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Carbon Border Adjustment Mechanism: An Exploratory Analysis of its Effects on the EU Imports and Respective Emissions

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Abstract

This paper explores the effect that the EU Carbon Border Adjustment Mechanism will have on EU imports of carbon-intensive products, as well as on the CO_2 emissions embodied in them. A structural gravity model was built and estimated with PPML, from which resulted statistically significant tariff elasticities for almost all the considered sectors. These elasticities were then used to simulate how EU imports and respective emissions will change under several CBAM scenarios. This methodology was also applied for Portuguese imports. Overall, EU imports decline more than 50%, while emissions drop by more than 60%. Portuguese imports decline less severely.

Keywords: International Trade, Gravity Model, Carbon Leakage, Carbon Emissions, CBAM

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1 Introduction

On the 14th of July 2021, the European Commission presented the first proposal for the Carbon Border Adjustment Mechanism (CBAM), as part of the 'Fit for 55' package, under the European Green Deal. Among other initiatives, the Commission proposed the CBAM as an innovative strategy to control carbon leakage, mitigate climate change and achieve the target of reducing carbon emissions by 55% by 2030, as well as ensuring a level playing field between European Union (EU) and non-EU producers.

Moreover, in August of the same year, the Intergovernmental Panel on Climate Change (IPCC) released their sixth assessment report (IPCC 2021), where the organization warned for the risk of temperatures reaching the 1.5ºC limit in 2030 (ten years earlier than previously estimated) and expressed that it was an absolute necessity that countries reduced their greenhouse gas (GHG) emissions by at least 45% until 2030. Moreover, the COP26 summit organized by the United Nations in November 2021 joined 120 country leaders to reinforce the importance of intensifying efforts to reduce emissions, support poor nations in their mitigation efforts and bring fossil fuel subsidies to an end.

With such an eventful year when it comes to the protection of the environment and the proposal of environmental legislation, and given the urgency that this topic must be treated with, it only seemed reasonable and convenient to present my contribution to the cause with this paper.

This being said, the purpose of this work is to analyze the CBAM and explore in detail the effects that it will have on the imports of the EU for carbon-intensive goods, as well as the emissions embodied in those trade flows. To do this, I resort to a structural gravity model, from which it is possible to obtain the elasticity of the import flows to changes in tariffs. Those elasticities are then used in a simulation of how EU imports and respective emissions will change under different CBAM scenarios. Through this methodology, we find out that the aluminium and fertilizers sectors are the most sensitive to increases in tariffs. Moreover, the overall EU imports face a decline of more than 50% in any of the CBAM scenarios, while the respective emissions drop by more than 60%. When looking at the Portuguese imports in specific, these declines are less severe.

The remainder of this work is organized as follows. **Section 2** provides a description of the CBAM. In **section 3**, one can find the literature review and in **section 4**, a thorough explanation of the methodology used. **Section 5** presents the sources of data, **section 6** the results of the estimation and the simulations, and **section 7** ends this paper with a short conclusion.

2 The CBAM

In 2005, the European Commission launched the European Union Emissions Trading System (EU ETS), the first and the largest mechanism of its kind to ever be put in place, which consists in the attribution of a price to GHG emissions so that companies account for this cost in their production functions, thus motivating them to reduce the pollutants emitted in their production process and to invest in cleaner technologies. The EU ETS is a cap-and-trade approach: the EU sets a limit (a cap) on the amount of emissions that can be produced within its Member-States (and for specific sectors) each year and for each ton of carbon dioxide (CO_2) that a firm wishes to emit, it must hold a permit to do so. Additionally, firms can trade permits: those in larger need of licenses buy from those in better conditions to switch to cleaner methods, thus creating a market for the permits. This quantity-based mechanism (in contrast to price-based) allows for the internalization of the uncompensated external cost produced by corporations as a by-product of their activities and for a greater efficiency in the allocation of permits.

Moreover, the EU allocates some free allowances across more energy-intensive industries, in part to prevent carbon leakage. The EU defines carbon leakage as "the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries with laxer emission constraints” (European Commission 2021a). There are two main channels through which leakage may happen. The energy markets channel consists in the decrease in the prices of fossil fuels as a result of domestic restrictions on their use. Because prices fall, less regulated countries will have an incentive to make a greater use of them. A more direct and common channel though, is the competitiveness channel. Industries which production relies on higher levels of emissions face larger costs in the acquisition of permits and a greater advantage in moving their production to countries with more relaxed environmental policies where they would not have those costs.

The EU ETS was implemented among its Member States as well as Iceland, Liechtenstein, and Norway, covering the power sector, civil aviation (only flights inside the European Economic Area) and energy-intensive industries (such as oil refineries, producers of iron, aluminium, paper and cement). Until 2019, the EU ETS had already lowered emissions by 35% in the industries covered. However, the free allocation of permits is not cost-effective. Although it addresses the problem of carbon leakage, it decreases the incentives of those who receive them to invest in cleaner technologies and greener production methods. Moreover, the rapid increase in the price of carbon also motivates carbon leakage, even when free allocation exists. Before 2018, the price of the EU carbon allowances (EUAs) was relatively low, most of the time below 10€ per ton (t) of carbon dioxide. However, this price escalated from 4€ in 2018 to more than 70€ in November 2021. With such high prices, free allocation may not be sufficient to convince European firms to keep their production within the EU (Energy Monitor 2021).

To respond to this problem, the European Commission decided to introduce the Carbon Border Adjustment Mechanism (CBAM), complementing the EU ETS and progressively replacing the free allocation of permits. Six design options for the CBAM were proposed and assessed according to their effectiveness, efficiency, coherence, and subsidiarity/proportionality (European Commission 2021b). These options (thoroughly described in Part I of the Appendix) have a common goal of placing a price on emissions, but they all display distinct features[1]. Additionally, they are all evaluated against a set of reference scenarios, in order to account for the dynamic framework in which the CBAM is being proposed. The baseline scenario (designated REF in the official proposal) describes the present moment, in which the existing climate legislation aims at reducing emissions by 40% until 2030 and free allocation of allowances is still in place. However, the EU has recently agreed on a more ambitious target: reducing the level of emissions by 55% by 2030. So, a counterfactual scenario (designated MIX) was introduced, consisting of reducing EU ETS emission allowances by 55% until 2030, maintenance of free allowances, the expansion of carbon pricing to more sectors, among others. A variant of the MIX scenario was also included to account for the complete removal of free allowances, which facilitates the comparison of different leakage protection alternatives and allows for a fair evaluation of the CBAM options.

In the end, the option with better results was **option 4**, a replication of the EU ETS to countries outside the EU, where the permit prices are the same as in the ETS, but the amount of permits available is unlimited. Every exporter must declare the actual emissions of its products and free allocation of allowances is gradually removed in a 10-year phase out period. The chosen design is expected to, at least in the beginning, be applied to sectors at greater risk of carbon leakage: cement, fertilizers, iron and steel and aluminium. Nevertheless, the list of sectors at risk of carbon leakage (European Commission 2021c) is long and the Commission is exploring the potential of expanding the CBAM to other sectors later in the process.

[1] These design options do not apply to the electricity sector, as it is more complex and significantly different from the other sectors. Electricity generation is not eligible for free allowances in the EU ETS and its transportation is uniquely made through interconnectors subject to capacity constraints and the limitations of the physical infrastructures. As such, this sector requires a particular CBAM specification.

In what regards the scope of emissions, the CBAM will cover those of carbon dioxide (CO_2), a global pollutant, and, when noteworthy, nitrous oxide (N2O) and perfluorocarbons (PFCs), that is, local pollutants. Only direct emissions from the production of basic materials will be covered[2], as well as indirect emissions when significant.

Importantly, the CBAM is not a first-best solution, which leads to some controversy and raises objections. This policy is considered to be a second-best solution because it is applied unilaterally, such that, even though the European Union intends to set a price on the emissions of the imports from all the countries outside the Union, those same countries can always export less to the EU and more to countries where the emissions of their goods will not be priced. Even when this is not the case, another problem may arise: because not all countries are applying the same policy, holding trade flows fixed, producers may sell to the EU the part of the production coming from cleaner processes that would otherwise be sold to a third buyer, while selling to the rest of the world the dirtier, more polluting production, having ultimately no impact on overall emissions (Mehling and Ritz 2020). This phenomenon, known as Resource Shuffling, has been one of the main concerns in California, where a carbon border adjustment has been placed on electricity imports from other US states. Moreover, another form of carbon leakage may derive from the introduction of a unilateral CBAM. Ignoring resource shuffling for now, an EU CBAM will make domestic production relatively cheaper for EU citizens and exports to countries outside the Union more attractive for EU producers. Thus, while reducing the amount of imports into the EU, the CBAM may as well increase the sales to the rest of the world, which is seen as a market-based form of carbon leakage.

[2] The emissions from transport will not be subject to the CBAM for now, since transport is a service, and the CBAM only applies to goods, but the EU intends to study this option during the revision of the CBAM´s proposal.

From this, one can infer that the first-best solution would be one that could be applied universally, such as a universally applied emission tax (Pigouvian tax) or a cap-and-trade mechanism, like the EU ETS, but in which all the countries participated (an example of Coasean Bargaining). Both options would work better in the sense that producers would face the same emission price no matter the country they were exporting to, which would contribute to an efficient allocation of resources, generating incentives for them to invest in cleaner methods of production. Most importantly, those incentives would be price or quantity incentives, not regulatory pressures, and they would be permanent, which is essential to reduce the stock of CO_2 in the atmosphere and fight climate change, given its intertemporal dimension.

Notwithstanding, such policies would require a tremendous level of international cooperation, convergence of interests, a large collection of information and time to define common goals and practices that apply equally to all the countries. This is a consequence of climate change being a global public good, thus requiring a global solution, and not just a local one (like the CBAM). However, this is not possible since, besides other issues, the consequences of climate change and the distribution of the benefits and costs of intervention are very different across the different nations. So, even though many institutions and researchers have been trying to enhance cooperation among countries and studying the potential of climate clubs, it is easy to recognize how difficult that task is. First, and as previously stated, it requires plenty of time to study how such a policy can be applied to so many countries (with different economies, levels of development and that face different costs from global intervention), time that may be incompatible with the 2030 and 2050 agendas set by several countries (mostly developed countries) for their environmental goals. Secondly, it is crucial to have an international institution especially dedicated to the supervision of the application of the policy. Finally, all the countries involved must have common goals and interests, which is particularly difficult to achieve as there is a great likelihood that different countries value the externality created by the emissions differently. This may be especially true for developing countries when compared to developed countries, as they tend to have different priorities. Therefore, even though the CBAM is not the most preferred solution, it is the second-best alternative to limit carbon leakage and to internalize the externality generated by pollution.

To conclude, we should be aware of the limitations of this mechanism. Many support the CBAM pricing should be a carbon added tax (CAT), paid at each step of the production process. This would allow a more accurate and precise pricing process and a wider scope as it would be possible to cover emissions of products down the value chain. However, a CAT would call for a very complex and comprehensive monitoring of every product, their composition and their carbon intensity at all stages of production, which would raise substantial administrative costs. Besides, several studies alert for the necessity of export rebates for EU producers to be compensated for the potential loss of competitiveness of EU businesses due to higher prices in the Union, resulting from the CBAM and the loss of free allocations. However, the problem underlying export rebates is that they go against the EU's climate goal for the mechanism by compromising its credibility. More importantly, they raise major compatibility concerns relative to the World Trade Organization (WTO)'s legislation since the EU would be subsidizing its producers' exports, thus distorting international trade, which is prohibited by the WTO. Thus, the Commission opted for the exclusion of the rebates from the CBAM.

The compatibility issues with the WTO do not stop here though. For example, countries from which the EU imports more carbon-intensive products (like China and Brazil) accuse the CBAM of violating the WTO's rule of non-discrimination since, according to them, the EU is judging the quality of their climate action and, by defining which sectors require emissions certificates, the Union is creating a bias towards those countries from which it imports less of those sectors. In the CBAM proposal (European Commission 2021b), the European Commission guarantees compliance with all the WTO legislation. In particular, it claims that free allocation is set to be replaced by a CBAM that accurately prices imports according to their carbon content, precisely to guarantee no discrimination, as well as the conformity with other international obligations.

3 Literature Review

Carbon tariffs and emissions pricing have been recurring topics of study in the past decades, as climate change became a more discussed topic, and the EU ETS came into practice. When considering carbon border adjustments, however, the literature becomes scarcer. The CBAM has not been applied yet and, for this reason, there is no data available that allows researchers to estimate impacts. Nevertheless, some research papers have been produced in recent years, even if they are all based on design proposals or assumptions about the potential characteristics of the CBAM, and the estimated impacts rely on proxies. For this reason, most of this research presents significantly different results from those of the European Commission. In the official proposal, the assessment of the CBAM made by the Commission relies on a Computable General Equilibrium (CGE) to estimate the consequences on all economic indicators and create a representation of the phase-in feature of the CBAM's chosen design. They estimate a reduction of 13.8% in the level of emissions of the CBAM sectors in the EU and a reduction of 0.4% in the emissions of the same sectors in the rest of the world (relative to the baseline) by 2030, leading to a negative leakage rate (-29%), which means that leakage would be reduced both in the EU and in the rest of the world. Additionally, EU imports of CBAM sectors are expected to fall by 11.9%.

CGEs are indeed very commonly used to estimate the impacts of the CBAM, precisely because of their capacity to evaluate the response of all the markets to the mechanism. Pyrka et al. (2020) use a CGE to estimate how the CBAM will impact the Member States' economies. They also attempt to predict how GHG emissions will change and, even though their border carbon adjustment design differs from the EU's (for example, they consider more sectors and their design lacks the phase-in trait), they estimate the CBAM to bring down global emissions by 24 $MtCO_2$ eq (relative to the scenario with no BCA). Similarly, Mörsdorf (2021) employs a CGE that allows him to predict how much the CBAM will reduce carbon leakage. In comparison to the 22.2% leakage rate associated with the reference scenario, the author predicts this indicator to fall to a rate ranging between 7.2% and 14.8%, depending on the features of the CBAM.

With a different goal in mind, Zhong and Pei (2021) take another approach on their analysis of the CBAM. The authors resort to a multi-regional input-output approach to estimate how the mechanism is expected to change the countries' competitiveness and the exports into the EU. Like CGEs, this methodology also reproduces the interdependencies between markets and sectors and captures the ripple effects of shocks across them.

Finally, some authors opt for gravity models. Typically, these models are simpler than CGEs, in the sense that researchers look for partial effects of the CBAM in a single specific market of the economy. Kuusi et al. (2020) construct several scenarios for what the CBAM design could be and apply a structural gravity model, finding that the scenario that is closest to the one chosen by the Commission's proposal actually shows a negligible impact on the CO_2 content of the EU imports. Notwithstanding, despite being the most similar to the EU's chosen design, the mentioned scenario still differs from it, mainly due to the fact that their model is static and only evaluates partial effects, therefore not capturing the feedback effects from other markets.

4 Methodology

The purpose of this project is to estimate the direct impact of the CBAM on the international trade flows between the EU Member States and the rest of the world, and consequently, on the amount of emissions released into the atmosphere as a result of those trade flows. As shown in the literature review, the majority of the studies on this topic rely on Computable General

Equilibrium (CGE) models, which are typically used when it comes to ex-ante evaluation since they allow for analyzing general equilibrium effects of large-scale policy changes, while considering the interdependence between industries and markets. Because of this feature, CGEs have been frequently employed in the context of the CBAM to estimate impacts on the whole economy, for example, on employment, prices, welfare and income distribution, among others.

Following Kuusi et al. (2020), in this project the methodology is instead based on a structural gravity model which provides a simpler and more intuitive set up, while also allowing for ex-ante evaluation (Larch and Wanner 2017). More importantly, while gravity models capture economy-wide effects as in general equilibrium setups, they can be simplified for partial equilibrium analysis. Since my goal is to estimate the effects of the CBAM directly on imports, the use of a structural gravity model, in a partial equilibrium setup, seems to be the best choice.

Gravity models derived from Newton's Law of Universal Gravitation and were applied to international economics, implying that countries trade proportionately to their market sizes and the distance between them[3]. According to the WTO (Yotov, Piermartini, Monteiro, and Larch 2016), gravity models present five main benefits that explain their success. Adding to their intuitive and flexible structure, they possess very solid theoretical foundations, contributing to their potential to conduct counterfactual analysis, and a remarkable predictive power, with a consistent fit between 60% and 90%. Lastly, these models portray a "realistic general equilibrium environment", as they capture the interactions between markets and countries.

The gravity equation can take many formats, but some are more appropriate than others to accommodate the recommendations proposed to tackle the challenges raised by the model. The first great challenge comes from the "multilateral resistance terms" observed in the theoretical

[3] Anderson (1979) was the first to provide a theoretical economic foundation for the gravity model, but it started being used long before that time, even though it only gained popularity from the late 1990s onwards.

derivation (Yotov, Piermartini, Monteiro, and Larch, 2016). These terms are theoretical concepts and consequently, they are not observable. Overall, they represent the importer's and the exporter's ease of market access. Multilateral resistances account for the trade costs from all possible bilateral routes, and not just the ones from the countries we are considering, which means that any change in the trade cost of any bilateral relationship will impact the other relationships through relative price effects. This is relevant because simpler models where trade costs are included, but multilateral resistances are not, end up originating an omitted variable bias, as the resistances are, by construction, correlated with those costs. Besides the importance of including the multilateral resistance terms, it is also challenging to find the ideal way of accounting for them in the model. The approach chosen for this project is the one recommended by Hummels (2001) and Feenstra (2016), and extended by Olivero and Yotov (2012). Their suggestion is to use directional (importer and exporter) fixed effects. In this case, because we have a sector and time dimension, importer-sector-time and exporter-sector-time fixed effects were included in the model[4]. However, apart from the multilateral resistance terms, these fixed effects will contain other time-varying variables specific to importer and exporter countries, such as output shares that represent the size of each country, national policies and exchange rates. Additionally, importer-exporter-sector[5] (pair) fixed effects were included to account for potential endogeneity from time-invariant variables and bilateral trade costs, such as distance between countries, that correlate with the trade policy between each pair of countries.

A second challenge comes from the fact that trade data might present a relatively large number of zero trade flows. When using Ordinary Least Squares, particularly when the gravity equation is in logarithmic form, all the observations where trade equals zero are dropped. So, not only is

[4] As explained later in this section, the gravity equation will be estimated for each sector separately and, consequently, these fixed effects become importer-time and exporter-time.

[5] As in the previous footnote, this fixed effect specification later becomes importer-exporter.

information lost, but the estimates are also incorrect. Santos Silva and Tenreyro (2006) recommend writing the model in a multiplicative form to solve this problem, and then to apply the Poisson Pseudo Maximum Likelihood (PPML) estimator, which performs very well even when there is a large amount of zero trade flows in the dataset. The third challenge we face is heteroskedasticity in trade data, which leads to biased and inconsistent estimates of the effects we are looking for. Once again, PPML is able to effectively handle this problem.

The methodology used is divided into two moments. The first one consists of estimating tariff elasticities to determine how tariffs impact import flows. Before running the gravity equation, the first step was to remove any duplicates. The dataset has four dimensions: the first is the importing (reporter) country, the second is the exporter (partner), the third is the sector, and the fourth is the year. So, each reporter-partner-sector-year group corresponds to a different import value and tariff, and the removal of duplicates is undertaken at the level of these groups. Then, the dataset is restricted at the sector level, to obtain tariff elasticities for each sector separately.

Because trade data is very dispersed, there is a strong presence of outliers. As such, the winsor procedure is applied on the 1% and 99% percentiles of the import variable. After following these procedures, the gravity equation can be stated as follows[6]:

$$M_{ijkt} = \exp\left(\alpha + \pi_{ikt} + \gamma_{jkt} + \mu_{ijk} + \beta * lntariff_{ijkt}\right) * e_{ijkt} \qquad (1)$$

Accordingly, M_{ijkt} is the monetary value of imports of reporter i from partner j, of goods from sector k, in year t. α is the constant term. π_{ikt} are the importer-sector-year fixed effects of reporter country i, sector k and time t. Similarly, γ_{jkt} are the exporter-sector-year fixed effects of partner country j , sector k and time t. μ_{ijk} are the importer-exporter-sector fixed effects for the relationship between reporter i and partner j, for each sector k. $lntariff_{ijkt}$ equals ln $(1 +$

[6] Even though (1) is applied to each sector separately, and consequently the k dimension disappears, I decided to keep it in the expression to make the explanation of the model clearer.

$tariff_{ijkt}$), where $tariff_{ijkt}$ is the *ad valorem* tariff applied by country i to the imports coming from country j, for each sector k and in year t, and its coefficient β is our parameter of interest, that is, the tariff elasticities we are looking for. These are presented in logarithmic form, which allows for directly estimating the elasticities. e_{ijkt} represents the error term. Lastly, as recommended, the equation was estimated using PPML. Note that PPML does not require data to follow a Poisson distribution, it is applicable to continuous variables. Additionally, under the presence of multiple levels of fixed effects, it is strongly recommended to use a variation of PPML that accounts for high dimensional fixed effects. Hence, the ppmlhdfe Stata command (Correia, Guimarães and Zylkin 2016) was used, clustering the standard errors at the country-pair level. By default, this command reports robust standard errors. Applying it to each restricted dataset, one is left with the desired tariff elasticities for each sector.

After the gravity equation, I computed the RESET test for potential misspecifications. This test consists in generating a variable with the squared fitted values of the gravity equation and then estimating the regression once again, with this new variable as a regressor. The statistical significance of this additional regressor must be tested, where under the null hypothesis the coefficient is not statistically different from zero. If the null hypothesis is not rejected, the model is believed to be correctly specified and no important variables are being omitted.

In the second step, the intention is to simulate how the CBAM may change import flows into the EU. These changes will be evaluated only in the last year of analysis (2018, in this case). Additionally, we need to include a variable that represents the mechanism, but because the CBAM is not yet in practice, a proxy was introduced as follows:

$$CBAM = \frac{emissions_{ijk}}{M_{ijk}} * (ETS\ carbon\ price - partner\ carbon\ price) \quad (2)$$

The first component of (2) is a carbon intensity ratio, that is, the amount of CO_2 emissions per unit of trade. The numerator $emissions_{ijk}$ is the total amount of CO_2 emissions that result from the production of goods in sector k and that are imported by country i from country j. The denominator M_{ijk} is the same as in (1), now without time dimension. The second component is the CBAM price paid by the partner country, which equals the EU ETS carbon price minus whatever carbon price the producer faces in its own country, according to the EU definition. This difference in emission prices was assumed to be constant and equal to 75€ in the baseline scenario (additional scenarios are explained in the results section), which was the carbon price in the EU ETS in the end of November 2021. Implicitly, this assumption means that the carbon price in non-EU countries is considered to be zero and invariable across them, to account for the impact of a changing CBAM price, when multiplying 75€ by the carbon intensity ratio.

This said, it was finally possible to proceed to the simulation. Using the previously estimated elasticities and adding the CBAM tariffs to the usual tariffs in the right-hand side of equation (1), the calculated expression provides a new value of imports for each group of importer-exporter-sector that represents the response of the import flow to the increased tariffs at the border of EU countries. It is relevant to note, however, that this is a very simplistic way of evaluating this change. It only makes sense to make such a simulation under the assumption that the change in tariffs upon the addition of the CBAM pricing is marginal. Otherwise, the elasticities would change in response to the change in the demand for imports. In other words, we are considering a movement along the demand curve, instead of the most likely movement of the curve. Therefore, it is possible to interpret the results of this simulation as an immediate (short-run) response of trade to the CBAM tariffs, before any adjustments take place. This exercise allows to obtain information on how relevant these sectors are when it comes to CO_2 emissions and inform public policies that help mitigate climate change.

Finally, multiplying the simulated import flows by the carbon intensities provides simulated values of the emissions associated with those flows under the several CBAM scenarios. Hence, a comparison of how emissions change when trade changes can be undertaken.

5 Data

In order to run the empirical model explained above a specific dataset were constructed from several sources. The first was the UN Comtrade database, from which I collected data on the monetary value of imports. Only annual imports of goods were considered, for the period between 2000 and 2018, and the Reporter countries selected were those belonging to the EU (as of 2018), as well as Norway and Iceland since they also participate in the EU ETS and therefore are part of the CBAM. As for the Partners, all the countries available were initially selected but these are reduced later on, as the data on tariffs and carbon intensity were not available for every Partner country, and every year. When choosing the commodities of interest, I followed the European Commission's proposal so that the estimation could be as realistic and as close to the Commission's plan for the CBAM as possible. As such, using the Harmonized System classification, I present in Table 1 of the Appendix the adopted products.

The data on tariffs were obtained from the WTO's Tariff Download Facility, where only the MFN tariffs (not including the bound tariffs) were selected, for the period 2000-2018, and the same commodity codes specified above[7]. For some years and countries, the facility did not present data on the value of tariffs applied. To avoid making unrealistic assumptions, the import flows corresponding to Reporter countries and years whose tariffs were not included in the WTO tariff database were deleted from my dataset. The exceptions to this strategy are the EU countries, for which the WTO does not have individual data after they joined the Union. Instead, the WTO presents the tariffs applied by the EU as whole, which I extrapolated to every Member-State for the years following their accession to the EU.

[7] For the fertilizers sectors, five different HS codes were selected: 2808, 2814, 2834, 3102 and 3105. To obtain results for this sector as a whole, their corresponding trade values were added, and the tariffs used resulted from the weighted average of the tariffs applied in the five mentioned sectors, for each reporter country and year.

Then, for the type of agreements between each pair of countries, I used the Regional Trade Agreements Database built by Professor Mario Larch, with data from the WTO, for a period between 1950 and 2019, and with 7 variables representing 7 possible types of trade agreements. For each exporter, importer, and year, each variable may present a 0 if that agreement is not in place, or 1 otherwise. This database contains all active and inactive agreements, thus providing information on those that come to an end or when the type of agreement between two countries changes. For this particular case, only customs union and free trade agreements between any reporter and partner countries were considered, in which cases the tariff between the two was set to zero. In all other cases, the previously sourced tariffs were adopted.

Finally, the carbon intensity of the import flows was sourced from the OECD's Trade in Embodied CO_2 Database ($TECO_2$), by selecting the "Intensity of CO_2 emissions embodied in gross imports" indicator, for the period 2000-2018. Although the Commission also accounts for other gases' emissions (when significant), their focus is primarily on CO_2, which makes the OECD data adequate for the purpose of this project, without moving away from the Commission's intentions. One disadvantage of this database is that the industry codes are not reported under the Harmonized System, but under the International Standard Industrial Classification (ISIC). Using a conversion table provided by the OECD, it was possible to find which ISIC codes corresponded to the HS ones and this correspondence is presented in Table 2 of the Appendix[8]. Lastly, the importing countries selected are the EU Member States (as of the year 2018), as well as Norway and Iceland, and the partner countries are all of those made available by the OECD database (excluding the importing countries), which equal 36 in total.

[8] Note that sectors 72, 73 and 76 (under the HS classification), which are analyzed separately throughout my methodology, correspond to the same ISIC code. As such, I calculated the weight of the imports of each of them relative to their total, and that weight was applied to the carbon intensity of the ISIC code where they are included, to obtain the carbon intensity of each of them.

Even though only these 36 partners are available, they constitute almost all trade into the EU (approximately 80% in 2018). Since the OECD only has carbon intensity data for these 36 partner countries[9], the remaining variables in this dataset were also restricted to these countries.

6 Results

First and foremost, the import flows are described in order to acknowledge the dimension of each sector in the EU's demand for other countries' goods in those sectors. In Table 1, it is possible to analyze the monetary value of the EU imports (from all countries) in each sector for the period 2000-2018, and then examine how much each sector weights in the sum of EU imports from those sectors, and in the sum of EU imports from all sectors.

Table 1: Quantitative description of EU imports for each considered sector

Sector	EU imports (million €)	Share in selected sectors	Share in all sectors
Cement	11 661	0.8%	0.02%
Fertilizers	76 441	5.4%	0.11%
Iron and Steel	580 211	40.8%	0.85%
Articles of Iron and Steel	392 711	27.6%	0.58%
Aluminium	359 915	25.3%	0.53%
Total	1 420 939	100%	2.09%

Iron and steel represent around 40% of the EU imports of the considered goods, being the largest among the five sectors. On the contrary, cement and fertilizers each represent less than 10% of the EU imports of the considered sectors. One reason for this is that, while the other three are full sectors, represented by a 2-digit code, cement and fertilizers are 4-digit codes, which means they are actually subcategories of 2-digit sectors[10]. Following this descriptive

[9] Please consult Table 3 in the Appendix for a full list of the 36 partner countries considered in the analysis.

[10] I selected the larger-digit code that included the industry codes chosen by the EU to be part of the CBAM. For the full list of codes considered by the European Commission, consult Table 4 of the Appendix.

analysis, the estimation of the gravity model was performed as explained before. Table 2 presents the estimates of the tariff elasticities provided by the gravity model for each sector[11].

Table 2: Tariff elasticities resulting from the gravity model estimation

Sector	Coefficient	Standard Error	P-Value	RESET test
Cement	-10.66	6.90	0.122	0.439
Fertilizers	-13.95	5.03	0.006	0.931
Iron and Steel	-6.87	3.25	0.035	0.004
Articles of Iron and Steel	-4.45	3.01	0.139	0.637
Aluminium	-14.68	5.50	0.008	0.234

These results indicate that the sectors react very differently to changes in tariffs. The aluminium sector faces the greatest change in the imports value in response to changes in the *ad valorem* tariffs set by the EU. Because the model is exponential and the tariffs are in logarithmic form, their coefficient is interpreted in the same way as a log-log linear regression model. As such, in the aluminium sector, when tariffs are raised by 1%, imports into the EU fall by approximately 14.7%, on average, ceteris paribus. This suggests that, when tariffs are higher, the Member-States' demand for this product decreases significantly, which in alternative would mean these countries could easily substitute this product. Similarly, when tariffs go up by 1% in the iron and steel sector, on average, ceteris paribus, the imports drop by approximately 6.9%. As for the fertilizers, like the aluminium, they present a very sensitive response to changes in tariffs: when these increase by 1%, imports fall approximately by 13.9%, on average, ceteris paribus. A reason for this might be the fact that the EU is a large producer of fertilizers. According to Fertilizers Europe (2021), although Russia is an extremely large exporter to the EU in this sector, the imported Nitrogen fertilizers (the most used and the main type considered in this analysis) only accounted for 30% of the Union's total consumption of these fertilizers in 2020.

[11] To present all sectors together, Table 2 only contains the most relevant statistical elements of each estimation. For further detail, consult Tables 5 to 9 in the Appendix.

Therefore, when tariffs are raised, there might be a substitution of foreign goods by domestically produced ones. In what regards cement and articles of iron and steel, these industries present non-significant estimates. Nonetheless, their p-values, even if larger than 0.1, do not go much further than that limit. Because these sectors are some of the most polluting ones, their elasticity estimates will still be used so that it is possible to explore how their trade and emissions change when potentiated by the CBAM.

Comparing with Kuusi et al. (2020), the closest approach to the one used in this work, these estimates are quite large. However, the data used in the estimation is different as well: while I focused solely on the EU countries as importers and the largest partners as exporters, they estimate their gravity equation with all the countries as importers and exporters, which provides a sensitiveness to changes in tariffs for the whole world and not just for EU Member-States.

Table 2 above also presents the RESET test. For most sectors, the p-value of the test is quite large, meaning that the null hypothesis of the correct specification of the model fails to be rejected. The only exception is iron and steel, where the p-value is below 1%, causing the null hypothesis to be rejected. However, given that the number of observations is very large, the fixed effects are rich and that the hypothesis of incorrect specification is strongly rejected for all the other sectors, there is little reason to believe the model is misspecified (especially when all the recommendations for its construction were closely followed).

After computing the elasticities, it is possible to simulate how the EU imports would have changed in 2018 (the last year of analysis) if the CBAM had been applied back then. Table 3 below presents the monetary value of the EU imports (in millions of Euros) in 2018 with no CBAM, with a CBAM price of 75€ and with a CBAM price of 100€, as well as the total of these sectors under each scenario as their weight on the total of EU imports (all sectors) in 2018. The price of 75€ was the EU ETS license price as of the 30th of November 2021 (current value).

The price of 100€ was chosen as a very likely scenario in the near future, given the fast increase that the EU ETS price has been experiencing[12].

Table 3: EU imports simulated for each CBAM scenario (million €)

Sector	No CBAM	CBAM price 75€	CBAM price 100€
Cement	170.67	2.95	2.26
Fertilizers	4 532.16	589.00	470.70
Iron and Steel	26 499.81	12 550.48	10 905.45
Articles of Iron and Steel	25 617.61	15 050.63	14 416.51
Aluminium	15 317.88	7 474.05	6 744.36
Total	72 138.13	35 667.11	32 539.28
Weight in total EU imports 2018	3.08%	1.52%	1.39%

We observe a large change in the volume of imports before and after applying the CBAM. The cement and fertilizers sectors suffer particularly strong reductions. For the second one, the main reason for such fall has already been stated before. For the first, one should remember that cement is very costly and difficult to transport and, as such, most countries have their own production of cement, even if it is still traded. So, when the CBAM is applied, many of those trade flows probably cease as the cost of importing is too high.

Overall, the monetary value of imports is reduced by 50.6% (36 471.02 million €) with a CBAM price of 75€, and by 54.9% (39 598.85 million €) under a CBAM price of 100€. Comparing with Kuusi et al. (2020), the difference in the imports caused by the CBAM is much larger in this work than in theirs. This results from four main factors: first, their estimated tariffs are much smaller; second, the authors use a baseline CBAM price of 25€ (EU ETS price in early 2020), which is much lower than the 75€ price used here; third, the authors use a different source and methodology for the computation of the CBAM tariffs; and fourth, while I run a simulation after the initial gravity equation, their methodology is somewhat distinct from mine.

[12] From November 1st, 2021, to November 30th, 2021, the ETS license price rose from around 56€ to around 75€ and it is expected to keep growing, as regulations become tighter and the natural gas market faces some stress.

Obviously, this is a simple and static formulation of the CBAM and, because the mechanism has not been applied yet, it would be difficult to estimate the effect that it would effectively have on trade, but this simulation still provides useful information for public policy purposes.

The following table shows the emissions, in millions of tonnes of CO_2 (Mt CO_2), associated with each CBAM scenario, as well as the total emissions of these sectors under each scenario as their weight on the total emissions from EU imports (all sectors) in 2018.

Table 4: Emissions embodied in EU imports in each CBAM scenario (Mt CO2)

Sector	No CBAM	CBAM price 75€	CBAM price 100€
Cement	0.348	0.004	0.002
Fertilizers	6.81	0.46	0.32
Iron and Steel	33.14	11.81	9.69
Articles of Iron and Steel	10.86	6.25	5.90
Aluminium	5.93	2.36	2.02
Total	57.088	20.884	17.932
Weight in total EU imports' emissions 2018	5.08%	1.86%	1.59%

In most cases, going from no CBAM to a CBAM price of 75€ reduces emissions by more than 50%. Cement shows the lowest values since it has a lower volume of imports, but it also shows the greatest variation in emissions after the CBAM application. Overall, we observe an emissions reduction of approximately 63% (36.2 Mt CO_2) with a CBAM of 75€, and a reduction of approximately 69% (39.2 Mt CO_2) with a CBAM of 100€. These values seem to be very large when comparing with those of previous studies, for example those presented in the literature review. Kuusi et al. (2020) actually find negligible impacts on the CO_2 content of the EU imports for the scenario that includes a group of sectors similar to the one analyzed in this project. Nonetheless, the emissions data in their work is somewhat outdated: they only have emissions for 2011, while I have collected carbon intensities for 2018, which is more realistic.

After completing the analysis for all the Member-States, it was possible to use the previously estimated fixed effects and elasticities to replicate the simulation for Portugal only.

Table 5: Portuguese imports simulated for each CBAM scenario (million €)

Sector	No CBAM	CBAM price 75€	CBAM price 100€
Cement	0.73	0.07	0.06
Fertilizers	0	0	0
Iron and Steel	781.37	480.53	415.81
Articles of Iron and Steel	146.46	125.26	119.21
Aluminium	70.59	52.92	48.44
Total	999.15	658.78	583.52
Weight in total Portuguese imports 2018	1.04%	0.69%	0.61%

Table 6: Emissions embodied in Portuguese imports in each CBAM scenario (Mt CO2)

Sector	No CBAM	CBAM price 75€	CBAM price 100€
Cement	0.001	0.000	0.000
Fertilizers	0	0	0
Iron and Steel	0.87	0.45	0.38
Articles of Iron and Steel	0.07	0.06	0.06
Aluminium	0.02	0.01	0.01
Total	0.96	0.52	0.45
Weight in total Portuguese imports' emissions 2018	2.77%	1.50%	1.30%

From Tables 5 and 6 above, Portugal does not seem to face such abrupt changes as those faced by the EU as a whole. In terms of import flows, these fall by 34% (340.37 million €) when a CBAM price of 75€ is applied, and by 42% (415.63 million €) under a CBAM price of 100€, relative to the scenario with no mechanism. Portugal did not import fertilizers from the considered partner countries in 2018, so under both of the CBAM scenarios, it would not make sense to do so. The cement sector seems to follow the same pattern as the EU as a whole, with a 90% drop in imports when the CBAM is put into practice. However, the other three sectors, whose imports fall more than 50% with a price of 75€ when considering all the Member-States, now fall by much less than a half. The reduction of emissions associated with the import flows into Portugal is also not as severe. Overall, the CO_2 emissions fall by approximately 46% (0.44 Mt CO_2) with a price of 75€ and by 53% (0.51 Mt CO_2) for a price of 100€, relative to the scenario with no CBAM. In what regards cement, aluminium and articles of iron and steel, emissions do not fall by much when the mechanism is put in place. The iron and steel sector is the one that suffers the greatest fall, more specifically, 48% (0.42 Mt CO_2) and 56% (0.49 Mt CO_2) when the CBAM price is 75€ and 100€, respectively.

Given the previous analysis, one must think of how it might impact public policies in the future. On one hand, we observe large reductions in CO_2 emissions, which motivates the implementation of the mechanism. But on the other hand, we also observe large reductions in imports and great sensitivity of their demand to increases in tariffs. This may boost domestic production and a substitution of imports for domestically produced ones and, as a result, it might have a positive impact on the creation and maintenance of jobs in the EU. Moreover, this may also contribute to reduce the dependency on foreign countries which became a concern with the coronavirus pandemic. However, prices are expected to rise and some competitiveness of EU businesses will be lost, which in turn may increase inequality. To which extent the first effect overcomes the second is a matter of great concern. In fact, in the CBAM proposal, all the potential design options present at least some overall negative economic impacts, even when the expected impact on employment is positive. One way of attenuating these impacts is to make use of the revenues that the CBAM will originate (revenue recycling). One alternative would be to support those businesses and sections of the population that may be more negatively affected. Another way is by supporting developing countries in their transition to climate neutrality. This has been another important topic of discussion: poor nations are not accompanying developed countries in the transition to sustainable practices and the application of climate goals, and so they are expected to be severely impacted from the CBAM. Hence, those revenues might make a difference in helping those countries in keeping up with the more developed ones, which in the end contributes to reduce emissions and mitigate climate change.

In conclusion, there is plenty of room for future research, especially due to the novelty that this mechanism represents. In the future, it would be relevant to consider more sectors and evaluate more EU countries in detail. Additionally, confidence intervals for the elasticities and more

CBAM scenarios could also significantly improve the quality of the analysis. Finally, depending on data availability, I believe it would be important to include more partner countries in the dataset, to obtain more realistic and robust results.

7 Conclusion

This paper develops a CBAM policy simulation exercise for EU imports, showing evidence that the majority of the most polluting sectors react to changes in tariffs by leading to a decrease in the demand for their imports. Because of these reactions, we observe that upon the introduction of the CBAM (and assuming tariff increases are marginal), the imports into the EU fall by around 50% and, consequently, the CO_2 emissions embodied in those imports have an even greater decrease. Even though only partial effects were analyzed, these results support the application of the mechanism as a way of contributing for the mitigation of climate change. Nevertheless, other effects of the mechanism must be weighted. For example, as production increases inside the EU as a result of the substitution of foreign goods for domestic ones, this may lead to an increase in emissions (even if not as much as they decrease, presumably). On the other hand, this impact becomes more ambiguous knowing that prices are also expected to rise, reducing consumption and, consequently, those emissions. Also, because prices may increase and consumption may fall, inequalities may get sharper, even if there is a potential for job creation in the EU. In the meantime, outside the EU, developing countries may be severely affected by the introduction of the CBAM due to their slow transition to greener technologies. This may be considerably attenuated by an adequate targeting of the CBAM revenues. But even with some negative impacts, the CBAM has a great potential for success in the reduction of carbon emissions. In the end, it is of utmost importance to implement policies that motivate a transition from polluting to cleaner and more sustainable practices. Like the European Commission's President Ursula von der Leyen stated in the COP26 summit, "Put a price on carbon, nature cannot pay that price anymore".

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Appendix

Part I: Description of the CBAM design options

Option 1 is an import tax paid by the importer at the border which combines the price of carbon in the EU with a default carbon intensity of the product imported, while offering the importer the possibility of a tax reduction in case its individual carbon footprint is lower than the default and/or the importer's country also has a carbon price in place.

Option 2 is the replication of the EU ETS regime to the countries outside the EU. Importers must purchase allowances (named CBAM certificates) based on the embedded emission intensity of their products and no goods are sold in the EU unless the importer holds certificates that cover for their respective emissions. These emission intensities are set by default but, similarly to option 1, importers are also offered the opportunity to demonstrate their individual carbon footprints and/or a carbon price already paid in the country of production. The CBAM certificates are not connected to the EU ETS and, contrary to it, the CBAM does not set a limit on the number of allowances available. Nevertheless, the price of these allowances is the same as the one in the ETS regime. Additionally, it is relevant to note that there is no free allocation of allowances under this setting.

Option 3 follows the same concept as option 2, with the sole difference that in this case default values are not available and, consequently, every exporter to the EU must declare the actual emissions embedded in their products. Moreover, once again, free allocation is not available.

Options 4 and 5 apply the same principle as option 3 with a few changes. Option 4's main feature is a 10-year phase in period, starting in 2026, and during which the free allocation of allowances in the EU ETS regime is gradually eliminated, at a 10-percentage-point rate each year. At the same time, the CBAM is gradually phased in and it is applied to the difference between the actual emissions declared by the importers and the proportion of the EU benchmark emissions that is still covered by free allowances each year, so that importers benefit from a free allowances' equivalent. This 10-year adjustment period allows firms that benefit from free allowances under the EU ETS to prepare for the moment at which they will no longer have access to them and will have to pay the carbon price for their entire production.

Option 5 is a variation of option 3 in which the scope of the CBAM is extended to the next stages of the value chain. This implies that, in addition to the emissions of specific carbon-intensive materials and basic products, those of carbon-intensive materials that compose semi-finished and finished products will also be covered by the CBAM. Moreover, exactly as in option 3, default values are not available (actual emissions must be reported) and free allocation is ceased.

Finally, **option 6** is an excise duty on carbon-intensive materials in basic, semi-finished and finished products. Because the excise duty is imposed at the moment of consumption in the EU, both domestic (inside EU) and foreign (outside EU) producers are entitled to pay it, even if the domestic producers are already under the EU ETS. To obtain the value of the duty, it is necessary to multiply the quantity of the carbon-intensive material in the product by a carbon intensity factor and by the relevant carbon price. The carbon intensity factor is computed using reference values, for example, the product benchmarks used in the EU ETS to determine the free allocation of licenses, and it should reflect the carbon content involved in the production of each material covered by the CBAM and present in the given product. This excise duty ensures that both domestic and imported products are taxed in the same way and generate the same liability, since this depends on the weight of the materials and not on the production process. Finally, this approach does not put an end to free allocation of allowances in the EU ETS mechanism.

Part II: Supplementing tables

Table 1: Description of the HS product codes used in the analysis

HS Code	Description
2523	Cement, incl. cement clinkers, whether or not colored
2808	Nitric acid; sulphonitric acids
2814	Ammonia, anhydrous or in aqueous solution
2834	Nitrites; nitrates
3102	Mineral or chemical nitrogenous fertilizers (excl. those in tablets or similar forms, or in packages with a gross weight of <= 10 kg)
3105	Mineral or chemical fertilizers containing two or three of the fertilizing elements nitrogen, phosphorus and potassium; other fertilizers (excl. pure animal or vegetable fertilizers or mineral or chemical nitrogenous, phosphatic or potassic fertilizers); animal, vegetable, mineral or chemical fertilizers in tablets or similar forms or in packages of a gross weight of <= 10 kg
72	Iron and steel
73	Articles of iron or steel
76	Aluminium or articles thereof

Source: UN Comtrade Database

Table 2: Conversion of the HS codes to ISIC codes

HS Code	ISIC Code	Description
2523	D23	Other non-metallic mineral products
2808	D20	Chemical and chemical products
2814	D20	Chemical and chemical products
2834	D20	Chemical and chemical products
3102	D20	Chemical and chemical products
3105	D20	Chemical and chemical products
72	D24T25	Basic metals and fabricated metal products
73	D24T25	Basic metals and fabricated metal products
76	D24T25	Basic metals and fabricated metal products

Source: OECD Trade in embodied CO2 (TECO2) database; HS to ISIC to End-use conversion key developed by the OECD, STAN Databases Team. Directorate for Science, Technology and Innovation (STI).

Table 3: List of partner countries considered in the analysis

Argentina	India	Peru
Australia	Indonesia	Philippines
Brazil	Israel	Russia
Brunei Darussalam	Japan	Saudi Arabia
Cambodia	Kazakhstan	Singapore
Canada	Korea	South Africa
Chile	Lao People's Democratic Republic	Switzerland
People’s Republic of China	Malaysia	Thailand
Chinese Taipei	Mexico	Tunisia
Colombia	Morocco	Turkey
Costa Rica	Myanmar	United States of America
Hong Kong	New Zealand	Vietnam

Table 4: HS codes used by the European Commission for the CBAM proposal

HS Code	Description
Cement	
2523 10 00	Cement clinkers
2523 21 00	White Portland cement, whether or not artificially colored
2523 29 00	Other Portland cement
2523 90 00	Other hydraulic cements
Fertilizers	
2808 00 00	Nitric acid; sulphonitric acids
2814	Ammonia, anhydrous or in aqueous solution
2834 21 00	Nitrates of potassium
3102	Mineral or chemical fertilizers, nitrogenous
3105	Mineral or chemical fertilizers containing two or three of the fertilizing elements nitrogen, phosphorus and potassium; other fertilizers; goods of this chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg [except: 3105 60 00 – Mineral or chemical fertilizers containing the two fertilizing elements phosphorus and potassium]
Iron and Steel	
72	Iron and steel [except: 7202 – Ferro-alloys; 7204 – Ferrous waste and scrap; remelting scrap ingots and steel]
7301	Sheet piling of iron or steel, whether or not drilled, punched or made from assembled elements; welded angles, shapes and sections, of iron or steel
7302	Railway or tramway track construction material of iron or steel, the following: rails, check-rails and rack rails, switch blades, crossing frogs, point rods and other crossing pieces, sleepers (cross-ties), fish- plates, chairs, chair wedges, sole plates (base plates), rail clips, bedplates, ties and other material specialized for jointing or fixing rails
7303 00	Tubes, pipes and hollow profiles, of cast iron
7304	Tubes, pipes and hollow profiles, seamless, of iron (other than cast iron) or steel
7305	Other tubes and pipes (for example, welded, riveted or similarly closed), having circular cross-sections, the external diameter of which exceeds 406,4 mm, of iron or steel
7306	Other tubes, pipes and hollow profiles (for example, open seam or welded, riveted or similarly closed), of iron or steel
7307	Tube or pipe fittings (for example, couplings, elbows, sleeves), of iron or steel
7308	Structures (excluding prefabricated buildings of heading 9406) and parts of structures (for example, bridges and bridge-sections, lock- gates, towers, lattice masts, roofs, roofing frameworks, doors and windows and their frames and thresholds for doors, shutters, balustrades, pillars and columns), of iron or steel; plates, rods, angles, shapes, sections, tubes and the like, prepared for use in structures, of iron or steel

7309	Reservoirs, tanks, vats and similar containers for any material (other than compressed or liquefied gas), of iron or steel, of a capacity exceeding 300 l, whether or not lined or heat-insulated, but not fitted with mechanical or thermal equipment
7310	Tanks, casks, drums, cans, boxes and similar containers, for any material (other than compressed or liquefied gas), of iron or steel, of a capacity not exceeding 300 l, whether or not lined or heat-insulated, but not fitted with mechanical or thermal equipment
7311	Containers for compressed or liquefied gas, of iron or steel
Aluminium	
7601	Unwrought aluminium
7603	Aluminium powders and flakes
7604	Aluminium bars, rods and profiles
7605	Aluminium wire
7606	Aluminium plates, sheets and strip, of a thickness exceeding 0,2 mm
7607	Aluminium foil (whether or not printed or backed with paper, paper-board, plastics or similar backing materials) of a thickness (excluding any backing) not exceeding 0,2 mm
7608	Aluminium tubes and pipes
7609 00 00	Aluminium tube or pipe fittings (for example, couplings, elbows, sleeves)

Source: European Commission. 2021b. "Proposal for a Regulation of the European Parliament and of the Council establishing a carbon border adjustment mechanism." *Official Journal of the European Union*

Table 5: Stata output of the gravity model for the Iron and Steel sector

VARIABLES	M
lntariff	-6.872**
	(3.253)
Constant	18.76***
	(0.00944)
Observations	15,923
RESET test (p-value)	0.0040

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Stata output of the gravity model for the Articles of Iron and Steel sector

VARIABLES	M
lntariff	-4.448
	(3.008)
Constant	18.52***
	(0.0401)
Observations	16,560
RESET test (p-value)	0.6367

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Stata output of the gravity model for the Aluminium sector

VARIABLES	M
lntariff	-14.68***
	(5.500)
Constant	18.66***
	(0.235)
Observations	13,230
RESET test (p-value)	0.2336

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: Stata output of the gravity model for the Cement sector

VARIABLES	M
lntariff	-10.66
	(6.901)
Constant	11.53***
	(0.0734)
Observations	8,109
RESET test (p-value)	0.4388

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Stata output of the gravity model for the Fertilizers sector

VARIABLES	M
lntariff	-13.95***
	(5.030)
Constant	18.06***
	(0.180)
Observations	8,741
RESET test (p-value)	0.9305

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1