Potential carbon leakage risk in agriculture under future EU-ETS scenarios

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Abstract: Unilateral climate mitigation policies could significantly increase carbon leakage risk in agricultural sectors. One of these policies is the European Union's Emission Trading System (EU-ETS), which could affect agricultural sectors differently depending on its future design and stringency. This paper reviews the relevant carbon leakage channels in agriculture and estimates its magnitude in these sectors under different future EU-ETS scenarios until 2050. To simulate these scenarios, we use the Modular Applied General Equilibrium Tool (MAGNET) model and consider CO2 and non-CO2 emissions. Our preliminary results (not shown) show considerable carbon leakage effects under some EU-ETS scenarios. Furthermore, we find that the proposed EU's carbon border adjustment mechanism cannot considerably reduce these effects.

Keywords: Applied general equilibrium analysis; climate policy; climate change; global economic analysis.

1 Introduction

Unilateral climate mitigation policies could significantly increase carbon leakage risk in agricultural sectors, even if these sectors remain out of these policies (Fournier Gabela and Freund 2022; Beck et al. 2023). Carbon leakage matters because it could slow down the mitigation levels required to achieve net-zero objectives pledged, to date, by more than 130 countries.[1] For example, carbon leakage risk is often cited as one of the main reasons why agricultural sectors refuse to adopt

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[1] https://zerotracker.net/

climate-friendly practices and participate in national climate policies (Murray and Rivers 2015; Wreford et al. 2017). This is not different in the European Union: carbon leakage risk has been a major reason for agricultural sectors remaining out of the EU's Emission Trading System (EU-ETS) (Grosjean et al. 2018). Moreover, due to the possible effects of the EU's carbon border adjustment mechanism (EU-CBAM), which would make imports of agricultural inputs (e.g., fertilizers) more expensive, there is political pressure for some of these sectors to receive public aid, for example, by including them in the EU-CBAM or allocating part of its revenue to them.[2]

But how strong could carbon leakage risk be in agriculture under different EU-ETS scenarios, and how does this magnitude compare to that in other economic sectors? Even though the extant literature provides a general idea, it has some limitations in answering these research questions. First, we are unaware of studies estimating carbon leakage risk in agricultural sectors due to the inclusion of these in the EU-ETS; although several studies analyze other climate policies, analyzing the EU-ETS is relevant because, being the main mitigation strategy of the European Union, it is the most probable carbon pricing mechanism to be applied to these sectors in the future. Second, studies analyzing the EU-ETS and the EU-CBAM treat agriculture as an aggregate sector; however, since carbon leakage magnitudes can vary widely between sub-sectors (Alexeeva-Talebi et al. 2012; Fischer and Fox 2018), a better sectoral resolution is vital to understand the carbon leakage dynamics and design anti-leakage mechanisms. These studies usually ignore non-CO2 emissions and land-use and land-use-change (LULUC) emissions; because these emissions have a significant weight for the agricultural sectors, ignoring them would imply strongly underestimating leakage risk in these sectors.

To fill this research gap, we estimate carbon leakage risk under different EU-ETS scenarios affecting agricultural sectors' production costs differently. The first scenario represents the current situation, in which the EU-ETS increases the price of domestic agricultural inputs covered by it (e.g., fertilizers). The second scenario represents a more stringent scenario, in which the EU-CBAM also makes importing agricultural inputs covered by the EU-ETS more expensive. Under the third scenario, the EU-ETS also covers agricultural sectors, thus making their production costs more expensive in direct proportion to their direct emissions. Finally, under the fourth scenario, the EU-CBAM also includes the agricultural sector; the difference between scenarios three and four represents the ability of the EU-CBAM to reduce leakage risk in agricultural sectors. To simulate these climate policy scenarios, we use the Modular Applied General Equilibrium Tool (MAGNET) model (Woltjer and Kuiper 2014), a multi-sector and multi-country computable general equilibrium model based on the standard Global Trade Analysis Project (GTAP) model (Hertel 1997). In contrast to it, the MAGNET model offers a greater sectoral granularity in agriculture and allows us using different useful extensions allowing us to estimate carbon leakage by considering CO2 and non-CO2 emissions, and including land-based emissions, e.g., due to deforestation.

Our article is structured as follows: section 2 presents the different forms that carbon leakage can take in agriculture and makes a literature review of the studies estimating its magnitude; section three introduces the model, its extensions, and the data; section four presents the results; section five discusses the policy implications and limitations of this study; finally, section six concludes and suggests some future research opportunities.

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=EP%3AAGRI_AD%282022%29699239

2 Background

2.1 The EU-ETS and carbon leakage

The EU-ETS is a main pillar of the European Union's climate policy and the world's largest multilateral greenhouse gas emissions trading regime. Under this cap-and-trade system, the European Union places a limit on the volume of GHG emissions that European producers can emit. These emission permits can then be traded among the different producers. This makes emissions mitigation happen where it is cheapest in the economy. In this way, the EU-ETS is a flexible and efficient way to reduce emissions. In the end, the EU-ETS provides a price signal that seeks to internalize the pollution costs of producers and encourage the reduction of emissions.

Including the agricultural sectors in the EU-ETS could be particularly relevant. First, mitigating agricultural emissions is necessary to achieve climate goals cost efficiently and on time (Rogelj et al. 2018; Wollenberg et al. 2016). Pricing agricultural GHG emissions in this way could help exploit the dormant mitigation potential in agriculture (OECD 2019) and generate a price signal that leads to changing consumer diets. Moreover, including agricultural GHG emission could increase the cost-efficiency of the EU-ETS because many mitigation opportunities could be cheaper in agricultural sectors than in other economic sectors (Metcalf and Weisbach 2009).

However, in a world of heterogenous mitigation efforts, a main disadvantage of the EU-ETS is that it could cause carbon leakage, i.e., its reduction in GHG emissions could lead to an increase in emissions in foreign countries with weaker mitigation policies.[3] Carbon leakage could reduce the effectiveness of domestic emission reductions, cause economic losses to affected sectors, and reduce international cooperation. Moreover, carbon leakage risk could reduce domestic support for more ambitious climate policies. For example, the risk of carbon leakage is cited as one of the main reasons why agricultural sectors remain outside the EU-ETS (Grosjean et al. 2018). Many studies also cite carbon leakage risk as a primary reason for opting for less attractive mitigation policies, such as providing abatement payments to cover farmers' mitigation costs (OECD 2019).

The main European Union' strategy to combat carbon leakage has long been the free allocation of emission certificates (Mörsdorf 2022). However, due to several disadvantages of this system, the new neutrality strategy points to the use of a CBAM, which would gradually displace the old system (Mörsdorf 2022). The EU-CBAM (European Commission 2021) would force importers of emission-intensive products (iron and steel, cement, fertilizers, aluminum, and electricity) to surrender certificates for the direct emissions embodied their imported products. In this way, local and international producers would be subject to the same carbon costs as the EU-ETS in Europe. However, several studies argue that a CBAM could also affect the competitiveness of downstream sectors (Houser et al. 2008; Kuik and Hofkes 2010).

[3] This policy-induced carbon leakage is known as strong carbon leakage, in contrast to weak carbon leakage, which is caused by changes in consumption, e.g., dietary changes Peters 2010.

2.2 How could the EU-ETS cause carbon leakage in agriculture?

The EU-ETS could cause carbon leakage in the agricultural sectors in different ways. The first is through an increase in carbon costs, which can be direct or indirect (Foucherot and Bellassen 2013). While direct carbon costs refer to the costs that producers would have to incur when purchasing emission certificates due to their direct emissions, indirect carbon costs refer to carbon costs passed on to buyers via more expensive production inputs due to mitigation actions in other sectors. Rising carbon costs could make domestic products more expensive relative to foreign products exempt from comparable mitigation policies. This could cause some of these domestic products to be replaced by foreign products and therefore production and carbon emissions to simply be shifted to these countries. Importantly, if the intensity of emissions in foreign countries is higher than in the EU, these emissions could be greater than the emissions savings. This carbon leakage channel could be of relative concern in agriculture because many of its products have low value added, which implies that future carbon costs have a relatively stronger impact on their production costs (Fournier Gabela and Freund 2022).

The EU-ETS could also generate carbon leakage in agriculture through its impact on food and agricultural inputs prices. Similarly to the its effect on energy markets, if the EU-ETS led to a reduction in the demand for certain of these products, their prices could be reduced. This could, in turn, increase their demand and emissions in international markets. Note, however, that the effect of this channel can also be negative, if the increased demand in foreign countries leads to the substitution of other even more polluting products (Caron 2022).

Another important way in which the EU-ETS could lead to carbon leakage in agriculture would be through its impact in land demand. For example, if the EU-ETS leads to the adoption of climate friendly agricultural practices, such as extensification practices, it is possible that this will increase the demand for agricultural land in countries where these practices are not adopted (Clora et al. 2021). Depending on the type of country where this happens, it could lead to converting natural ecosystems such as forests, grasslands, and wetlands into cropland, which could result in an overall increase in GHG emissions.

Note that there are other possible forms of carbon leakage in agriculture that would not be applicable to the EU-ETS. The first is market redirection leakage(Wilman 2019), according to which a climate policy could cause producers to ship dirty products to less-selective markets and clean products to countries with stringent mitigation policies, without changing their total emissions. Although it could happen under a CBAM based on actual emission intensities, this type of carbon leakage is more applicable to consumption-side mitigation policies, e.g., food taxes or import tariffs. The second is carbon leakage occurring when a migration policy seeks to reduce emissions in a specific country, which could increase emissions in other countries. An example of these policies are zero deforestation policies (Villoria et al. 2022).

Finally, note that there are also channels associated with negative carbon leakage. For example, this could occur if domestic mitigation policies encourage technological innovations, which, when adopted by foreign countries, could reduce their emissions per unit of production (Gerlagh and Kuik 2014). This *international technology spillover* channel could be relatively important in agriculture because of the large productivity gaps between developed and developing countries (Lybbert and Sumner 2012).

2.3 Carbon leakage projections

Due to the lack of empirical evidence, one of the most popular ways to estimate the magnitude of carbon leakage is with the help of economic models. One option would be to look at studies simulating carbon prices in agriculture (Pérez Domínguez et al.; Key and Tallard 2012; Golub et al. 2013; van Doorslaer et al. 2015; Himics et al. 2018; OECD 2019; Frank et al. 2021). The carbon leakage rate in these studies, i.e., the ratio between emission increases in third countries and emission reductions inside countries implementing carbon pricing, ranges from 16% to 153%. A leakage rate exceeding 100% means that emission increases in unregulated countries exceed emission savings in the regulated country, thus generating a carbon misallocation from a global perspective (Blandford 2018). Importantly, the previous estimates suggest that carbon leakage risk could be higher in the agricultural sector than in energy-intensive industries, with leakage rates typically ranging from 5% to 25% (Branger and Quirion 2014). Unfortunately these studies suffer from several limitations; for example, most studies ignore carbon pricing in other economic sectors, which masks carbon leakage effect due to indirect carbon costs. Similarly, most studies use partial economic models, which did not allow for some of the carbon leakage channels, such as the international price channel.

An idea might also be gained from studies that simulate economy-wide mitigation policies, some of which report carbon leakage in the agricultural sector as a whole. Unfortunately, these studies also suffer from several limitations. Firstly, they ignore non-CO2 emissions and land-use and land-use-change (LULUC) emissions; because these emissions have a significant weight for the agricultural sectors, ignoring them would imply strongly underestimating leakage risk in these sectors. Secondly, these studies treat agriculture as an aggregate sector; however, since carbon leakage magnitudes can vary widely between sub-sectors (Alexeeva-Talebi et al. 2012; Fischer and Fox 2018), a better sectoral resolution is vital to understand the carbon leakage dynamics in agriculture.

A final option could be to look studies using carbon leakage risk indicators. For example, Fournier and Freund (2022) use the European Union’s carbon leakage risk indicator to compare carbon leakage risk across sectors in the OECD area. The authors find that carbon leakage risk in agriculture could be comparable to that in industrial or materials sectors under various hypothetical climate policy scenarios implying different carbon costs. However, note that this indicator only gives an idea of the potential risk of carbon leakage due to increases in carbon costs.

3 Methods, data, and scenarios

3.1 The MAGNET model & extensions

We use the MAGNET model for the assessment of our four future EU-ETS scenarios. The MAGNET model (Woltjer and Kuiper 2014) is a dynamic multi-sector and multi-country computable general equilibrium model based on the standard Global Trade Analysis Project (GTAP) model (Hertel 1997). While the GTAP model and its different versions have been widely used for climate policy analysis, including the EU-ETS (e.g., Mörsdorf 2022), the MAGNET model has been mainly used for food policy analysis and rather recently for climate policy analysis (see, e.g., Frank et al. 2021 or Fujimori et al. 2022). CGE models are especially well-suited to analyze carbon leakage and have several advantages over other models (Carbone and Rivers 2017, pp. 29–30).

In MAGNET, trade is presented by an Armington spatial equilibrium, meaning that imports and domestic goods are imperfect substitutes. MAGNET considers CO2 and non-CO2 emissions which are generated by production sectors, governments, and households. More specifically, these emissions include: 1) combustion emissions from fossil fuels, which change for different quantities of inputs used and technical change; 2) non-combustion emissions, which happen as a consequence or are a by-product of undertaking specific activities. As usual in the literature, we incorporate the EU-CBAM into the model by means of a region and sector-specific import duty equal to the emission intensity of an imported product times the EU-ETS carbon price. The emission intensity equals a sector's direct emissions over its output value

We calculate the economy-wide carbon leakage rate as the change in emissions in foreign countries over the change in EU emissions (equation 1). This rate considers carbon leakage in all economic sectors and via all carbon leakage channels. We also calculate sector-specific carbon leakage rates by taking sector's direct and indirect emissions into account (equation 2). Similar to Kuik and Hofkes (2010), we incorporate indirect emissions in equation 2 by assuming that these are equal to the direct emissions of the first layer of sector's production inputs. That is, we ignore the indirect emissions embedded in in the production of sectors' production inputs.

$$LR = |\Delta GHGE^{nc}/\Delta GHGE^{c}|\ x\ 100$$

$$LR_i = \left|\frac{\Delta\left(GHGE_i^{nc} + \sum_j \theta_j\, GHGE_j^{nc}\right)}{\Delta\left(GHGE_i^{c} + \sum_j \theta_j\, GHGE_j^{c}\right)}\right|\ x\ 100$$

3.2 Data

The MAGNET model is based on the GTAP 10 database (Aguiar et al. 2019) provides economic data for 141 world regions and 65 economic sectors for 2014. MAGNET further disaggregates these to 127 sectors and commodities. However, to limit the computational burden of the simulations, we consider five world regions which are representative of future international climate policy: the European Union, other carbon pricing countries, Latin America, Asia, and Africa. Similarly we have aggregated the dataset to twenty-seven sectors, most of which are agricultural sectors.

3.3 Baseline scenario

To qualitatively assess the impacts of climate policies, we first build a baseline. In dynamic models, a baseline is a referential economic trajectory (business-as-usual path) that assumes the absence of the policy under analysis. By contrasting the results of the policy scenarios, the baseline makes it possible to derive causal relationships. Our baseline assumes a carbon pricing free world from 2014 to 2050, which we divided into five smaller time periods: 2014-2020, 2020-2030, 2030-2040, 2040-2050. As usual in the literature, our baseline follows macroeconomic projections consistent with the second Shared Socioeconomic Pathway (SSP2), which assumes a "middle-of-the-road" world development (Riahi et al. 2017). More specifically, we assume that GDP and population increases along their historical trends.

3.4 Climate policy scenarios

Building upon the baseline, we consider four climate policy scenarios. These scenarios reflect different EU-ETS trajectories until 2050. In all EU-ETS scenarios, all emission allowances are auctioned and can be traded among sectors inside the EU area. The allowance equilibrium price depends on the emission mitigation objective, which is set at XX tCO2eq until 2050. For simplicity, we assume that other countries do not implement climate mitigation policies.

1) The EU-ETS keeps its current form until 2050. It covers emissions from energy, industry, and aviation. This scenario will increase agricultural sectors' indirect carbon costs due to higher price of domestic agricultural inputs covered by the EU-ETS (e.g., energy.).
2) the EU-ETS also covers agricultural sectors. This scenario will increase agricultural sectors' direct and indirect carbon costs. Direct carbon costs increase due to the fact that agricultural sectors' need to purchase emission allowances. Indirect carbon costs increase, as before, due to more expensive production inputs, including self-produced inputs.
3) The EU-ETS implements the EU-CBAM but excludes agricultural sectors. The EU-CBAM coverage limits to emission-intensive trade-exposed sectors, i.e., fertilizers, iron and steel, and cement. Under this scenario, domestic and imported agricultural inputs covered by the EU-ETS become more expensive and affect the competitiveness of downstream agricultural sectors. However, the effect is not easy to grasp, because the effect of a CBAM depends on its design. The EU-CBAM will first only cover electricity and fertilizers, and be based on direct emissions.

4) The EU-ETS covers agricultural sectors and the EU-CBAM also includes these sectors; the difference between scenarios two and four represents the ability of the EU-CBAM to reduce leakage risk in agricultural sectors.

4 Results

4.1 Leakage rates

4.2 Sectors' competitiveness

5 Discussion

6 Conclusion

7 Publication bibliography

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