmed a long-term objective to reduce GHG emissions in 2050 by at least 80% relative to 1990 levels.

The net macroeconomic impact on countries that pursue unilateral action in mitigating GHG emissions has been widely studied [5–8]. The net impact is uncertain as early movers incur costs but may also benefit from gaining a cost comparative advantage on producing low carbon technologies; the costs depend on the loss in competitiveness that leads to a decrease of their shares in global markets.

The purpose of this paper is to explore the effects of unilateral climate policy of the EU and quantify the carbon leakage within a dynamic and policy relevant framework by 2050. The paper also examines how the leakage rate changes if other regions join the ambitious emission reduction targets of the EU, such as China and the USA. The current paper is part of the AMPERE study on staged accession scenarios for climate policy (which is presented in detail in [37]). Apart a reference case projection, used as a benchmark for scenario comparison, the paper presents three alternative scenarios which vary regarding the extent of emission reduction coalition, namely the EU-only case, the China and the EU case and the USA and the EU case. As the leakage rate depends on the degree of competition in world trade[4] the (Armington [9]) substitution elasticity values are assumed to vary across sensitivity analysis scenarios. The sensitivity analysis assumes either uniform variation (i.e. doubling or halving elasticity values for all industries) or industry specific variation (different changes of elasticity values by sector).

The paper estimates carbon leakage rates from quantitative projections of the world economy, under different assumptions, using the GEM-E3 model, a computable general equilibrium model covering the whole world disaggregated into 37 countries/regions and 27 types of activity [10]. GEM-E3 is a recursive dynamic model with a bottom-up representation of the energy system and covers the period from 2010 to 2050 in 5-year steps. The model links all countries and sectors through endogenous bilateral trade flows.

The specification of the reference scenario takes into account the current fragmentation in global climate policies and includes a very detailed assessment of regional emission targets and thus it takes into account climate policies as currently announced by the various countries.

The remainder of this paper is organized as follows. In Section 2 the paper provides a short review of the literature on carbon leakage. Section 3 summarizes the main channels and drivers of carbon leakage. Section 4 presents the model-based policy simulations. Section 5 discusses the results of the scenario projections and the sensitivity analysis. Section 6 draws concluding remarks.

2. Literature review

A substantial empirical literature examining the issue of carbon leakage has already emerged. General equilibrium models have been used to quantify the carbon leakage rates for cases assuming that the EU or a larger coalition (i.e. Annex I countries of the Kyoto Protocol) unilaterally adopt GHG emission reduction policies. A leakage rate is defined as the ratio of emissions increased in the regions not pursuing climate mitigation actions over the emissions reduced in the regions applying emission reduction policies.

The Energy Modeling Forum EMF-29[5] carried out a model inter-comparison study with twelve static CGE models involved in the assessment of the role of Border Carbon Adjustment (BCA) in unilateral climate policies [1,11]. The EMF study shows that the sectors that present the higher carbon leakage rates are the energy intensive industries and generally the sectors with high exposure to foreign trade. The carbon leakage can be significantly reduced by the imposition of appropriate counter balance measures such as BCA, exemptions, output based allocations. However BCA and other measures such as exemptions and output based allocations are found to have distributional (among countries) and cost impacts.

The literature is not conclusive on whether the industry channel or the energy channel contributes more to carbon leakage. If the effects from the energy channel are canceled out (i.e. OPEC adjust its production so that international prices do not decrease) the leakage rate is reduced from 11.8 to 2.5% [12]. But [13] suggests that when the adverse effect on the industry competitiveness is moderated, the leakage rate can be as low as 1% without accounting for leakage from the energy channel.

Leakage from the energy channel depends on the size of the economies that participate in the emission reduction effort and their energy intensity, as the impact on fossil fuel prices at global level depends on the volume of demand reduction. If emission reduction does not reduce demand for fossil fuels, as for example by employing carbon capture and storage, the effect on international fossil fuel prices can be modest.

[4] In the model domestically produced and imported commodities are considered as imperfect substitutes (Armington assumption).

[5] "The Role of Border Carbon Adjustment in Unilateral Climate Policy".