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Analysis

Would border carbon adjustments prevent carbon leakage and heavy industry competitiveness losses? Insights from a meta-analysis of recent economic studies

Frédéric Branger [a,b,*], Philippe Quirion [a,c]

[a] CIRED, 45 bis avenue de la Belle Gabrielle, 94736 Nogent-sur-Marne Cedex, France
[b] ENGREF AgroParistech, 19 avenue du maine, 75732 Paris Cedex 15, France
[c] CNRS, France

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ABSTRACT

The efficiency of unilateral climate policies may be hampered by carbon leakage and competitiveness losses. A widely discussed policy option to reduce leakage and protect competitiveness of heavy industries is to impose border carbon adjustments (BCAs). The estimation of carbon leakage as well as the assessment of different policy options led to a substantial body of literature in energy-economic modeling.

In order to give a quantitative overview on the most recent research of the topic, we conduct a meta-analysis on 25 studies, altogether providing 310 estimates of carbon leakage ratio according to different assumptions and models. The typical range of carbon leakage estimates are from 5% to 25% (mean 14%) without policy and from −5% to 15% (mean 6%) with BCAs.

A meta-regression analysis is performed to further investigate the impact of different assumptions on the leakage estimates. The decrease of the leakage ratio with the size of the coalition is confirmed and quantified. Among the BCA options, the extension of BCAs to all sectors and the inclusion of export rebates are the most efficient features in the meta-regression model to reduce the leakage ratio. All other parameters being constant, BCAs reduce leakage ratio by 6 percentage points.

1. Introduction

International climate agreements are likely to remain subglobal in the years to come: the global climate architecture is shifting from a UNFCCC-led top-down regime to a bottom-up approach (Rayner, 2010). Differences in abatement targets among countries may lead to two distinct but interrelated issues: carbon leakage and competitiveness losses, especially among Energy Intensive Trade Exposed (EITE) sectors, such as cement, steel or aluminum (Dröge, 2009). Indeed, the asymmetry of carbon costs between regions may induce a shift of production of carbon intensive products from carbon-constrained countries to less carbon-constrained countries. As carbon dioxide is a global pollutant, i.e. the geographic location of emissions has no influence on its environmental impacts, this carbon leakage would reduce the environmental effectiveness of the climate policies. Moreover, these production losses in heavy industries would also damage the economy and involve job destructions.

Carbon leakage and competitiveness issues have been two of the main arguments against the implementation of ambitious climate policies. A growing body of academic literature has been developed in the recent years to quantify the impacts of uneven climate policies and to find the best policy measures to counteract them. Among them, border carbon adjustments (BCAs), which consist in taxing products at the border on their carbon content, are widely discussed. Their consistency with the World Trade Organization (WTO) as well as their political consequences remain highly contentious among legal experts: they could constitute an incentive to join the climate coalition or trigger a trade war because of green protectionism suspicions.

Ex post econometrical studies have not revealed so far any evidence of carbon leakage (Ellerman et al., 2010; Quirion, 2011; Reinaud, 2008; Sartor, 2013) predicted in analytical models (Fischer and Fox, 2012; Hoel, 1996; Jakob et al., 2013; Markusen, 1975). Ex ante modeling are dominated by computable general equilibrium (CGE) models (Böhringer et al., 2012a) but there are also some sectoral partial equilibrium models (Mathiesen and Maestad, 2004; Monjon and Quirion, 2011b). Some literature reviews have been published recently on the subject (Branger and Quirion, 2013; Dröge, 2009; Gerlagh and Kuik, 2007; Quirion, 2010; Zhang, 2012) but to our knowledge no quantitative meta-analysis has been conducted on this topic.

Meta-analysis is a method developed to provide a summary of empirical results from different studies and test hypotheses regarding the determinants of these estimates (Nelson and Kennedy, 2009). It has been extensively used in medical research. The first meta-analysis

* Corresponding author at: CIRED, 45 bis avenue de la Belle Gabrielle, 94736 Nogent-sur-Marne Cedex, France.
E-mail addresses: branger@centre-cired.fr (F. Branger), quirion@centre-cired.fr (P. Quirion).

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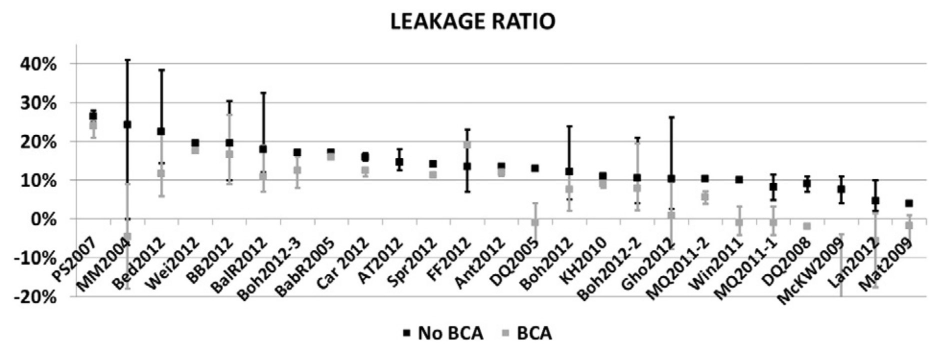

Fig. 1. Leakage ratio in selected studies (mean, minimum and maximal values with or without BCAs), ranked by mean value without BCAs.

in economics can be traced back to Stanley and Jarrell (1989). In the field of environmental and resource economics, the majority of meta-analyses summarizes the results of different nonmarket valuation studies (Barrio and Loureiro, 2010; Brander and Koetse, 2011; Ojea and Loureiro, 2011; Richardson and Loomis, 2009; Van Houtven et al., 2007). Closer to our subject, one can cite two studies on marginal abatement costs to mitigate climate change, one for all sectors (Kuik et al., 2009) and the other specifics to agriculture (Vermont and De Cara, 2010). An extensive review of meta-analysis methods in environmental economics is given in Nelson and Kennedy (Nelson and Kennedy, 2009).

In this article, we conduct a meta-analysis on 25 studies dating from 2004 to 2012, altogether providing 310 estimates of carbon leakage ratios according to different assumptions and models. The typical range of carbon leakage estimates is from 5% to 25% (mean 14%) without policy and from −5% to 15% (mean 6%) with BCAs. We conduct a meta-regression analysis to further investigate the impact of different assumptions on carbon leakage estimates. Impact of key model parameters, such as Armington elasticities, and policy features such as linking carbon markets or extending pricing to all greenhouse gases sources can be highlighted. We find that, all other parameters being constant, BCAs' implementation reduces the leakage ratio by 6 percentage points.

The remainder of this paper is structured as follows. Section 2 describes the database and Section 3 provides some descriptive statistics. The meta-regression model is explained in Section 4 and results are discussed in Section 5. Section 6 concludes.

2. Database Description

Many articles and working papers deal with carbon leakage and competitiveness issues but only some of them are models giving ex ante numerical estimates. The body of literature regarding these issues also comprises ex post econometrical analyses, analytical models and political or juridical studies (Cosbey et al., 2012; Ismer and Neuhoff, 2007; Monjon and Quirion, 2011b). The first criterion to be part of our sample was to provide numerical estimations of carbon leakage with a model. The second criterion was, since the purpose of this paper is to investigate the impact of border carbon adjustments on leakage, to include BCAs in the scenarios. Thirdly, we discarded old studies (before 2004) to focus on the recent literature.

To constitute our sample, we searched for studies in standard search engines (Web of Science, Google Scholar) and cross references with keywords "carbon leakage" and "border carbon adjustments". The research was completed in December 2012. Our sample is made of 25 studies dating from 2004 to 2012, most of them (14) are part of the recent Energy Economics Special Issue. Some are grey literature (MIT working paper, World Bank working paper, etc.); others are published in energy economics and environmental economics journals (Energy Economics, Energy Policy, the Energy Journal, Energy Policy, Climate Policy etc.). The majorities are computable general equilibrium (CGE) models which rely on the GTAP database (except for one); the others are sectoral or multi-sectoral partial equilibrium models. The number of carbon leakage estimates per study varies from 2 (Weitzel et al., 2012) to 54 (Alexeeva-Talebi et al., 2012a), with a mean of 12.6.

The studied effect-size in the meta-regression analysis is the leakage-to-reduction ratio or leakage ratio,

$$l = \frac{\Delta E_{NonCOA}}{-\Delta E_{COA}}.$$

where ΔE_{COA} is the emission variation in the climate coalition between the climate policy scenario and the counterfactual business-as-usual scenario, and ΔE_{nonCOA} is the emission variation in the rest of the world. Its common use avoids us to make approximate conversions between studies. In other words all studies calculate the same thing, which is necessary in a meta-analysis as a "synthesis requires the ability to define a common concept to be measured" (Smith and Pattanayak, 2002).

The majority of the case results were available on tables, but sometimes they were taken from graphs or derived from own calculation like in Mattoo et al. (2009).

3. Descriptive Statistics

3.1. First Sight

Fig. 1 presents ranges of leakage ratio estimates for the 25 studies (mean, minimum and maximal values with or without BCAs). Leakage ratio estimates range from 2% to 41% without BCAs and from −41% to 27% with BCAs. Eight studies find negative values of leakage ratio in case of BCAs, with three studies (Lanzi et al., 2012; Mathiesen and Maestad, 2004; McKibbin et al., 2008) finding values below −15%. Internal variations (within one study) of leakage ratio estimates range from almost null (Alexeeva-Talebi et al., 2012b) to relatively high (Bednar-Friedl et al., 2012; Ghosh et al., 2012; Mathiesen and Maestad, 2004) depending on the scenarios and models.

Comparing scenarios by pair (with and without BCAs, all the other parameters being constant); we can observe that in all cases, BCAs led to a reduction of the leakage ratio (see Fig. 2).[1] These results are in contrast with Jakob et al. (2013) who found that BCAs could increase the leakage ratio.[2] For each pair, we calculate the leakage ratio reduction in percentage points (defined as $LeakageRatioReduction = -LeakageRatio_{NoBCAs} - LeakageRatio_{BCAs}$). In the majority of the cases, the leakage ratio reduction due to BCAs stands between 1 and 15 percentage points, but there are some outliers above 30 percentage points, where BCAs actually generate negative leakage ratios (Mathiesen and Maestad, 2004; McKibbin et al., 2008).

[1] In Fig. 1, for FF2012 (Fischer and Fox, 2012), the mean with BCAs is higher than that with no BCAs, but the equivalent BCA scenarios correspond to the highest value of leakage ratio of the no BCA scenario (Europe only abating).

[2] In this paper, under certain conditions, if in non-coalition countries, the carbon intensity of exports (clean sector) is higher than those of local production (dirty sector), a reallocation of production induced by BCAs from clean to dirty sector would increase emissions in non-coalition countries and then leakage ratio on a global scale.