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Agriculture carbon pricing in EU, carbon leakage and carbon adjustment mechanism impacts in southern cone beef exports

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Abstract

Climate change poses a challenge to agri-food systems. Recognizing the need for emission reduction, the European Union (EU) is contemplating the integration of the agricultural sector into formal carbon pricing mechanisms. This study employs the CLIMTRADE model to assess the potential consequences of a EU's carbon border adjustment mechanism (CBAM) on beef trade for Argentina, Brazil and Uruguay. The model considers a baseline bilateral trade matrix, emission intensities, international transport emissions, and potential carbon prices, resulting in the corresponding impacts on imports and exports, depending on the scenario considered. The results indicate that imposing a carbon tax within the EU leads to reduced beef imports, increased domestic prices, and potential carbon leakage. However, deploying a CBAM could mitigate carbon leakage and further reduce emissions. This study contributes to the discussion on the consequences for livestock production in South America of the advancement of emission reduction policies in agriculture driven by developed countries and their implications for the configuration of international trade.

JEL Codes: Q580, H230, F180

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Introduction

Climate change poses a complex challenge to agri-foods systems. On one hand, these systems are particularly vulnerable to the effects of this phenomenon, and therefore, concerns about food security have led to a focus on adaptation strategies to climate change. On the other hand, agricultural production is a significant source of greenhouse gas (GHG) emissions, responsible for 23% of global emissions worldwide (IPCC, 2020). While the agricultural sector has faced fewer demands for emission reduction so far, increased requirements to decrease emissions are anticipated in the near future (European Court of Auditors, 2021; Stepanyan, Heidecke, Osterburg, & Gocht, 2023; OECD 2022).

It is evident that, to limit the increase in global temperature to below 2°C, as specified in the Paris Agreement, a significant reduction in emissions from the agri-food sector is necessary. Recent reports indicate that agriculture must not only reduce emissions but also adapt to climate change (Isermeyer, Heidecke, and Osterburg 2019; OECD 2022).

Currently, agriculture participates in voluntary carbon credit markets, which have experienced significant growth in recent years (The World Bank, 2022). However, these activities have not yet been included in the official emissions trading systems in the EU (ETS). The integration of the agricultural sector into formal carbon pricing mechanisms seems imminent (Isermeyer, Heidecke, & Osterburg, 2019). Particularly in the European Union (EU), where these markets play a crucial role in emissions control under the Green Deal. Discussions are ongoing about alternatives to reduce emissions from agricultural production through emissions trading (Stepanyan et al., 2023). Agricultural and forestry products are traded internationally on a large scale, so pricing carbon in Europe may lead to the relocation of emissions-intensive production activities to third countries (carbon leakage). Carbon border adjustment mechanisms are instruments that could help reduce these leaks to regions where such activities are not regulated (Hufbauer, Schott, Hogan, & Kim, 2022).

Another key regulation for trade in agricultural products is the EU and US proposals to require "deforestation-free" certification of origin. This regulation requires a geographical registry to prove that the products or their ingredients do not come from deforested land after December 2020. The obligations will be applicable from December 2024, and in regions with a higher risk of deforestation, the requirements for records will be more stringent (Conte Grand, Schulz-Antipa, & Rozenberg, 2023). Despite criticisms from major agro-exporting countries, this regulation is progressing steadily.

Livestock production, along with crop fertilization and changes in land use, is identified as a major contributor to GHG emissions from agri-food systems (European Court of Auditors, 2021; Gonzalez Fischer & Bilenca, 2020). In particular, beef production is one of the activities where the implementation of carbon pricing can have significant impacts.

This paper explores the effects of carbon pricing in agriculture potentially implemented by the EU, specifically in the exports of beef from the Southern Cone. The study considers the impacts of implementing border carbon taxes to control carbon leakage. A partial equilibrium model is employed to simulate international trade in beef and analyze the economic effects of EU carbon pricing on the beef export sector of Argentina, Brazil and Uruguay.

The Importance of South America in the Global Beef Market

The agro-exporting countries can be heavily affected by changes in regulations that involve a carbon tax on agricultural and livestock product exports. Argentina, Brazil and Uruguay consistently rank among the world's top beef-exporting nations. With a combined production of 14 million tons of meat (3.1, 10.3, and 0.6, respectively), they contribute one-fifth of global beef production and one-third of global exports (FAOSTAT 2023). For the economies of these South American countries, cattle production is one of the main sectors for export (fifth in importance for Argentina – INDEC, 2023, first for Uruguay - INAC, 2023, seventh for Brazil – OECD country stats) and has a strong territorial presence in all three countries.

However, this activity poses significant environmental challenges, as beef is one of the products with the highest emission intensity according to global databases (FAO Emission intensity - FAOSTAT). Based on a recent study, simulating different amounts of carbon border taxes applied by EU countries results in significant impacts on Argentine beef exports (Marquardt et al., 2022, Cabrini et al., 2024).

Data and Methods

The partial equilibrium model CLIMTRADE was employed to simulate international beef trade for different scenarios of carbon pricing mechanisms and carbon price levels. The study particularly analyzes the impacts on the exports of the main beef-exporting countries in South America: Argentina, Brazil, and Uruguay.

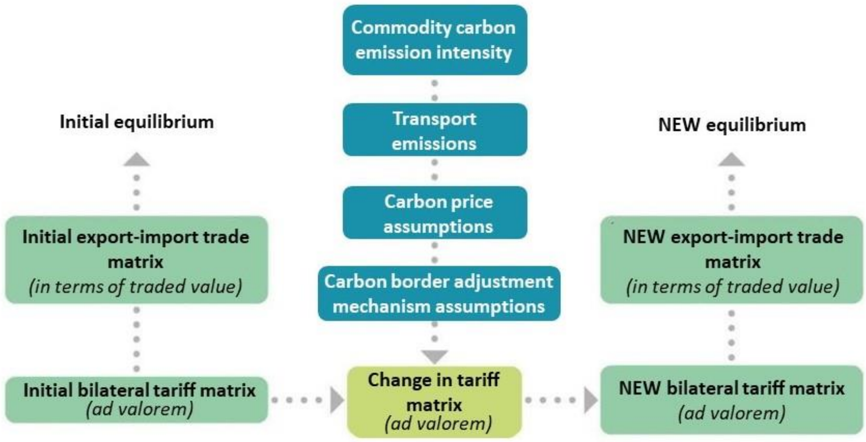
The model compares three scenarios: 1) a baseline scenario with no carbon price for beef, 2) a scenario with a carbon tax imposed within the EU (EUTAX), and 3) a scenario with a border tax adjustment mechanism imposed for EU imports (CBAM).

CLIMTRADE Model

CLIMTRADE (Marquardt et al., 2022) enables the modeling of the impact of carbon tariffs and mitigation measures adopted by different countries on trade flows. The tool is based on the Global Simulation Model (GSIM) (Francois & Hall, 2002). GSIM is a partial equilibrium representation of the global market, considering trade between various countries at the industry or product level, assuming product differentiation based on their origin (imports from different sources are imperfect substitutes). Model input variables include an initial bilateral trade matrix at world prices and an initial bilateral ad valorem tariff matrix. Exogenously defined are the substitution elasticities, import demand elasticities, and export supply elasticities.

CLIMTRADE extends the original GSIM approach by integrating the modeling of the impact on trade of carbon tariffs and mitigation measures represented as lower greenhouse gas emission intensity values per unit of product compared to a reference situation. In this study, CLIMTRADE is used to model the impact on beef trade of the EU's introduction of a tariff proportional to the emission intensity of the marketed product. The magnitude of the tariff increase is determined based on the emission intensities of beef (specific to each country), international transport emissions, and the underlying carbon price subject to the carbon tariff.

The model estimates a new equilibrium through price adjustments that ensure the absence of excess supply and/or demand in the global market, thus obtaining new equilibrium prices and the corresponding imported and exported quantities of a specific product for each country. Aggregate total impacts are the sum of the impact on exports and imports for each country and the impact on domestic trade. Figure 1 illustrates the modeling procedure in diagram form.



Source: Author's own elaboration.

Figure 1. CLIMTRADE model representation for assessing the impact of carbon pricing and border adjustment mechanism in the global beef market.

Partial Equilibrium Analysis Assumptions

Default elasticities from (Holzner, 2004) combined with those obtained in more recent empirical studies (Cicowiez & Lofgren, 2017) and sector-specific elasticities (Kawashima & Puspito Sari, 2010; Sbarai & Galvão de Miranda, 2012) are considered in the model:

Price elasticity of export supply: 1.5

Price elasticity of import demand: 1.25

Substitution elasticity: 2

Initial tariffs are expressed as bilateral Most Favored Nation (MFN) tariff lines. Preferential tariff lines on restricted volume quotas are not considered.

Non-tariff barriers (NTBs), as well as export taxes and subsidies, are held constant. Existing export taxes in Argentina are assumed to remain constant.

Only EU countries introduce a carbon border tax affecting other countries involved in global beef trade.

Carbon Price

It is necessary to define a range of carbon price levels to estimate the impacts. In real markets, these price levels are determined by the level of emissions restriction ("the cap") and the abatement costs of the activity, both factors are challenging to estimate for agricultural activities. Stepanyan et al. (2023) proposed using values of €100/tCO2eq to simulate the effects of nETS (ETS for sectors not covered by the EU ETS, based on the possibility that ETS and nETS markets converge toward these values in the near future.). The maximum value for EU ETS reached in 2022 (Figure 2). Other authors (Isermeyer et al. 2019) have employed broader price ranges between €25 and €180/tCO2eq. Based on previous references, this study considered a carbon price range of $25 to $100 USD/tCO2eq.

Source: Own elaboration based on data from ICAP (International Carbon Action Partnership)

Figure 2. Evolution of prices in the EU ETS carbon market.

Data Sources for CLIMTRADE

The model includes Argentina, Brazil, Uruguay, a set of 21 countries, and the rest of the world (ROW). Selected countries in the model are those relevant in the international meat market (either as major producers or consumers) and those important for the Southern Cone external trade. In the model, EU countries are the ones introducing the carbon tax.

All data used in the model correspond to the year 2019. If this data is not available, the closest available year is used and indicated. This choice is motivated by 2019 being the most recent data available outside the years affected by the Covid-19 pandemic (this period was excluded to avoid distortions in trade that could be caused by this extraordinary event). The data sources are detailed below:

Trade flows between countries: COMTRADE. The considered categories are 201 (Fresh or chilled beef) and 202 (Frozen beef)

Total beef production: FAOSTAT (Meat of cattle with the bone, fresh or chilled)

World beef price: Obtained from Food Price Monitoring and Analysis (FPMA) of FAO, using the annual average for 2019 between the international export price of beef from Brazil and the U.S.

Emission intensity: FAOSTAT (emission intensity, kg CO2eq/kg product). The emission intensity of beef production is taken from this database, following the IPCC 2006 level 1 calculation methodology. Emission categories considered include enteric fermentation, manure management, and manure on pastures. It is important to note that the IPCC methodology does not consider carbon sequestration sources associated with pastoral systems, pastures, etc.

Distances: Maritime distance between CERDI-sea distance ports (in km) for all countries. An average distance is assumed for trade relationships involving the rest of the world.

Transport emission intensities: Calculated in gCO2/ton of product/km. Source: European Chemical Transport Association.

Tariffs: UNCTAD-TRAINS.

Results

Imposing a carbon tax within the EU (EUTAX) causes a 5.9 billion USD reduction (-33%) in total beef imports in EU countries and a 66.2 million USD increase (9%) in imports from Argentina, Brazil and Uruguay combined (ABU) for a carbon price of 100 USD/ tCO2eq (See Figure 3 for more detail on these results for different prices, Figure 4 for exports changes from each of the South America selected countries to EU, and Table 1 for the changes in the exports from the Argentina, Brazil and Uruguay to various destinations).

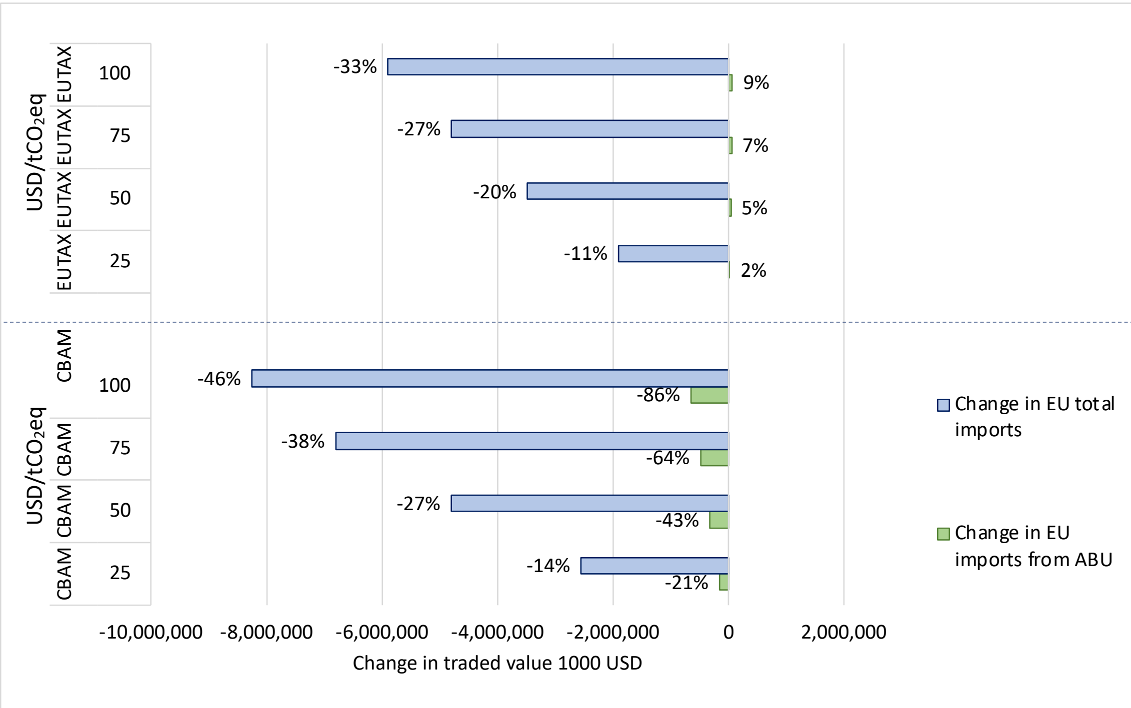


Figure 3. Changes in EU total imports and EU imports from Argentina, Brazil, and Uruguay (ABU) for scenarios with a carbon tax imposed within the EU (EUTAX) and a border tax adjustment mechanism imposed for EU imports (CBAM), in comparison to a baseline scenario with no carbon price for beef.

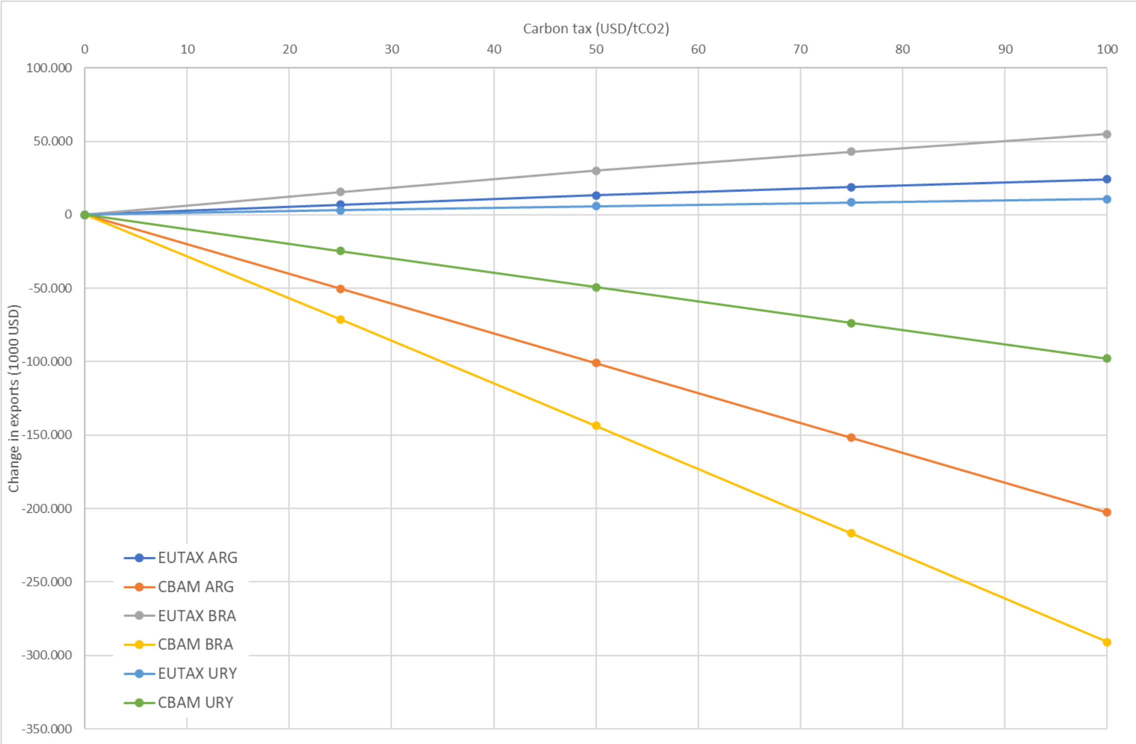


Figure 4. Changes in Argentina, Brazil, and Uruguay exports to the EU for scenarios with a carbon tax imposed within the EU (EUTAX) and a border tax adjustment mechanism imposed for EU imports (CBAM), in comparison to a baseline scenario with no carbon price for beef.

For the EUTAX scenario, with a 100 USD/tCO_2eq tax, there is an average 14% rise in the domestic price for the EU countries included in the model. The world's supply is reduced by 1.4 billion USD (-2%), EU countries' beef supply is reduced by 1.5 billion USD (-25.7%) and ABU supply is increased by 12 million USD (+0.1%) (See more detail on these results for different prices in Figure 5).

In the EUTAX scenario, beef becomes more expensive within the region. Under these conditions, ABU, as well as other countries, supply an additional quantity to the EU that can be thought of as carbon leakage. In this simulation, with a 100 USD/tCO_2eq tax, EU beef consumption-induced emissions are reduced by 17.7%, ABU emissions rise by 0.1% and total world emissions are reduced by 1.1%, all these in reference to the baseline situation, i.e. no carbon tax outside EU.

If a CBAM is imposed, and for the same hypothetical carbon price of 100 USD/t, the reduction on the selected EU countries' beef imports rises to 8.3 billion USD (-46.2%), of which imports from ABU account for 652 million USD (-85.9%). This could be seen as an almost complete shutdown of the carbon leakage. As we evaluate scenarios with lower prices, all the effects behave approximately linearly. In this scenario, the rise on the domestic EU price doubles that of the EU tax, reaching a 28% increase, the world's supply is reduced by 1.6 billion USD (-2.3%), EU countries' beef supply is reduced by 1.4 billion USD (-23.4%) and ABU beef supply is reduced by 83 million USD (-0.6%) (See more detail on these results for different prices in Figures 3 and 5).

In this case, beef becomes even more expensive in the EU and this wave propagates worldwide more intensely. Now extra-EU beef imports decline as they are reached by the carbon tax, and the world commerce adjusts to this new equilibrium, resulting in EU countries beef consumption dropping by 1.6 billion USD (-29.8%) vs the 1.1 billion USD (-19.9%) drop attributable to EU tax but without CBAM.

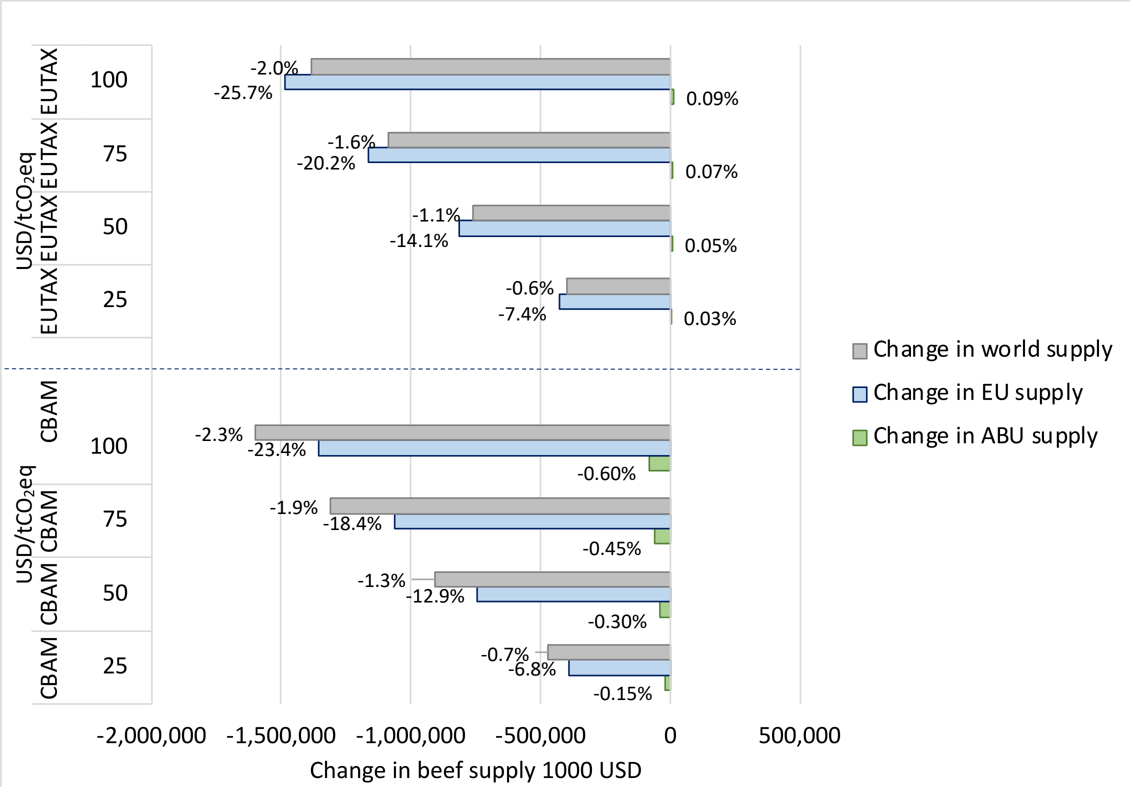


Figure 5. Changes in beef supply for scenarios with a carbon tax imposed within the EU (EUTAX) and a border tax adjustment mechanism imposed for EU imports (CBAM), in comparison to a baseline scenario with no carbon price for beef

Table 1. Changes (%) in Argentina, Brazil and Uruguay beef exports per destiny for scenarios with a carbon tax of 75 USD/tCO_2eq imposed within the EU (EUTAX) and a border tax adjustment mechanism imposed for EU imports (CBAM), in comparison to a baseline scenario with no carbon price for beef

(1000 USD)		ARGENTINA			BRAZIL			URUGUAY		
Destination country	Code	Baseline	EUTAX	CBAM	Baseline	EUTAX	CBAM	Baseline	EUTAX	CBAM
Argentina	ARG	9,422,483	0.0	0.1	61,647	0.0	-0.1	1	-0.1	0.9
Australia	AUS	0			159	0.0	0.2	0		
Brazil	BRA	49,514	0.0	0.3	32,040,348	0.0	0.0	41,649	-0.1	1.0
Canada	CAN	0			272	0.0	0.2	33,168	-0.1	1.2
Chile	CHL	170,213	0.0	0.3	627,572	0.0	0.0	12,124	-0.1	1.0
China	CHN	2,408,602	0.0	0.3	2,833,868	0.0	0.1	1,245,528	-0.1	1.1
Germany	DEU	146,186	7.5	-61.6	36,733	7.6	-72.8	26,962	7.5	-65.6
Spain	ESP	6,442	9.7	-62.6	50,372	9.7	-74.3	17,924	9.7	-65.3
France	FRA	649	12.0	-61.9	7,159	12.1	-73.2	2,302	12.0	-65.6
United Kingdom	GBR	4,032	3.4	2.7	19,615	3.4	2.5	14,870	3.3	3.5
China, Hong Kong SAR	HKG	7,424	0.4	0.7	1,283,073	0.4	0.5	581	0.3	1.5
India	IND	0			322	0.1	0.0	0		
Ireland	IRL	0			0	7.0	-100.0	0		
Israel	ISR	135,345	0.6	1.0	145,683	0.6	0.7	26,198	0.5	1.7
Italy	ITA	41,837	7.7	-61.6	156,949	7.7	-72.7	21,200	7.6	-65.2
Japan	JPN	0			40	0.0	0.2	11,488	-0.1	1.2
Republic of Korea	KOR	0			2,814	0.0	0.2	1,712	-0.1	1.2
Mexico	MEX	0			0			603	-0.1	1.2
Netherlands	NLD	81,524	4.4	-52.2	78,388	4.4	-63.7	84,165	4.3	-56.3
Poland	POL	0			0	8.8	-74.8	0		
Russian Federation	RUS	93,086	0.0	0.4	362,691	0.0	0.1	3,421	-0.1	1.1
Uruguay	URY	0			159,519	0.1	-0.5	562,082	0.0	0.5
United States of America	USA	12,145	0.0	0.4	531	0.0	0.2	176,831	-0.1	1.2
Uzbekistan	UZB	0			0			0		
Rest of the World	ROW	18,794	0.4	0.5	3,109,986	0.4	0.2	48,584	0.3	1.2
Exports to EU countries		276,638	6.7	-58.8	329,601	7.3	-70.9	152,552	6.1	-60.4
Total exports		12,598,277	0.1	-1.1	40,977,742	0.1	-0.5	2,331,392	0.3	-3.0

Note: Countries from EU in blue. Baseline trade is expressed in 1000 USD. EUTAX and CBAM columns are expressed in percentages.

In the CBAM simulation, for a carbon price of 100 USD/t, EU beef consumption-induced emissions are reduced by 38.1% (Figure 6), ABU emissions decrease by 0.6% and total world emissions are reduced by 1.6%, which helps to show how the carbon leakage is being counteracted by this policy device.

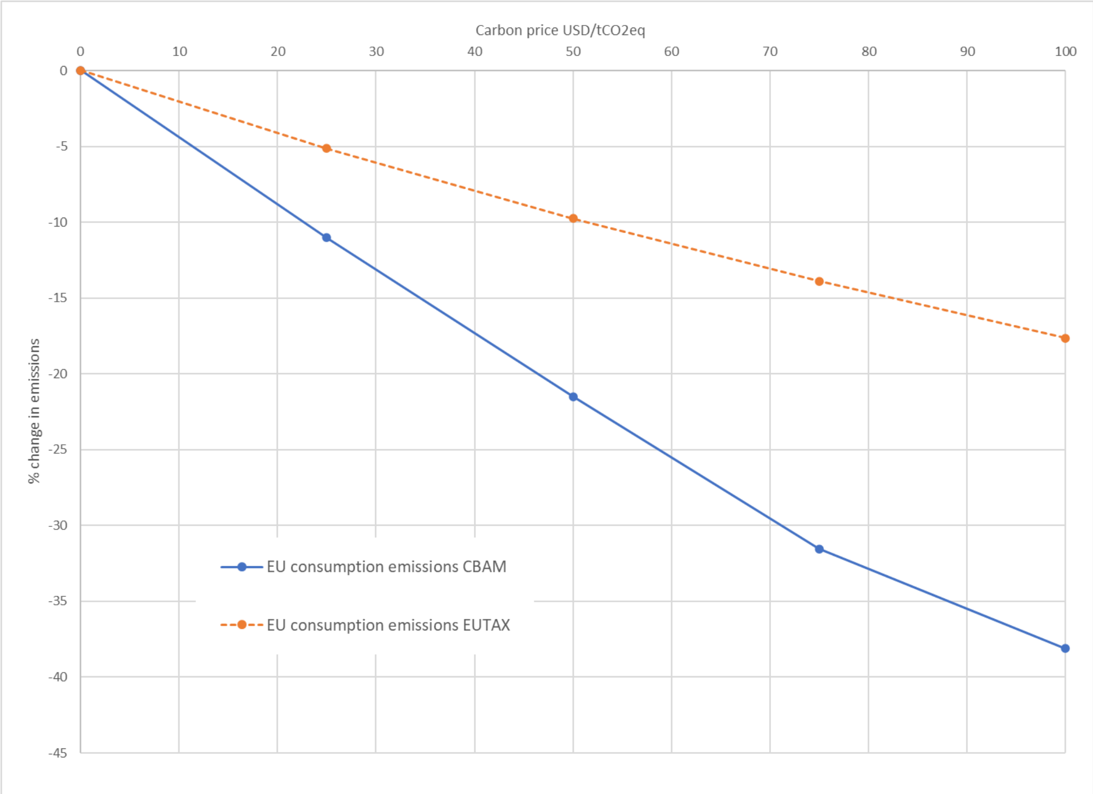


Figure 6. EU emissions reduction (%) for scenarios with a carbon tax imposed within the EU (EUTAX) and a border tax adjustment mechanism imposed for EU imports (CBAM), in comparison to a baseline scenario with no carbon price for beef

Discussion and conclusions

The results demonstrate that a carbon pricing mechanism implemented within the EU would have significant impacts on the global beef trade, particularly a sharp decrease in trade towards EU. Other studies using different models have reported similar outcomes (Arvanitopoulos, Garsous, & Agnolucci, 2021; Stepanyan et al., 2023).

Specifically, in the selected countries of South America: Argentina, Brazil, and Uruguay, which are significant beef exporters, a carbon border adjustment mechanism could have significant impacts, with reductions in total beef exports of up to 9%.

It is important to highlight the associated uncertainty in emission calculations. Addressing this uncertainty through meticulous analysis and the selection of metrics supported by a robust scientific evidence base is essential. In this regard, it is encouraging to observe efforts in the selected countries to compile national-level information, both in terms of activity data and emission factors.

The estimation of the greenhouse gas balance at the farm level, considering the carbon capture of the system, is the theoretically correct way to assess livestock systems (Isermeyer et al., 2019). However, in line with what the European Commission (2021) suggests, there are difficulties in determining the necessary information requirements considering the heterogeneity in various variables characterizing a farm that impact greenhouse gas emissions and capture.

In summary, the results obtained from this study contribute to the discussion on the consequences for livestock production in South America of the advancement of emission reduction policies in agriculture driven by developed countries and their implications for the configuration of international trade. There are still uncertainties about their realization and implementation. However, it is cautioned that this new scenario, with the uncertainties it brings, requires swift and concrete actions through coordinated actions between the public and private sectors aimed at promoting climate-smart livestock farming. This involves considering heterogeneities within and between regions through the incorporation of technology and management practices that increase productive efficiency, reduce emissions, and promote carbon capture. These efforts should be accompanied by the development of scientific knowledge and processes of evaluation and traceability that allow the certification of environmental performance.

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