Technological Forecasting & Social Change 90 (2015) 192–203

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Carbon leakage in a fragmented climate regime: The dynamic response of global energy markets

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ARTICLE INFO

Article history:
Received 9 April 2013
Received in revised form 2 October 2013
Accepted 3 October 2013
Available online 10 November 2013

JEL classification:
F47
Q54
Q56

Keywords:
Climate policy
Copenhagen pledges
Carbon leakage
Fossil energy markets

ABSTRACT

As a global climate agreement has not yet been achieved, a variety of national climate policy agendas are being pursued in different parts of the world. Regionally fragmented climate policy regimes are prone to carbon leakage between regions, which has given rise to concerns about the environmental effectiveness of this approach. This study investigates carbon leakage through energy markets and the resulting macro-economic effects by exploring the sensitivity of leakage to the size and composition of pioneering regions that adopt ambitious climate action early on. The study uses the multi-regional energy–economy–climate model REMIND 1.5 to analyze the implications of Europe, China and the United States taking unilateral or joint early action. We find that carbon leakage is the combined effect of fossil fuel and capital market re-allocation. Leakage is limited to 15% of the emission reductions in the pioneering regions, and depends on the size and composition of the pioneering coalition and the decarbonization strategy in the energy sector. There is an incentive to delay action to avoid near-term costs, but the immediate GDP losses after acceding to a global climate regime can be higher in the case of delayed action compared to early action. We conclude that carbon leakage is not a strong counter-argument against early action by pioneers to induce other regions to adopt more stringent mitigation.

1. Introduction

Despite the international ambition to keep global warming below 2 °C relative to pre-industrial mean temperature, higher levels of warming are increasingly probable as GHG emissions continue to rise. There is a gap between the stringency of current GHG emission-reduction commitments and long-term mitigation efforts that would be needed to limit warming to 2 °C, or to stabilize atmospheric GHG concentration at 450 ppm CO_2e. Due to the extremely demanding set of challenges that it represents [1,2] a globally binding agreement to stabilize climate change has not yet been reached. In the absence of a global agreement, action on climate change mitigation is emerging in a fragmented manner. A fragmented climate regime is characterized by unequal carbon prices across regions and sectors. A fragmented climate regime, like the Copenhagen pledges [3] can pave the way for a broader and universal regime in the long run [4]. However, in the short- and medium-term, carbon leakage may impact the effectiveness of overall mitigation [5,6].

Carbon leakage is defined as the additional CO_2 emissions of non-mitigating participants (i.e. subjected to a weak reference policy) compared to the CO_2 abatement achieved by pioneering regions (i.e. pursuing additional policy ambition). Carbon leakage is an important aspect of fragmented regimes as it has implications on GDP growth [7], trade [8], employment [9], emissions [10,11] and business decisions [12].

Carbon leakage can take place through four different mechanisms or channels that are activated by policy-induced changes in relative prices [13]: (i) changes of international fossil fuel trade, which has been called the energy channel; (ii) changes of international trade in goods and services that

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http://dx.doi.org/10.1016/j.techfore.2013.10.002

embody carbon emissions generated during the production process, also known as the product market or competitiveness channel; (iii) international trade in factors of production, i.e. the capital market channel; and, (iv) international spillovers, i.e. the technology and policy diffusion channel. Channels (ii & iii) are theoretically explained by the pollution haven or factor endowment hypotheses [14]. The energy channel [15] results from reduced demand for fossil fuels due to unilateral action in emission abating regions, which depresses global energy prices and induces larger demand and consumption in non-abating regions.

Hassler and Krusell [16] assessed qualitatively the welfare consequences of different carbon taxes across, as well as within, oil-consuming and -producing regions, using a dynamic stochastic general-equilibrium model. Their results showed a "perfect leakage" effect (i.e. all emission reductions of one country are off-set by other countries) when carbon taxation was imposed unilaterally, particularly due to a re-allocation effect on oil use from oil producing to oil consuming regions, by lowering the oil price.

Following a regionally specific approach, Böhringer et al. [8] studied quantitatively the impact of specific climate policies by two major economies, Europe and the United States, over global distribution of economic and environmental outcomes. In their study a generic multiregional, multi-sector CGE model of global trade and energy was used and showed a global carbon leakage rate[1] of up to 28% and 10% when Europe and the United States, respectively, reduced emissions due to climate policy. The study highlights the energy channel as the main reason for carbon leakage.

Kuik [13] estimated quantitatively carbon leakage under a fragmented climate policy regime such as the Kyoto Protocol. Using a CGE model, his assessment showed emission increase in non-constrained regions due to increase in energy use and decrease of energy efficiency. He estimated a rate of about 11% due to fragmented climate action.

Bosetti and de Cian [17] studied the cost–benefit considerations that would lead OECD countries to undertake increasing abatement efforts in line with the Copenhagen pledges. In contrast to the previous studies, they used an integrated assessment model with game theoretic structure and detailed representation of the energy sector as well as economic growth. The results showed that when OECD countries followed ambitious targets, free-riding incentives and carbon leakage induced non-members to increase emissions compared to reference baseline. However, the carbon leakage rate decreases with the level of ambition as more ambitious targets by the coalition fostered innovations and technology advancements, and induced reduction of emissions in non-signatory regions due to technology and knowledge transfers.

Böhringer et al. [18] summarized the results of a CGE model inter-comparison exercise aiming at investigating the economic impacts of border carbon adjustment as a complementary instrument to domestic climate policy. In the exercise, a collective CO_2 emission reduction target of 20% below the 2004 levels was imposed on the abatement coalition roughly reflecting post-Kyoto reduction commitments. Based on this, the exercise showed statically a carbon leakage rate between 5% and 19%. The range of leakage effects among the models used in the exercise was traced back and attributed to assumptions about the degree of fossil fuel supply responses and heterogeneity in traded goods, and the regions' flexibility to substitute domestic and foreign goods. The study showed that as model regions can more easily substitute new sources for energy-intensive and trade-exposed goods in response to changes induced by climate policy, the stronger leakage it was. Additionally, the authors highlighted the importance of the competitiveness channel rather than the energy channel for carbon leakage.

McKibbin et al. [19] studied the role of the capital market channel in the context of the Kyoto Protocol. Based on an empirical relationship to represent the saving-consumption decision of households, the study does not find a positive contribution to carbon leakage because the implementation of uni-lateral climate policies induces a net capital inflow for example for the US.

The present study contributes to the scientific literature of carbon leakage via the energy and the capital market channel by studying long-term impacts of additional policy ambition in a fragmented global climate policy regime. Regarding the energy channel, we (i) explore the sensitivity of leakage to the size and composition of abatement action of mitigating regions, focusing on Europe, China and the United States; and, (ii) assess the dynamic leakage effects due to unilateral or joint early action, taking into account its potential evolution in time. The present study also contributes to the literature by analyzing carbon leakage via the capital market channel, which is a novelty, since capital market reallocations are induced by regional interest rate differentials within an intertemporal framework. In this context, we applied the multi-regional energy–economy–climate model REMIND 1.5. REMIND is suitable for the analysis of long-term impacts of fragmented climate policy because it captures the interactions between economy, energy sector, trade and climate mitigation policy.

We start the analysis with scenarios in which the world adopts weak and fragmented policies to limit carbon emissions and non-fossil technology targets. In this setting Europe acts as a front runner by implementing additional policies. Looking at early European unilateral action is interesting as, to date, it has been a leading region in adopting climate policy [20]. For this reason, it is possible to think that Europe is in the position to foster the shift towards low-carbon development pathways, and at the same time motivating other regions to increase efforts towards climate change mitigation. We investigate what is the role for carbon leakage in such unilateral climate action.

Next, we explore the role of partial cooperation of China or the United States in bridging the transition to a global cooperative regime. Thus, this investigation aims to analyze how the size of the pioneering coalition impacts on the role for carbon leakage. Choosing China and the United States as cooperating regions follows three main arguments. Firstly, both countries are top GHG emitters in the world, which makes it interesting to assess given the potential overall environmental effects that could arise when they pursue stringent mitigation in coalition with Europe. Secondly, as China is a fossil resource importer and the United States a potentially significant coal exporter, it is relevant to analyze the impact their emissions abatement would have on global energy trade; particularly, regarding supply changes in fossil fuel rich regions and demand changes in non-cooperating regions. Finally, a broadening of international

[1] In this context, carbon leakage rate is defined as the change in non-abating regions' emissions over domestic emission reduction.