



WORKING PAPER:

TRANSITION RISKS FOR ARGENTINA'S AGRICULTURAL SECTOR

A2A PHASE II

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KEY FINDINGS

Argentina's export-oriented agriculture sector is the backbone of the country's economy. Agricultural commodity exports generated more than 65% of total export revenues in 2020, representing the country's main source of foreign currency. Argentina is among the most important global exporters of soybean derivatives, maize, and bovine meat and aims to further boost agricultural output under its agri-export model.

Argentina's agriculture, forestry and other land use (AFOLU) sectors, however, also represent 37% of the country's total greenhouse gas (GHG) emissions. Sector growth targets and Argentina's objective to secure its strategic position as a key exporter of soybean derivatives and bovine meat are difficult to reconcile with the country's stated climate ambition. Argentina has reiterated in its second Nationally Determined Contribution (NDC) the ambition to achieve carbon neutrality by 2050. A credible pathway to carbon neutrality requires all sectors of Argentina's economy to start decarbonising today.

Contrary to the country's climate action pledges, survey results indicate that stakeholders representative of Argentina's export-oriented cropping, dairy, and livestock sectors do not expect the introduction of more stringent domestic GHG mitigation commitments for the agriculture sector in the nearby future. Stakeholders also do not perceive GHG mitigation commitments to be of critical relevance for export volumes nor export prices of agricultural commodities on aggregate (some variation across commodities exists). However, most stakeholders indicate to be actively working on issues related to environmental sustainability including carbon emission measurement programs.

Argentine stakeholders are aware of transition risks associated with more ambitious climate action in third countries. Survey results show that stakeholders expect the EU to be among those most likely to introduce more stringent environmental requirements or taxation schemes, but generally perceive the economic risks as low.

Stakeholders may underestimate the implication and economic impacts of more stringent environmental requirements imposed on international trade flows by countries with more progressive climate action agenda. The ratification of the EU-Mercosur trade agreement, which faces strong political opposition over the lack of environmental safeguards and enforcement mechanisms, as well as political voices calling for the introduction of a meat tax in the EU, exemplify this.

In this study, we show that an EU carbon tariff with full coverage of agriculture commodity imports would have disruptive impacts on global trade flows, significantly decreasing the competitiveness of exports from key producers such as Argentina to the European Union. Evidence from partial equilibrium modelling suggests that Argentina would incur significant economic losses in terms of forgone revenue already at moderate carbon tariff levels. This is as a result of a stark decrease in EU demand for Argentine exports of soybean derivatives and bovine meat as well as lower commodity price levels.

The carbon footprint of the agriculture sector and the fact that it is prone to carbon leakage underline the need for carbon pricing and border adjustment mechanisms. However, questions remain regarding the feasibility of application, legal grounds, as well as effectiveness of border adjustment mechanisms or related measures.

As countries increasingly introduce stricter environmental requirements and taxation schemes, which are imperative for reaching the Paris temperature goals, global trade in agriculture will become more GHG-constrained. The decarbonisation of trade flows is likely to represent a transition risk to key exporters of agricultural commodities such as Argentina. Taking early steps to reduce the GHG intensity of agricultural production systems, in turn, could represent a decisive source of competitive advantage for exporting countries.

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ABBREVIATIONS

AFOLU	Agriculture, Forestry and Other Land Use
BMU	Federal Ministry of the Environment, Nature Conservation and Nuclear Safety
CAT	Climate Action Tracker
CBAM	Carbon Border Adjustment
CGE	Computable General Equilibrium
EITE	Emission-Intensive Trade-Exposed
EU ETS	European Union Emission Trading System
GDP	Gross Domestic Product
GHG	Green House Gases
GMO	Genetically Modified Organisms
GSIM	Global Simulation Model
HACCP	Hazard Analysis and Critical Control Point
IKI	International Climate Initiative
INTA	National Institute of Agricultural Technology
IP	Impact on Price
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
IV	Impact on Volume
LTS	Long Term Strategy
MBGI	Plan Nacional de Manejo de Bosques con Ganadería Integrada
MFN	Most Favoured Nation
NDC	Nationally Determined Contribution
NTB	Non-Tariff Barrier
PO	Probability of Occurrence
ROW	Rest of the World
TFP	Total Factor Productivity
UN	United Nations
USD	United States Dollar
WTO	World Trade Organisation

1 INTRODUCTION

Argentina is one of the most important producer and exporter of agricultural commodities globally, supplying specifically soybeans and its derivatives, bovine meat, cereals, as well as dairy products to the world market. Argentina's agri-export model is the country's economic backbone; agricultural commodity exports generated more than 65% of total export revenues in 2020 (Ministerio de Economía, 2020). Agriculture, forestry, and other land use (AFOLU) sectors, including livestock farming and cropping systems, however, are not only of economic relevance for the country, but also represent 37% of Argentina's total greenhouse gas (GHG) emissions (Moreira Muzio, 2019).

Demand for Argentina's agriculture exports is growing dynamically, with China importing increasing volumes of soy products and bovine meat. As a consequence, the share of cultivated land in Argentina is increasing, and producers adopt more intensive and efficient cropping and farming processes to respond to the rapidly growing demand for Argentina's exports. With agriculture commodity prices at high and rising levels (FAO, 2021a), producers remain incentivized to boost agricultural output and push outward the frontiers of land used for agriculture; often into regions with forest area. The environmental impact of the intensification of the agriculture sector is a major concern.

Argentina has reiterated in its second Nationally Determined Contribution (NDC) the ambition to achieve carbon neutrality by 2050 (MAYDS, 2020a), but there remains uncertainty regarding the implementation of required action in the agriculture sector. Argentina is also in the process of developing a 2050 Long Term Strategy (LTS) and should reflect the economic and environmental concerns regarding the agriculture sector within it. Argentina's agricultural sector needs to define and pursue transformational pathways that are aligned with the country's stated climate action ambition.

It remains unclear how and when these strategies are likely to manifest, as Argentina continues to struggle with the COVID-19-induced economic and social crisis, facing high levels of inflation in basic consumer goods (Jourdan, 2021). Burdened by high debt levels already before the crisis, efforts and limited public resources are allocated to crisis relief and short-term macro-economic stabilization, rather than to long term recovery plans (Koop, 2021). Failure to align recovery efforts with low-carbon development pathways can result in significant transition and lock-in risks for the agriculture sector, both domestically and regarding the agri-export model.

Environmental protection along global value chains has become subject to scrutiny in developed countries and global markets are increasingly becoming more GHG-constrained. Some countries and economic unions, notably the European Union (EU), are considering the introduction of carbon border adjustment taxes or related mechanisms to prevent the leakage of carbon emissions to countries without equivalent carbon pricing schemes. For Argentina, increasingly ambitious climate action in progressive countries can represent a transition risk that can have adverse impact on its economic recovery and future development.

The objective of this study is to identify and understand economic transition risks to Argentina's export-oriented agriculture sector, in particular related to climate action domestically and of its trading partners. To this end, this study employs a mixed-method approach, combining survey-based insights on agricultural stakeholders' perception of predominant transition risks with evidence from quantitative scenario modelling of the impact of a hypothetical carbon tariff applied to agriculture commodity imports into the EU.

2 THE ARGENTINE EXPORT-ORIENTED AGRICULTURE SECTOR

Agriculture sector and context

Argentina's agriculture sector is dynamic and growing, making up 6.8% of GDP in 2020 (World Bank, 2021a). In 2018, the country's agriculture sector (agriculture and livestock primary production) formally employed about 5.26% of the total workforce (Calzada & Treboux, 2019). The share of employment in the agriculture sector is decreasing, as a result of the growing degree of mechanisation and automation of production systems (OECD, 2020), especially in soybean production (Sly, 2017).

Agricultural land as a share of the country's total land area has increased by more than 7 percentage points since the early 2000's and currently accounts for more than 54% of total land area (World Bank, 2019). Argentina's regionally diverse climate influences the territorial distribution of agricultural production systems and has traditionally led to a concentration of livestock and cropping systems, especially in the wet-warm Pampas region. Livestock production accounted for about one-third of total agricultural value in 2018, while cropping systems contribute the remaining two-thirds of the production value (OECD, 2020). Livestock production systems are increasingly competing for land with grain and oil seed cropping systems and, as a result, grass-fed livestock production systems are being transformed to feedlot production systems or are pushed out of the Pampean region

Argentina, unlike most countries, imposes a "negative protection" on its export-oriented agriculture sector. Albeit with some variation since the 1970s, public policies have generally pushed down domestic price levels and squeezed revenues for farmers, while increasing the costs of inputs (Lema, 2018). Argentina had almost always imposed export taxes for agricultural products. In the last decade, tax rates ranged from 25% to 35% for soybeans (beans and meal) and up to 23% for other agricultural products. Currently, export taxes amount to 33% for soybeans, 12% for maize and wheat, and 9% for beef. Foreign exchange regulation and export quotas represent additional measures that the government continues to adopt, which have significant impact on the export sector.

Livestock sector

Beef is by a large margin Argentina's most valuable livestock output in terms of production value, amounting to USD 6.6 billion (see Figure 1). Argentina is among the top five producers of bovine meat products worldwide, accounting for around 5% of global output (Gonzalez Fischer & Bilenca, 2020). Livestock production systems have increasingly become more intensive in Argentina, with around 50% of slaughtered cattle originating from feedlots (Hartmann & Fritz, 2018). However, regional differences in the level of intensification remain (Gonzalez Fischer & Bilenca, 2020).

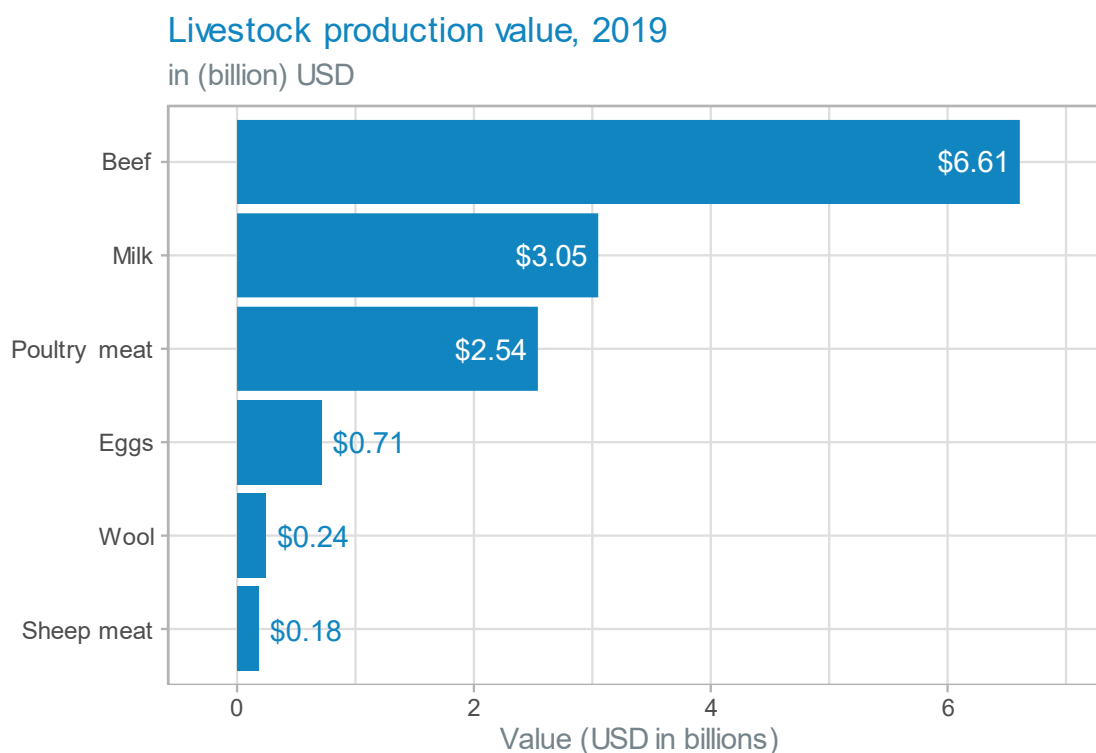


Figure 1: Argentine livestock production value of key commodities, based on FAO (2021b)

The expansion of soybean cropping systems, especially in the Pampas region, has been a primary driver for reducing the share of grass-fed cattle in the country, as land requirements for intensive feedlot farming are limited (Evans, 2008). Beef production is a strategic sector with strong growth targets and prospects, as domestic and foreign demand is projected to remain strong under a business-as-usual scenario (FAO, 2017). Key strategic priorities to ensure sector growth are efforts to improve weaning rates (from 68% to 75%) and to increase carcass weight by 10% (Gonzalez Fischer & Bilenca, 2020).

The environmental impact of Argentina's livestock production systems is significant, making up 21.6% of national emissions (excluding associated land use change) according to the latest budget (Moreira Muzio, 2019). The emissions intensity of bovine meat production in Argentina is on average 29.4 kg CO₂ eq./kg, but varies regionally depending on the level of intensification of the production system (FAO, 2017). The cow-calf stages of the value chain are estimated to contribute most significantly to GHG emissions (75%), while finishing systems are disproportionately responsible for biodiversity loss and ecotoxicity (Gonzalez Fischer & Bilenca, 2020).

Cropping systems

Cropping systems, especially those producing cereals and oil seeds such as soybeans, have undergone significant productivity growth since the 2000s (Antón et al., 2019). Especially in the Pampas region, rising shares of land under agricultural production and total factor productivity (TFP)¹ growth in cropping systems has vastly driven production output. The diffusion of technology and high-yielding varieties (such as genetically modified varieties), the adoption of modern cropping practices (no-tillage), as well

¹ Total factor productivity is measuring the productive efficiency of a production system by comparing how much output can be generated from given number of inputs. TFP is growing where more output is generated from the same number of inputs, i.e. the production system becomes more efficient.

as the emergence of more effective institutions and legal frameworks have been the predominant factors of growth in agricultural productivity (Antón et al., 2019).

At the same time, Argentina's agricultural diversity, in terms of the variety of crops and cereals produced, has decreased. In central Pampas, soybean has become the only or predominant crop in full year crop rotation (Cabrini et al., 2019). The country has undergone what is sometimes termed a "soybeanization" (Phelinas & Choumert, 2017). Soybean production and the processing of its derivatives amounted to more than USD 3 billion in 2019, exceeding the production value of maize and wheat combined (see Figure 2)². Argentina's agri-export model, favourable commodity prices, and the adoption of genetically modified soybean varieties at an unprecedented pace since the late 1990s have brought impressive efficiency gains and revenues, albeit not without adverse social (concentration of production impacting land tenancy and employment in agriculture) and environmental impacts (intensification of farming practices) (Hernandez & Phélinas, 2017).

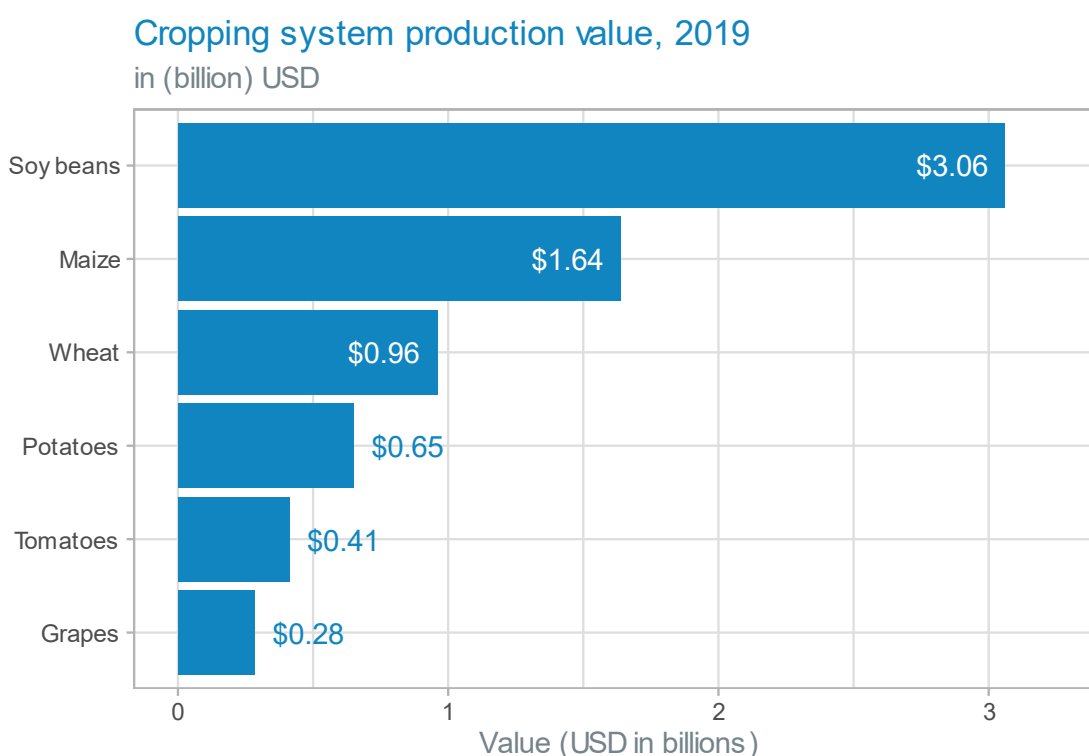


Figure 2: Argentine crops and cereals production value, based on FAO (2021b)

Cropping systems in Argentina comprise 5.8% of national emissions (excluding associated land use change) according to the latest budget (Moreira Muzio, 2019). With the widespread cultivation of soybeans, soil quality increasingly becomes a matter of concern. Under current land use and crop management practices, soil nutrients and organic carbon tend to decrease (e.g. see Cabrini et al. (2019)). In the Argentine Pampas, soil organic carbon and nutrient losses are mainly attributed to the large proportion of cropping systems employing full-season soybean in crop rotations. Additionally, the nature of Argentina's land tenure law, which allows for short-term leases, offers little incentive for appropriate soil conservation practices, such as the optimal application of chemical fertilizer (Hiba, 2021).

² Local value estimates of production are often reported higher in national studies.

Growing foreign demand for Argentina's agricultural commodities and the disappearance of traditional farming operations, where cropping systems were combined with livestock farming, adds to competition for land that also affects forest systems. Since the onset of the intensification of soybean cropping systems with the introduction of GMO varieties in the 1990s, Argentina has lost about a quarter of its forest coverage (Goni, 2018). Between 2000 and 2019, the land area devoted to soybean cultivation in Argentina increased by 57% (Kimbrough, 2021). The expansion of soybean cultivation, specifically into the Gran Chaco ecosystem, drives deforestation, although not always directly related to, but in close interplay with, livestock systems. Soybeanisation dynamics tend to first displace livestock production systems, which in turn drives deforestation as the frontiers of cattle raising and pasture systems are pushed outwards (Song et al., 2021).

In 2007, Argentina introduced a national native forest law, restricting commercial use of forest systems in specifically defined areas. Enforcement mechanisms are lacking, however, as monetary fines are not sufficient to deter large-scale breach (Goni, 2018). Since the introduction of the forest law, more than 2.6 million hectares of forest have been cleared, more than 30% of which were under protection by the law (De Ambrosio, 2019).

3 ARGENTINA'S AGRICULTURE EXPORTS

Argentina's key commodity exports and trading partners

Argentina's agriculture sector is the export sector that generates the largest export revenue (Ministerio de Economía, 2020). Soybean derivatives, maize, wheat, bovine meat, and dairy products are among the countries' key export commodities and the focus of this study's analysis. The share of agricultural commodity exports grew dynamically over the last years, while exports from the automotive and petrochemical sectors have been declining (Ministerio de Economía, 2020).

Table 1: Export value of key agriculture commodities

Commodity	2017 (mil US\$)	2018 (mil US\$)	2019 (mil US\$)	2020 (mil US\$)	2020 / 2017	2020 / 2019	Share of exports in 2020
Soy	17 170	15 054	16 943	14 865	-13.4%	-12.3%	27.1%
Maize	3 938	4 301	6 025	6 151	56.2%	2.1%	11.2%
Bovine meat	1 603	2 345	3 447	3 043	89.8%	-11.7%	5.5%
Wheat	2 706	2 839	2 836	2 471	-8.7%	-12.9%	4.5%
Dairy	618	878	798	1 002	62.1%	25.6%	1.8%

Based on Ministerio de Economía (2020)

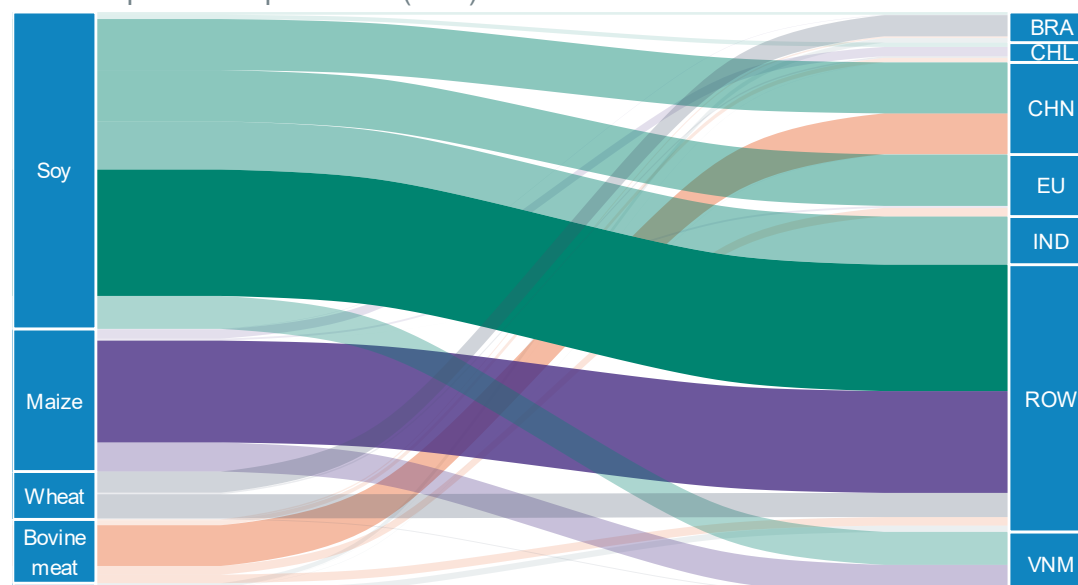
Soy is Argentina's most valuable export commodity at 27% of total exports (see Table 1), although the global COVID-19 crisis had adverse effects on 2020 revenues (Ministerio de Economía, 2020). Maize exports, representing about 11% of the country's total exports, grew close to 2% in 2020 and by about 56% since 2017, proving more resilient compared to other major export commodities such as wheat. The share of bovine meat in Argentina's total export was at around 5.5% in 2020 and has dynamically gained importance over recent years, but experienced a crises-induced year-on-year decrease of 11.7% in 2020 versus 2019.

China is Argentina's most important trading partner for agricultural commodities, followed by the EU, Vietnam, and India (see Figure 3)³. More than 16% of Argentina's soy exports and about 64% of the country's bovine meat exports went to China in 2020 (in terms of revenue) (Ministerio de Economía, 2020). The EU is the second largest export destination for bovine meat and a significant off-taker for soybean derivatives (especially soybean meal). The EU, however, is not a key trading partner for wheat, which it itself exports on a large scale, or for maize or dairy products. In part, this is the result of the EU's high import tariffs for dairy products and maize, as well as non-tariff barriers (e.g. unapproved GMO crop varieties).

³ In terms of the soybean derivatives, maize, wheat, bovine meat, as well as milk and cream exports.

Argentina's Agriculture Exports to Key Trading Partners

Flows represent export value (USD) in 2020



Note: Depicted commodities include soybean derivatives, maize, wheat, bovine meat, as well as milk and cream (not labelled explicitly).

Figure 3: Key trading partners and agriculture commodities, based on UN Comtrade (2021)

Exports of bovine meat to China have increased rapidly since 2015 (see Figure 4), and maintained pre-COVID-19 levels in 2020 (Heath, 2020). The value of meat exports to China was nonetheless lower in 2020, due to squeezed international meat prices (FAO, 2021d). Chinese producers of bovine meat, traditionally small-scale operations, have not been able to keep pace with domestic demand, which is driven by growing income levels in a broad cross section of China's population. Rising land, labour and fodder prices mean that Chinese producers are unlikely to pick up required pace and scale production output, meaning Chinese beef imports are anticipated to continue on a strong growth trend (Chen, 2020; Hussain et al., 2015).

For soy products and its derivatives⁴, exports to Europe and China have been declining on average over the last decade (in terms of value), while India and Vietnam have emerged as key export destinations for the Argentine product. China, however, remains the primary buyer of Argentine soy products, with Chinese demand mostly driven by livestock fodder needs (Reidy, 2021). Brazil and the United States are strong competitors on the global soy market, together supplying more than 80% of globally traded soybeans (UN Comtrade, 2021).

⁴ Argentina's soybean supply chain involves the processing of the soybeans via crushing to produce crude and refined soy oil as well as soy meal. Soybean meal is primarily used in animal feed, specifically fed to poultry and swine, but also for cattle and aquaculture systems. Soybean meal is a by-product of soybean oil production. Soybean oil is predominantly refined for cooking and edible uses, or turned into biodiesel via transesterification (NC Soybean, 2019).

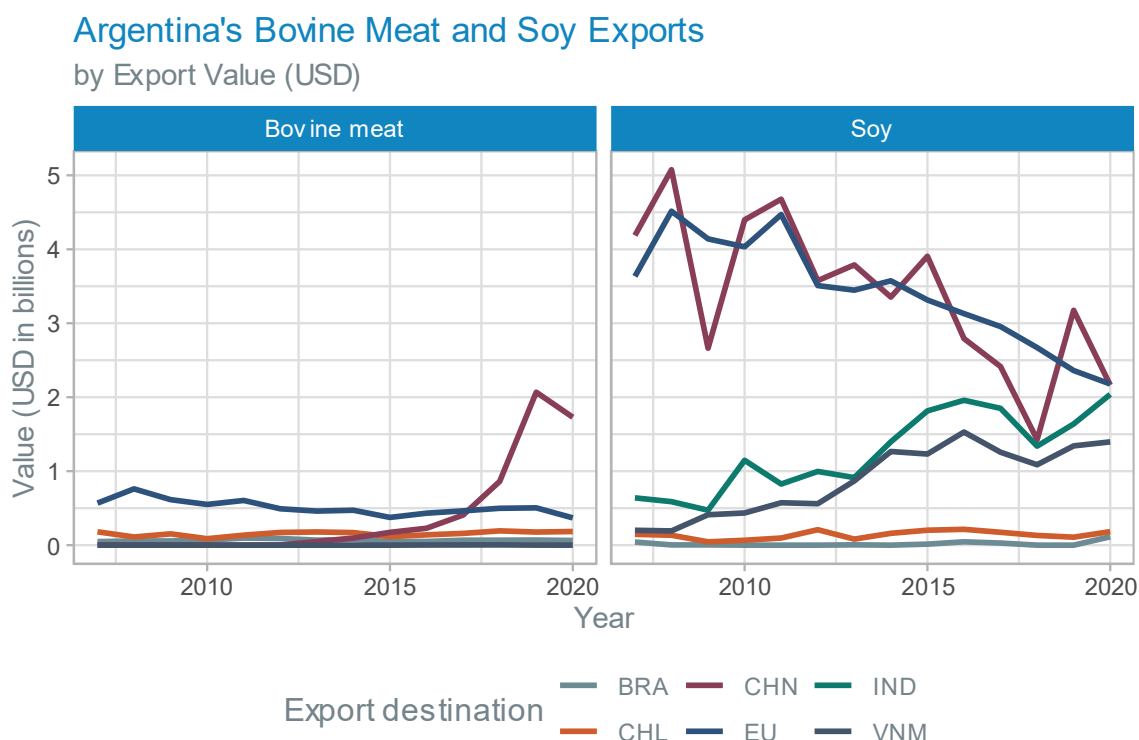


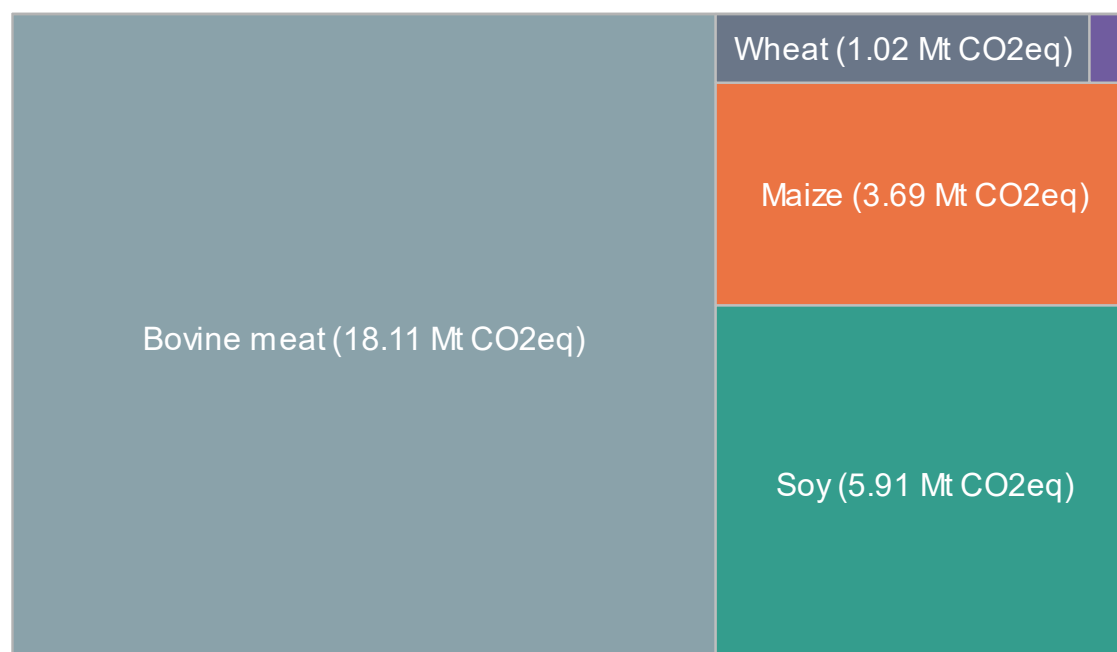
Figure 4: Bovine meat and soy exports over time, based on UN Comtrade (2021)

Emissions embodied in trade

Bovine meat and soybean derivatives are among Argentina's most valuable export commodities, but their export also contributed significantly to Argentina's GHG footprint embodied in agricultural trade in 2020. Bovine meat production has the largest emissions intensity by far (see Table 2), which explains why meat exports account for more than half of the total GHG footprint embodied in modelled trade flows while representing only a fraction of agriculture exports in terms of revenue (see Figure 3). The export of bovine meat, soybean derivatives, maize, wheat, as well as milk and cream resulted in total emissions of 28.9 MtCO₂eq in 2020 (see Figure 5), estimated as a function of export volume (UN Comtrade, 2021) and country- and commodity-specific CO₂eq emission intensity factors (see Table 2, Argentina's CO₂eq emission factor was used).

Argentina's High Emission Intensity Export Commodities

by Emission Embodied in Exports in 2020



Note: Depicted commodities include soybean derivatives, maize, wheat, bovine meat, as well as milk and cream (not labelled explicitly). Based on Argentina's CO₂eq emission factor (kg CO₂eq / kg) without land use change, as shown in Table 2.

Figure 5: GHG footprints of key export commodities, based on UN Comtrade (2021)

The GHG emission intensity of agricultural production varies across the regions, considering climate, production process and choice of inputs, as well as other contextual factors. In comparison to global average GHG emission intensity factors, Argentina's livestock production and cropping systems are relatively less GHG-intensive (see Table 2). For cropping systems, the widespread adoption of low/no-tillage practices, as well as limited use of fertilizer, and high productivity levels are responsible for relatively lower emission intensities in Argentina. In the livestock sector, it is the large and growing share of feedlot systems that reduces the emission intensity of beef production (enteric emissions are higher for longer finishing times and lower finishing weight) (Lupo et al., 2013).

Table 2: Emission intensities of key export commodities, measured in kg CO₂eq / kg

Commodity	Argentina's emission factor without land-use change	Global Average emission factor without land-use change	Global Average emission factor with land-use change
Soybeans	0.93**	1.3***	2.3***
Maize	0.1*	0.6***	0.9***
Bovine meat	29.4*	42.2***	58.2***
Wheat	0.1*	1.1***	1.1***
Milk and cream	0.7*	1.8***	2.3***

* Based on FAO (2019); ** Based on IPCC (2006); *** Based on Poore & Nemecek (2018) / Roser & Ritchie (2021)

4 STAKEHOLDER PERCEPTION OF TRADE RISKS

Introduction: What transition risks do Argentine stakeholders face?

The Argentine export-oriented agriculture sector and its stakeholders face internal, external, and exogenous transition risks (see Figure 6). Internal risks refer to Argentina's commitment to reduce GHG emissions and associated or required policies and plans, e.g. the country's NDC or LTS. External risks comprise border adjustment mechanisms such as carbon tariffs, as well as non-tariff barriers such as environmental standards imposed by third countries. Exogenous transitions risks are non-market factors affecting the demand for Argentine exports, such as climate-relevant demand shocks originating in changing consumer preferences or pests and diseases affecting a certain commodity.

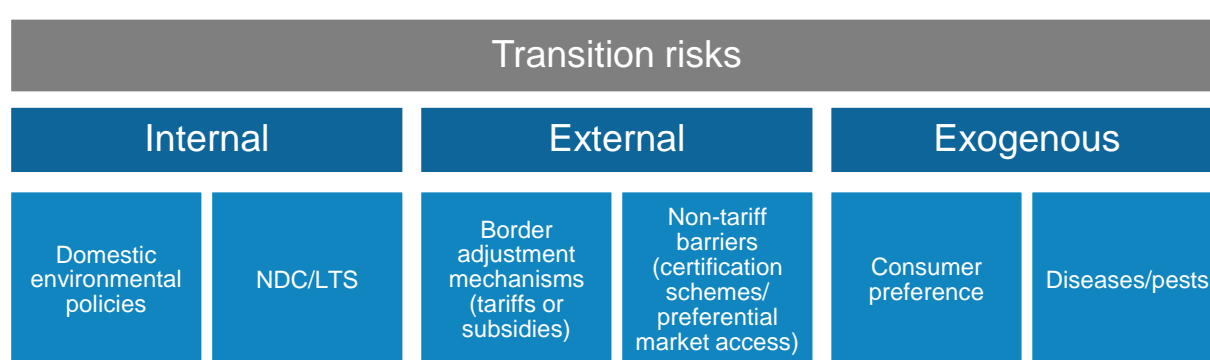


Figure 6: Transition risk topology

We surveyed a sample of key sector stakeholders (representing 17% of the country's export-oriented agriculture sector) to evaluate Argentina's transition risks in the export-oriented agriculture sector as perceived from the perspective of those most directly affected. The objective of this analysis was to obtain insights on the perceived likelihood of different risk factors resulting in potentially adverse impacts on trade revenue, as well as to understand the perceived relative importance of internal, external, and exogenous transition risks.

Internal transition risks: Argentina's climate action ambition

The agriculture sector, including land-use, land-use change and forestry, contributes about 37% of Argentina's total emissions (Moreira Muzio, 2019). The country has pledged to become carbon neutral by 2050 (Government of Argentina, 2020), but has so far not been successful in reconciling growth aspirations and the GHG emissions mitigation imperative of the sector. Argentina has introduced some targeted environmental policies and initiatives (see Table 3) aimed at promoting good practices and minimizing negative environmental externalities, but policy frameworks and sector-specific mitigation targets remain fragmented (CAT, 2020).

Table 3: Argentina's environmental protection initiatives and policies, based on CAT (2020)

Plans/Resolutions	Description
Second NDC	Argentina expects its agricultural sector to sustain its significant contribution to its GDP. Cereal production is to increase based on yield improvements and using limited additional land. Similarly, Argentina foresees an increase in meat production primarily based on increasing productivity through genetic improvements and good practices. Argentina aims to substantially reduce deforestation through sustainable forest management and the implementation of the National Forest Management Plan with Integrated Livestock (MBGI) (MAyDS, 2020b).
National Plan for Agriculture and Climate Change	Argentina's National Plan for Agriculture and Climate Change features three dedicated mitigation measures that are to be implemented by 2030 (MAGyP, 2019): <ul style="list-style-type: none"> - Increased afforestation (reduction of ~18 MtCO₂eq); - Improved crop rotation (reduction of ~4.3 MtCO₂eq); and - The use of biomass for energy generation (reduction of ~3.4 MtCO₂eq).
National Forest Management Plan with Integrated Livestock (MBGI)	Argentina aims to substantially reduce deforestation through sustainable forest management and the implementation of the National Forest Management Plan with Integrated Livestock (MBGI). The objective of the MBGI is to contribute to the sustainable use of native forests as an alternative to land-use change. This plan aims at integrating livestock activities that take place in native forests into the production matrix taking into account ecological, economic and social criteria (MAyDS, 2021).
Resolution 120/2011	Programme for Smart Agriculture, which supports the implementation and further distribution of smart agricultural practices and technologies, as well as research and development.
Resolution 174/2018	National Programme for Good Agricultural Practices in Fruit and Vegetable Products, which mandates the promotion of agriculture that preserves natural resources (water, soil and energy).
Law 26.331	Native Forest Law, which includes incentives for sustainable agro-forestry.

In addition to existing environmental regulations, most export-oriented agriculture stakeholders report facing sanitary and phytosanitary certifications requirements (87% of interviewed stakeholders), they are required to provide certificates of origin (80%) and hazard analysis and critical control point (HACCP) certification (53%), or they are required to follow good practice (40%) and ISO (13%) protocols. Certification requirements are specifically stringent for stakeholders exporting meat or animal products.

However, stakeholders report to not be bound to GHG emissions standards nor specific environmental certification requirements. Nevertheless, most stakeholders indicate to be actively working on issues related to environmental sustainability, particularly those that are exporters of crops and dairy commodities (see Figure 7).

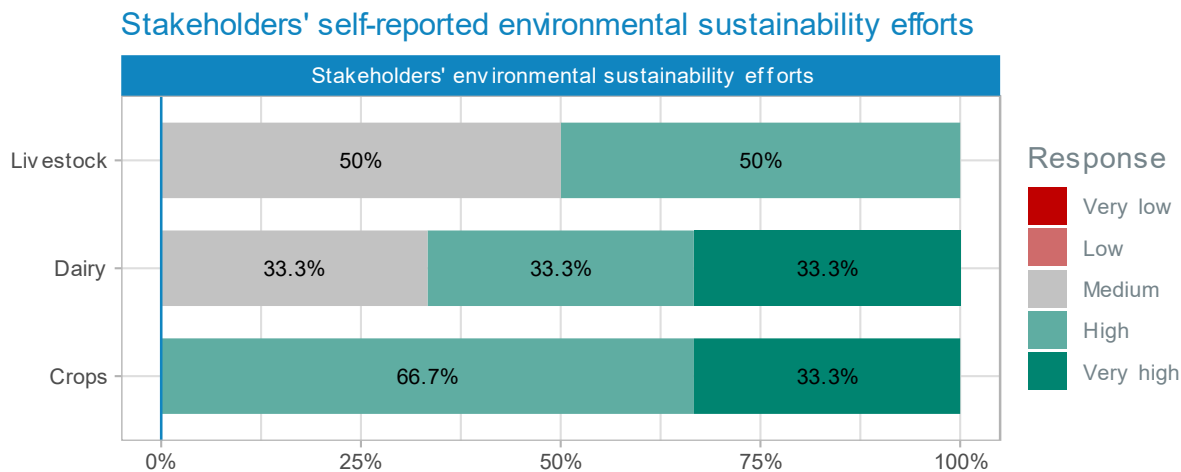


Figure 7: Stakeholders' efforts on environmental sustainability

Stakeholders believe that chances are higher that the Argentine government commits to more restrictive GHG targets for cropping systems as compared to livestock farming and dairy production, and expect impacts on export volume and prices for meat and crop products to be positive on average (see Figure 8). The perception of the likelihood and impact of stricter national requirements for dairy products is opposite, with stakeholders on average expecting Argentina's climate action ambition to rather decrease export volume and prices, although responses are much more dispersed.

Generally, surveyed stakeholders do not express strong opinions about the probability of the Argentine government imposing more stringent or ambitious climate action commitments in the agriculture sector for a 10-year horizon. Stakeholders also perceive the total impact of national climate action on export volume and prices to be rather moderate for all sectors, potentially indicating a high degree of uncertainty about the effectiveness of the government's actions on the matter. As the prevailing perception is that Argentina's climate ambition is not strongly conflicting with agricultural output, stakeholders are neither incentivized nor pressured to introduce mitigation options and advance the decarbonisation of the sector.

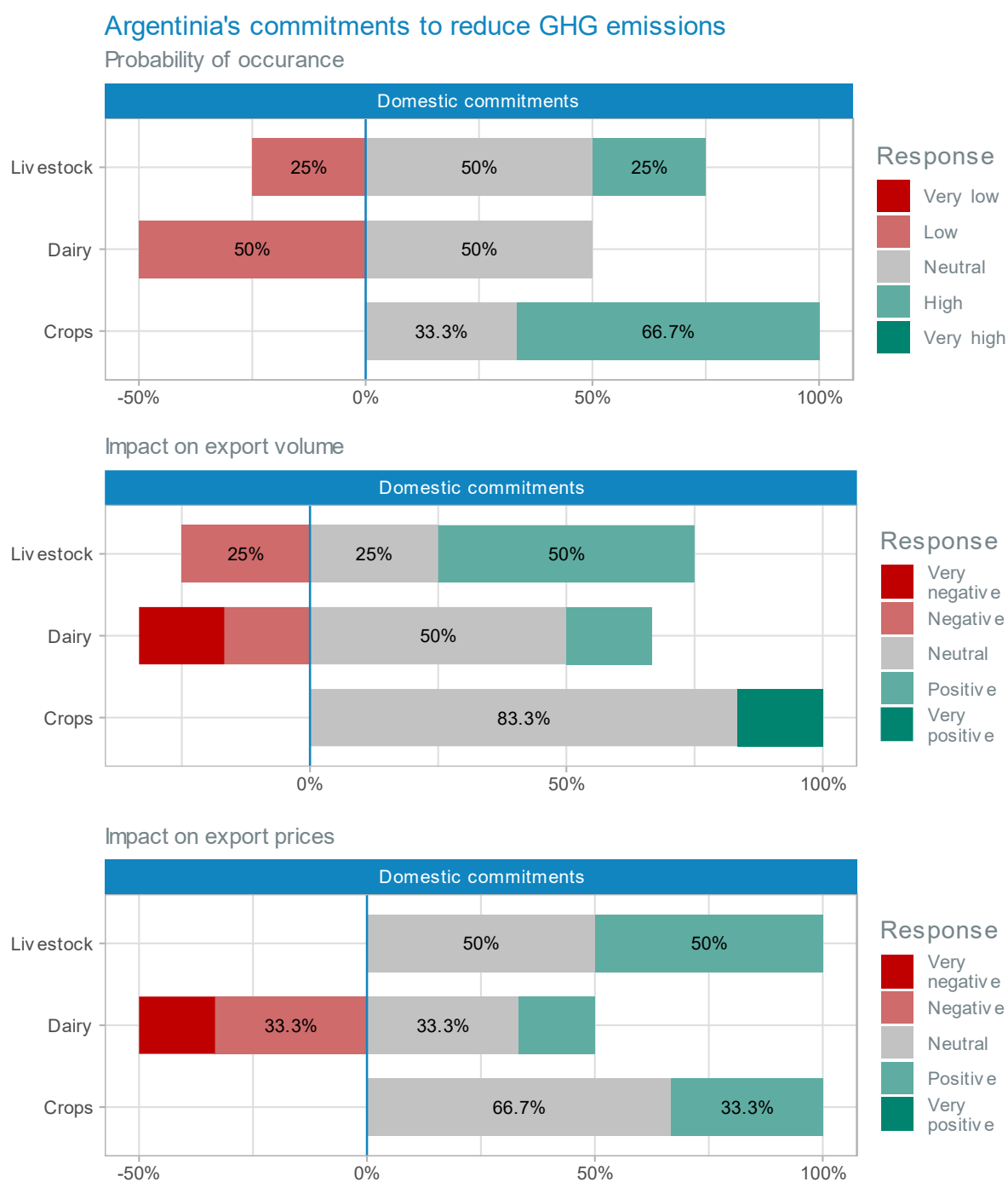


Figure 8: The perception of the risk of occurrence and the impact of an increase in Argentina's commitments to reduce greenhouse gas emissions

External and exogenous transition risks: Climate action and changing preference in Argentina's trading partners

Surveyed stakeholders report mixed views regarding the impact and likelihood of Argentina's trading partners imposing restrictive environmental regulation or environmental taxes (see Figure 9). Stakeholders consider the EU to be most likely to introduce more stringent environmental regulation, and to a lesser extent harsher environmental taxation (responses vary more significantly for the latter), in the foreseeable future. Ongoing debates around insufficient environmental controls in the yet to be ratified EU-Mercosur preferential trade agreement, as well as emerging plans to impose carbon border adjustments in the EU, may have likely raised stakeholders' concerns. Relative to other regions, surveyed stakeholders perceive governments of the Mercosur region to be the least likely to impose stronger environmental controls and taxes. Stricter environmental requirements are perceived as more likely in general across all regions, but responses show notable levels of variation for the US, China, as well as the rest of the world.

Stakeholders expect environmental requirements and taxation schemes to have only moderate impacts on export volume or prices across all export destinations, although several outlying responses indicate mixed views. Notably, impacts on trade volume and export prices are assumed to be slightly more pronounced where the EU is the trading partner. Stricter environmental requirements imposed by the EU are assumed to positively impact export prices, potentially highlighting exporters' expectation to be able to tap into emerging premium markets (i.e. certified or organic products). Stakeholders perceive, however, that EU taxation schemes would have an opposite effect on export prices.

This also holds more generally. On average, higher environmental taxes are expected to be deflationary or neutral for export prices across all export destinations, while stakeholders perceive more stringent environmental requirements to affect export prices rather positively. While marginal and subject to outlying responses, stakeholders expect the impact of higher environmental taxes to be generally detrimental for export volumes, while stricter environmental requirements are perceived to have mostly neutral impact on export volumes.

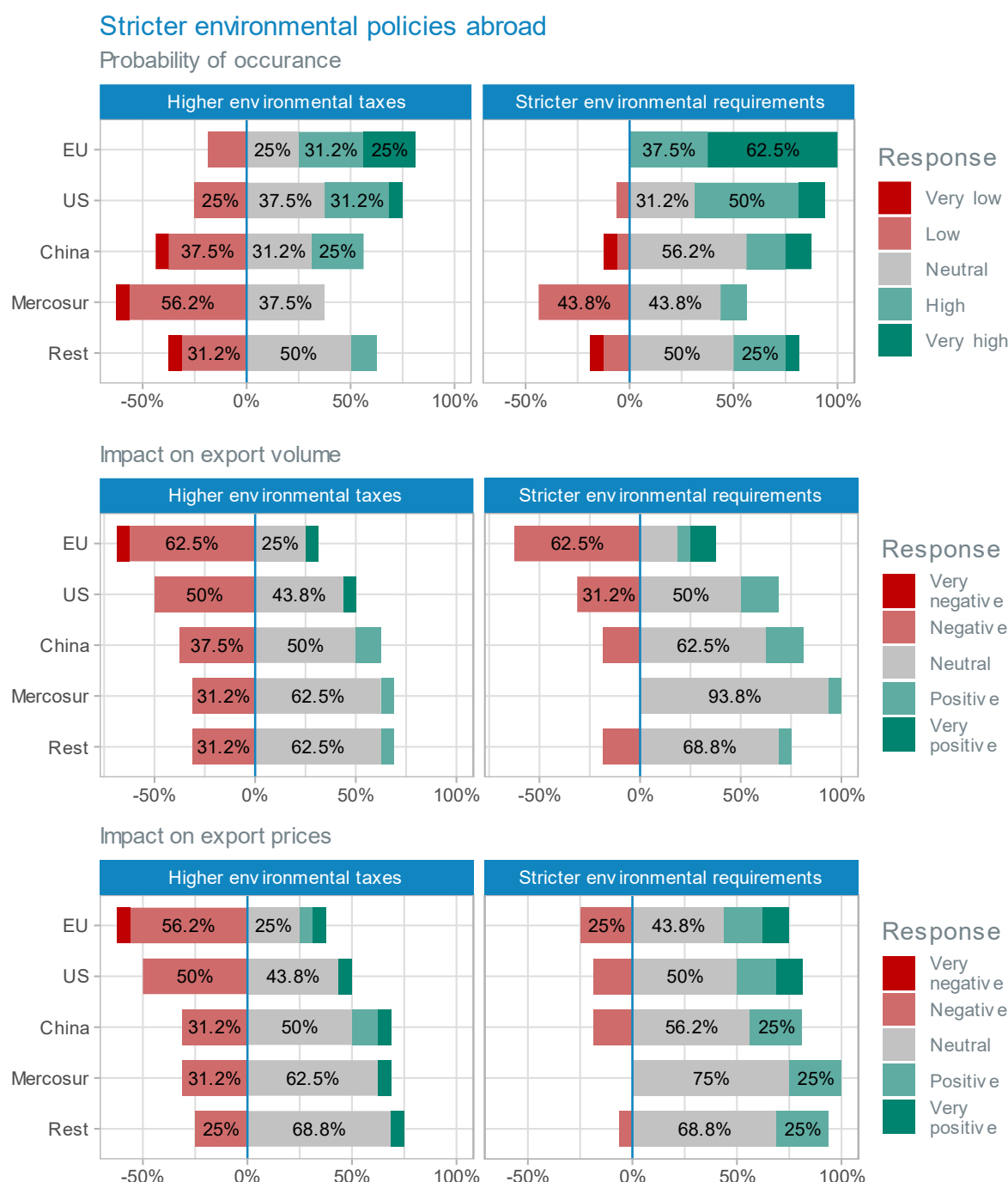


Figure 9: Perception of the risk of occurrence and the impact of more restrictive environmental regulation and taxation by region

Stakeholders perceive consumer consumption preferences to be most likely emerging in the European Union and the US, and most clearly for livestock commodities (see Figure 10). All surveyed stakeholders expect the probability of significant consumer preference change in the Mercosur region to remain low or neutral. China is expected to change its preference for dairy products, but less likely for livestock commodities or crops. The impact on export volume is believed to be mostly neutral for all commodities, although responses are varied. Stakeholders, however, expect export prices for crops and livestock commodities to be positively affected by changing consumer preferences on average, specifically in the

European Union and the US. This may be indicative of surveyed stakeholders expecting preferences to shift towards premium or high value produce that is selling at higher price levels.



Figure 10: Perception of the probability and the impact of changing consumer preferences by region

Macroeconomic stability and legal/regulatory certainty

Argentina's agri-exporters face significant macroeconomic and regulatory risks beyond the internal, external, or exogenous transition risks discussed above. Incumbent President Fernandez has increased export taxes on key agricultural commodities (soy, wheat and maize) upon taking office in late 2019 (Matera, 2020) in an attempt to generate tax revenues to avoid default on large volumes of sovereign debt (Heath & Bronstein, 2019). He has also installed a controversial short-term export ban for meat products to counteract increasing domestic foodstuff inflation in 2021 (Heath, 2021).

Current export taxes for soybeans are at 33%, while export taxes for soy oil and soy meal are at 31%. Maize and wheat exports are taxed at 12% (Donley, 2021). Import tariffs for agricultural capital goods, such as machinery and agrochemicals, as well as non-tariff barriers also remain high (Grundke & Arnold, 2019).

Favourable commodity prices have allowed Argentina to remain a key global provider of agricultural products, specifically soy, cereals and bovine meat, irrespective of its history of policy- and macroeconomic instability and volatility (Antón et al., 2019). Soybean exports have become the backbone of the country's economy, providing significant shares of foreign currency reserves and public revenue (Hernandez & Phélinas, 2017), a form of primary commodity export dependence that can carry transition risks in times of changing market structures and growing environmental concerns along all stages of global value chains.

In this context, unsurprisingly, most surveyed stakeholders consider stabilizing Argentina's macroeconomic situation and ensuring legal and regulatory certainty as key priorities for fostering agricultural sector development – more relevant than risks related to increasingly restrictive environmental regulation or taxation, domestically or abroad.

5 GLOBAL PERSPECTIVE: GHG-CONSTRAINED COMMODITY MARKETS

Introduction: How do global commodity markets become GHG-constrained?

The global economy and the trade flows that drive commodity markets will undoubtedly have to become more GHG-constrained. It is an imperative for mitigating climate change and reaching the objectives of the Paris Agreement. Countries' climate ambitions may differ in timing and nature under the domestically-driven architecture of the Paris Agreement (Abbas, 2020), but exposure to the global economy can beget a convergence towards more ambitious and homogeneous action – an environmental “race to the top”.

Several ambitious countries have started introducing carbon pricing schemes, such as carbon taxes or cap and trade systems of emission certificates (Pérez & Rhode, 2020). Carbon pricing schemes intend to internalize the social cost of unaccounted carbon emissions from economic activities. The internalization of the cost of negative externalities, however, can drive carbon leakage, i.e. the transfer of emissions intensive activities to countries with weaker climate policies. This particularly applies to emissions-intensive and trade exposed (EITE) industries whose competitiveness on the world market is adversely affected by higher production costs.

Countries with such progressive domestic climate policies may increasingly seek to counteract uneven ambition by advancing the decarbonization of trade flows through either environmental requirements enforced via bilateral/multilateral trade agreements or via carbon border adjustment mechanisms. The EU-Mercosur trade agreement, facing strong political opposition over the lack of environmental safeguards and enforcement mechanisms, represents one of the latest manifestations of this trend (see Box 1).

Although channels may differ, both market-driven and regulatory barriers to trade in carbon intensive goods can present a transition risk to exporters of such commodities, either because of increases to the relative cost of exports or as a result of limited access to sales markets.

We conduct an explorative ex-ante analysis of the possible economic impacts associated with these transition risks for Argentina by modelling the introduction of a hypothetical carbon tariff at the EU border. We evaluate the potential impact of the introduction of such carbon tariff assuming full coverage of agriculture imports, on Argentine export revenue, GDP and employment, for selected commodities.

Box 1: The EU-Mercosur Trade Agreement, based on Mendez-Parra et al. (2020), GRAIN (2019), and Bauer-Babef (2021)

EU-Mercosur Trade Agreement

The EU-Mercosur preferential trade agreement (PTA) is designed to remove tariff- and non-tariff trade barriers and facilitate market access specifically in the agricultural sectors of both blocs. Under the agreement, imports into the EU from Argentina's bovine meat and soy producers would gain preferential treatment. The PTA is modelled to increase GDP in Argentina by 0.5% in 2032, against a baseline without the PTA (Mendez-Parra et al., 2020). New and additional preferential treatment quotas and imposed duties are provided below (the table does not feature trade in wheat, as the EU does not currently impose any import tariffs on wheat).

Current EU-Mercosur quotas

Commodity	Existing Quota	Duty
Bovine meat	200 000 tonnes	20%
Soy	No quota	33% export tax
Poultry	330 000 tonnes	131 EUR per tonne
Pork	No quota	268 EUR per tonne
Cheese	No quota	Avg. 37.5%
Milk	No quota	Avg. 37.5%

Quotas under PTA

Commodity	PTA Quota	Duty
Bovine meat	99 000 tonnes	7.5%
Soy	No quota	0% export tax*
Poultry	180 000 tonnes	0%
Pork	25 000 tonnes	83 EUR per tonne
Cheese	30 000 tonnes	Sequential reduction
Milk	10 000 tonnes	Sequential reduction

* The PTA seeks to address export taxes imposed by Mercosur countries on products such as soy, based on GRAIN (2019).

Increased bilateral trade as a result of the EU-Mercosur PTA is conservatively estimated (excluding additional soybean exports) to generate nearly 9 million tonnes of additional greenhouse gas emissions per year, representing a 34% increase (GRAIN, 2019). The PTA is, however, unlikely to be ratified, facing strong political opposition over the lack of environmental safeguards and enforcement mechanisms it offers (Bauer-Babef, 2021).

An EU carbon tariff with coverage of agricultural commodities?

The European Union (EU) is considering introducing carbon border adjustment taxes or related mechanisms to prevent the leakage of carbon emissions to countries without equivalent carbon pricing schemes. Essentially, such mechanisms impose an equivalent tax on imported goods or services (or provide export rebates for domestic goods or services) to level the playing field for domestic and foreign producers (Nedumpara & Pradeep, 2021).

The introduction of carbon border adjustment mechanism, such as a carbon tariff, can distort international trade flows. For countries such as Argentina, that are characterized by a large export-oriented agriculture sector which contributes significantly to GDP, carbon tariff-induced trade diversion can result in deteriorating terms of trade (the ratio of export prices to import prices) (Weko et al., 2020). By virtue of how carbon border adjustment works, economic risks are particularly high for countries producing goods that are comparatively emission intensive and for which there is strong international competition.

The EU has passed an initial resolution to support the introduction of a WTO-compatible carbon border adjustment mechanism (CBAM) in March 2021, but is still in the process of assessing suitable CBAM design elements (such as mechanisms, coverage, etc.) (European Parliament, 2021). Initial proposals of the EU CBAM are unlikely to cover agricultural imports, since the EU's emission trading system (EU ETS) currently does not cover emissions from the agriculture sector either. However, some EU member countries are proactively pushing for an inclusion of agricultural imports in the CBAM, given the sector's carbon leakage risk (Appunn, 2021).

Box 2: Modelling an EU carbon tariff, drawing on World Bank (2021b) and Bellora & Fontagn (2021)

The CLIMTRADE tool: Modelling an EU carbon tariff

Carbon tariffs can have disruptive impact on global trade flows, where they significantly decrease the competitiveness of exports from key producers to major markets. The introduction of carbon-related trade barriers can result in trade diversion, the disintegration of previous trade patterns and the emergence of new trade flows. Carbon tariffs can influence commodity prices on the world market, specifically when tariffs are introduced in major import markets, i.e. as a consequence of the supply overhang resulting from lower global demand for exports. Modelling this relationship to obtain robust estimates of the economic impact of introducing a carbon tariff is complex, and choosing an appropriate methodology requires balancing robustness of findings versus feasibility of implementation.

Quantitative research on the economic impact of carbon border adjustment mechanisms is limited or lacks granularity with respect to how specific economies or traded goods are impacted. The World Bank (2021c) estimated the first-order impact of the EU CBAM for cement, steel, and aluminium imports from Thailand, India, and Vietnam. The first-order economic impact represents the carbon cost ("carbon bill") to exporters facing the carbon tariff, assuming unchanged trade flows. First-order effects do not capture how changes in the price for emission-intensive imported goods divert trade, and as such provide no understanding of changes to trade flows between country pairs. For more comprehensive analysis of market dynamics, general equilibrium modelling (CGE) is commonly applied, which allows estimating the economic and environmental impacts of carbon border adjustments more comprehensively (see Bellora & Fontagn (2021) for an overview). These models have the advantage of determining prices and quantities simultaneously in multiple interconnected markets, but tend to lack detailed representation of underlying dynamics. Quantitative analyses on the economic impact of carbon tariffs for the agriculture sector and specific commodities is generally sparse, and non-existent for the case of Argentina.

To model the impact of carbon tariffs in this study we apply our in-house CLIMTRADE tool. The tool combines partial equilibrium modelling of trade dynamics and input-output analysis for the estimation of domestic economic impacts. It employs a methodology that goes beyond a simple first-order effects approach in that it explicitly models price adjustments and changes in trade flows resulting from the introduction of carbon tariffs. For this study, we explicitly model trade relationships between 24 countries plus an aggregation of the rest of the world. The modelled countries represent the largest importers of Argentina's agriculture commodity exports. The estimation of economic impacts is conducted on the commodity level, for five of Argentina's most valuable agriculture export commodities, i.e. soybean derivatives, maize, wheat, bovine meat, as well as milk and cream. Four carbon price scenarios are modelled explicitly (USD 25, USD 50, USD 75, and USD 100 per tonne of CO₂eq), and in-depth analysis of changing trade patterns is provided for a carbon price of USD 50 per tonne of CO₂eq. A full discussion of the methodology and its assumptions is provided in the Annex.

More information on the CLIMTRADE tool at:

<https://newclimate.org/2021/11/05/climtrade-tool/>



Significant transition risks on the horizon

Overall, the introduction of a European carbon tariff for agricultural commodities would decrease the competitiveness of these imports to the EU. The results of the modelling exercise suggest that Argentina would incur revenue losses from forgone trade and face unfavourable export prices for all commodities modelled. Economic impacts are significant for bovine meat, maize and soybeans, and wheat, but comparatively small for dairy products.

Total forgone revenue, estimated as the aggregated forgone revenue from all five modelled commodities at a given carbon price, ranges between about USD 450 million and USD 1.4 billion, in the four carbon price scenarios.⁵ Lost revenue from trade in soybean derivatives and bovine meat, Argentina's most valuable agricultural export commodities, is particularly notable. The forgone revenue is significant, taking into account that only about 9% of soybean and 11% of bovine meat export value modelled is associated with tariff-imposing countries, i.e. exports to EU countries. The introduction of a carbon tariff is similarly disruptive for maize, wheat, as well as milk and cream. Although estimated forgone revenue is smaller in absolute terms for these commodities, impacts are significant when taking into account that the modelled tariff imposing countries buy only a negligible share of Argentina's exports (0.28% for maize, 0% for wheat and milk and cream).

The total domestic impact of the carbon tariff induced demand shocks are sizeable, given the importance of the agricultural sector in Argentina. Using input-output analysis, we find that indirect and induced economic impacts caused by lower household income result in domestic economic output losses of between around USD 1 billion and USD 3 billion. Expressed as a share of total output, the introduction of carbon tariffs for the modelled commodities results in GDP shocks of between 0.2% and 0.7% (3.1% - 9.2% for agriculture GDP only).

⁵ The modelled scenarios are hypothetical and represent an incomplete set of possible outcomes. Further, the analysis is based on several assumption and simplifications that may influence the output of the model (see Annex for a detailed discussion). Specifically at high carbon prices the outputs of the model should be taken with caution.

Table 4: Economic impacts across four carbon price scenarios

Commodity	USD 25 per tonne of CO ₂ eq	USD 50 per tonne of CO ₂ eq	USD 75 per tonne of CO ₂ eq	USD 100 per tonne of CO ₂ eq
Soybeans	\$ -281,489	\$ -557,181	\$ -827,238	\$ -1,015,573
Maize	\$ -30,544	\$ -60,811	\$ -88,021	\$ -112,976
Bovine meat	\$ -124,705	\$ -249,840	\$ -254,967	\$ -227,484
Wheat	\$ -9,722	\$ -19,351	\$ -28,888	\$ -38,334
Milk and cream	\$ -46	\$ -91	\$ -137	\$ -183
Total forgone revenue	\$ -446,507	\$ -887,274	\$ -1,199,252	\$ -1,394,550
Total domestic impact	\$ -994,057	\$ -1,976,974	\$ -2,605,539	\$ -2,974,330
Impact on total GDP (%) (2019)*	-0.2%	-0.4%	-0.6%	-0.7%
Impact on agricultural GDP (%) (2019)**	-3.1%	-6.1%	-8.1%	-9.2%
Impact on employment (job years)	-13,496	-26,851	-34,953	-39,528

Note: USD values refer to '000s.

* GDP data based on (World Bank, 2020b)

** Agriculture GDP data based on (World Bank, 2020a)

The total domestic impact of forgone trade revenue is in parts driven by impacts on employment and associated changes to household incomes. Direct and indirect jobs are lost in the agriculture sector, but induced impacts on employment also affect other sectors such as manufacturing. Overall, the introduction of carbon tariffs based on carbon prices between 25 USD per tonne of CO₂eq and 100 USD per tonne of CO₂eq in the EU for modelled commodities is estimated to result in a loss of between 13,000 and 40,000 job years⁶ (see also Figure 11).

The introduction of a carbon tariff based on a conservative carbon price of USD 50 per tonne of CO₂eq⁷ on agricultural imports to the EU may strongly divert Argentinian bovine meat and soy exports from the EU. Modelled EU member countries (Germany, Spain, Italy, and Poland) shift to internally sourcing imports, i.e. from within the EU. Germany, accounting for around 8.6% of Argentina's total bovine meat exports in 2019, would drastically reduce its reliance on Argentine meat imports (see Figure 12), alone representing close to USD 240 million of forgone revenue. Spain, Italy, and Poland are estimated to heavily curtail imports of Argentine soy. China may absorb significant shares of the resulting excess commodity supply, but by far not enough to offset forgone trade with EU countries. Lower price levels, stemming from the supply overhang caused by reduced EU demand, further reduce revenues generated from trade in the modelled commodities, including trade flows that remain largely unaffected by the introduction of the tariffs.

⁶ A job-year is one year of work for one person.

⁷ EU carbon prices rose above EUR 60 (~USD 70) per tonne of CO₂eq in 2021 (Simon, 2021). To decarbonize by 2050, a carbon price of EUR 120 (~USD 140) per tonne of CO₂eq may be necessary (OECD, 2021).

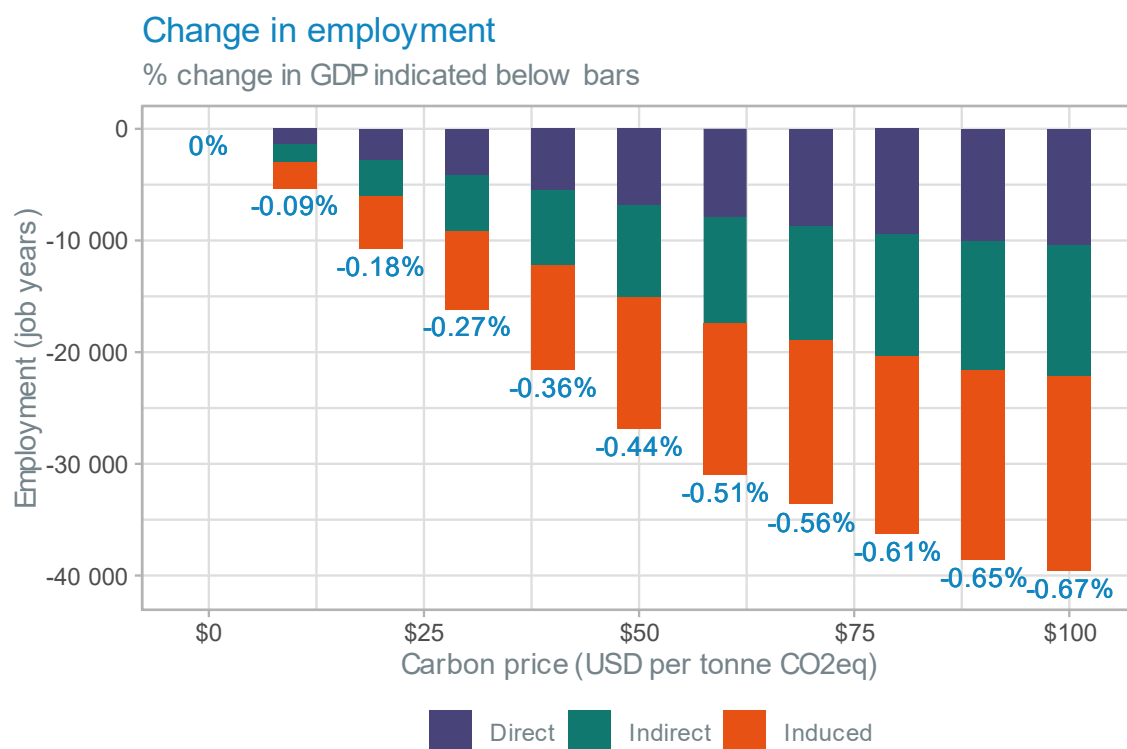
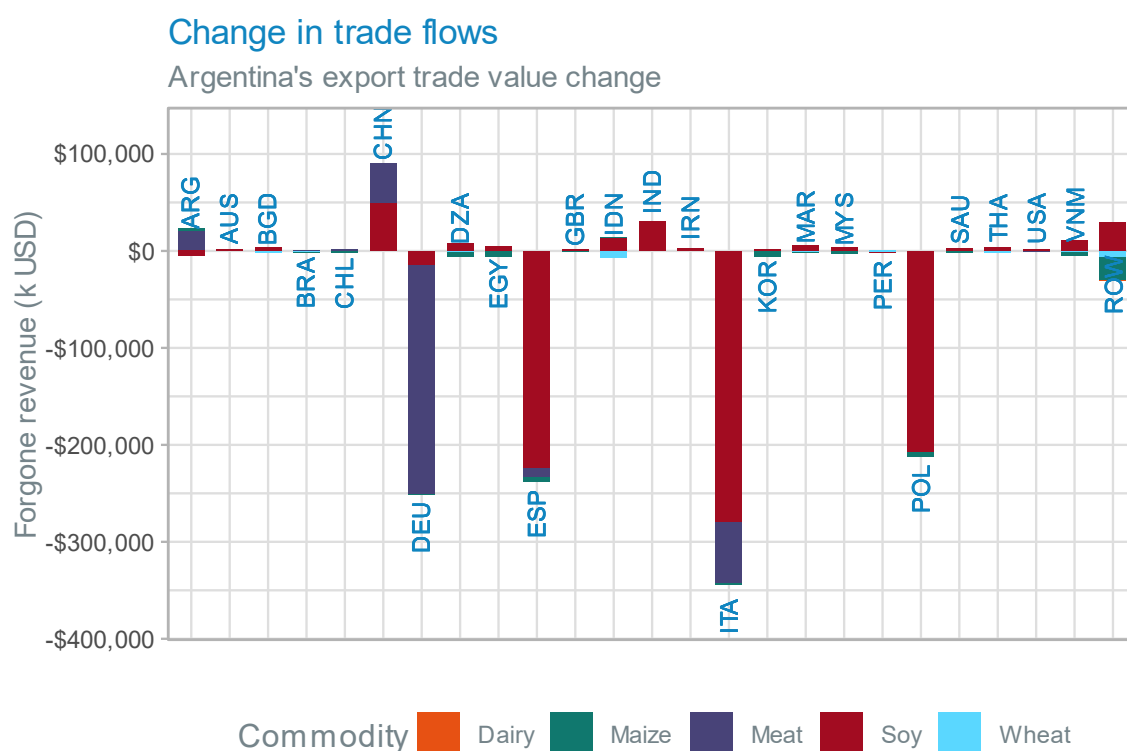


Figure 11: Employment and GDP (2019) impacts

Figure 12: Changing trade patterns at a carbon price of USD 50 per tonne of CO₂eq

6 CONCLUSION

Argentina's agriculture sector is the backbone of the country's economy and will likely play a decisive role in pulling the country out of its debt- and COVID-19-induced crises. While the sector's access to the world market is complicated by export tariffs, its stakeholders remain confident of its growth potential and actively promote the adoption of modern agricultural processes and technologies to advance productivity and output.

At the same time, however, the agriculture sector is the country's second largest source of GHG emissions. Foremost, this poses a significant challenge to Argentina as it develops plans to achieve carbon neutrality by 2050. As the world and international markets become more GHG-constrained, Argentina's GHG emissions embodied in trade increasingly become a transition risk with likely adverse economic impacts in the medium- and long-run.

Climate constrained markets are not perceived as a significant risk

Argentina's most relevant industry stakeholders do not perceive climate action, domestic and that implemented by trading partners, to be a significant risk factor to the sector. Predominant concerns regard the administration's export taxation schemes and export bans, as well as the general macroeconomic stability of the country, which are perceived to be more impactful and more likely to remain a significant barrier to the sector's growth. Nonetheless, stakeholders indicate to be actively working on issues related to environmental sustainability, including the participation in carbon emission reduction programs.

Stakeholders expect the European Union to be most likely to introduce stricter environmental requirements and taxation schemes, which reflects the current reality and ongoing discussions around the EU-Mercosur preferential trade agreement. Despite stakeholders' acknowledgement of the existing and prospective transition risks, specifically those associated with regulations and policies introduced in the EU, trade volumes and price levels are on average not expected to be strongly influenced.

These findings may be indicative of a general uncertainty shared among stakeholders with respect to how unprecedented environmental policies and stricter regulation may affect demand for Argentine exports and trade patterns. However, it is possible that stakeholders underestimate the relevance of external and exogenous transition risks vis-à-vis domestic regulation by falling prey to availability bias⁸, given the country's history of macroeconomic instability and lacking regulatory support for the export-oriented agriculture sector.

Consumer preference change is expected to have the largest impact on export volumes and prices in relative terms. Especially the European and US markets are perceived to follow these trends. Changing preferences may be perceived to have more pronounced impacts on export price and volume, as exporters are directly exposed to the changing consumption behaviour of consumers via private trade agreements with supermarket suppliers in export markets in the EU and US.

⁸ A heuristic whereby one is likely to overestimate the likelihood and/or impact of an event based on its familiarity or how easily it comes to mind (Dale, 2015).

Competitiveness via low-carbon production

Global markets become emission constrained as countries introduce strict domestic environmental requirements or emission pricing schemes that also affect the prices of goods traded internationally. The European carbon border adjustment mechanism, to be implemented to counter the risk of carbon leakage, is one example of how climate action ambition in progressive countries or trade unions can have impact on third-party countries.

The analysis of the effects associated with the introduction of an EU carbon tariff with full coverage of agriculture commodities has highlighted the transition risks faced by Argentina as an exporter of emission-intensive commodities in increasingly emission-constrained markets. The introduction of an EU carbon tariff can be disruptive for the Argentine agri-export model, even for commodities for which the European Union is not a relevant (in terms of revenue) export market, e.g. wheat, maize, and milk and cream. Forgone revenue and associated domestic economic and employment impacts are mostly driven by the decline in demand for soy derivatives and bovine meat exports, representing the most relevant agricultural export commodities and being tied to the EU export market. While significant export trade flows in these commodities may be diverted to China, supply overhang and resulting lower price levels mean that Argentina would unlikely be able to fully offset revenue losses.

The analysis conducted models a hypothetical scenario, assuming the introduction of a carbon tariff with full coverage of agricultural commodities. It portrays one among many possible scenarios of the risks faced by Argentina's agri-export model in a GHG-constrained world. Generally, questions remain regarding the feasibility of application, legal grounds, as well as effectiveness of border adjustment mechanisms or related measures. As such, it remains unclear whether countries with progressive carbon-pricing schemes will introduce market-linked approaches to limit carbon leakage, such as through carbon tariffs or other border adjustment mechanisms, or whether they will push for a decarbonisation of trade flows by means of non-tariff barriers, such as GHG-constrained trade agreements. Either way, it follows that in emission-constrained markets low-emission production systems can represent a competitive advantage that allows countries to secure strategic positioning as the global economy converges to full decarbonisation.

Realising opportunities to grow sustainably

Argentina should find ways of reconciling plans to promote its agri-export model with its stated climate ambition. The public and private sector should coordinate on identifying and realizing viable GHG emission mitigation options for its livestock farming and cropping systems. By exploring and implementing mitigation options that help the sector reduce its emission intensity, Argentina can strengthen its position as a key exporter of agriculture commodities on world markets.

The private sector and its key stakeholders have proven to be an innovative engine for growth and development throughout the country's modern history. The private sector should aim to realise the opportunities associated with rendering the sector more sustainable, by promoting the widespread adoption of best-available technology solutions and modern approaches to agriculture, and considering the need for output diversification.

The public sector should actively support its private sector counterpart by providing a favourable business ecosystem that mainstreams environmental sustainability with economic profitability. It should ensure that appropriate regulation and enforcement mechanisms are in place to effectively safeguard

the country's forests, soil and water resources, and should incentivize and support the adoption of GHG emission mitigation options wherever viable. Further, the Argentine Government should aim to reduce regulatory risks by retaining consistent and non-discriminatory policies, while simultaneously supporting the private sector in reinventing its competitive advantage in the increasingly GHG-constrained world.

7 ANNEX

Stakeholder perception survey methodology

In April and May 2021, an online survey was sent out to members of the agricultural, meat and dairy exports sector. The sample consisted of 16 responses (37.5% agriculture, 25% meat, 37.5% dairy), one representing the Provincial Chamber of meat exporters and another the Argentine Neutral Carbon Program. Based on the number of companies authorized to export, its representativeness is 17% (Ministerio de Relaciones Exteriores, n.d.).

The survey included three sections. In the first section, information was gathered on i) agro-industrial activity, ii) export volume, iii) main products and destinations, iv) certifications and regulations required in the main destination, v) company policy on sustainability environmental (Likert-scale), and vi) identification of key factors determining the company's capacity and export potential.

In the second section, respondents were asked about their perception of the probability of occurrence (PO), impact on exported volume (IV) and export prices (IP) of 4 scenarios over 10 years:

- E1: increase in Argentina's commitments to reduce greenhouse gas (GHG) emissions
- E2: increase in environmental requirements by export destination
- E3: increase in environmental taxes
- E4: changes in consumer preferences.

In this section, the respondents were asked to choose within a scale of 5 categories: very low (1) to very high (5) for PO and very negative (1) to very positive (5) for IV and IP. In the last three scenarios, questions were disaggregated by export destination: the European Union, the US, China, Brazil and the rest of the world.

Carbon tariff modelling methodology and limitations

The methodology applied in this study combines partial equilibrium modelling of trade dynamics and input-output analysis for the estimation of domestic economic impacts. It goes beyond a simple first-order effects approach in that it explicitly models price adjustments and changes in trade flows resulting from the introduction of a carbon tariff. The approach, however, excludes cross-sectorial interactions with other industries (which computable general equilibrium, or "CGE", analysis could offer), but as such retains minimal data requirements and the ability to conduct analyses at a disaggregated (commodity) level.

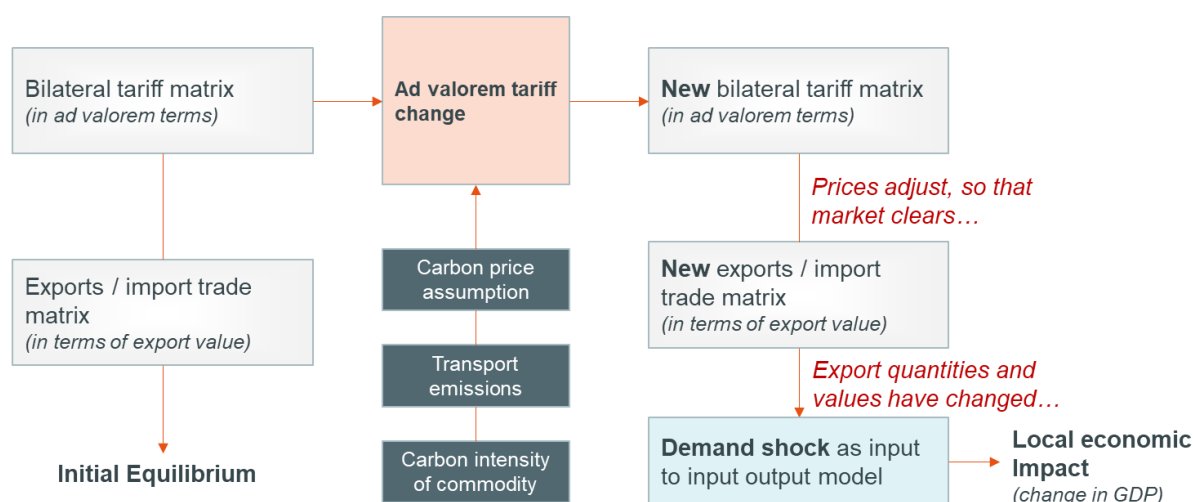
The partial equilibrium model estimates how changes to bilateral tariffs, such as imposed via a carbon tariff, affect trade flows and trade revenues between modelled countries. We adopt Francois & Hall (2002)'s global simulation model (GSIM), a multi-country global market partial equilibrium representation of industry- or product-level trade, assuming national product differentiation (i.e. imports from different origins are imperfect substitutes). Inputs to the model include an initial bilateral trade matrix at world prices and an initial bilateral tariff matrix in ad valorem form, as well as exogenously defined elasticities of substitution, import demand elasticities, and export supply elasticities. An overview of data sources is provided in Table 5.

Table 5: Input data and data sources

Data	Source
Domestic production data	FAOSTAT (2021b)
Bilateral trade flows in monetary terms	UN Comtrade (UN Comtrade, 2021)
Bilateral tariff data (Most Favoured Nation tariffs)	TRAINS (2015)
World prices	FAO (2021c)
Emission intensities	FAO (2019); IPCC (2006); Poore & Nemecek (2018) / Roser & Ritchie (2021)
Transport intensities	ECTA (2021)
Transport distances	Mayer & Zignago (2011)
Input-Output tables	OECD (2019)
Salary data	MTEySS (2020)

We model the introduction of a carbon tariff in the EU by exogenously defining a tariff increase for imported agriculture commodities into the EU (see Figure 13). The size of the tariff increase is determined as a function of (country-specific) commodity emission intensities, international transport emissions, and the carbon price underlying the carbon tariff. We model the carbon price, given that it is not known, as a variable range with values between USD 0-100/tonne of carbon dioxide equivalent units. The model solves for a new equilibrium by imposing market clearing (changing prices so that there is no excess supply or demand on the world market) to determine equilibrium prices and quantities imported and exported for a given commodity and for each country pair.

We further evaluate the impact of the tariff-induced forgone revenue on the Argentine economy by means of input-output analysis. Using the OECD input-output table for Argentina (OECD, 2019), we analyse the direct, indirect and induced economic impacts of demand shocks (reduced demand for Argentine exports). In this way, we estimate the impact of the tariff on Argentine GDP and employment.

**Figure 13: Overview of modelling logic**

The methodology imposes several assumptions and simplifications which are discussed in Table 6. The listed assumptions are specific to the employed data and to the partial equilibrium modelling of carbon tariffs, and do not represent a comprehensive list of assumptions taken in the derivation of the underlying model developed by Francois & Hall (2002).

Table 6: Assumptions and limitations of the partial equilibrium analysis

Assumption/Limitation	Description
Domestic shipments	<p>Assumption: Domestic shipments are proxied as commodity-specific production volumes derived from FAOSTAT (FAO, 2021b), multiplied by world prices as derived from FAO (FAO, 2021c), less commodity-specific export values as derived from UN Comtrade (UN Comtrade, 2021).</p> <p>Limitation: As data is drawn from different sources and subsequently combined, potential inconsistencies across the derived estimates can limit accuracy.</p>
Uniform elasticities	<p>Assumption: Given the limited availability of country- and commodity-specific trade elasticities, we follow Holzner (2004) in adopting Francois & Hall's (2002) quasi-uniform default elasticities:</p> <ul style="list-style-type: none"> - Export supply elasticity: 1.5 - Import demand elasticity: -1.25 - Elasticity of substitution: 5, except for ROW, where an infinite elasticity is assumed (9999) <p>Limitation: Assuming quasi-uniform elasticities does not reflect differences in supply and demand elasticities specifically between economies of significantly different size.</p>
Emission intensities	<p>Assumption: We assume commodity-specific emission intensities (CO₂eq) are uniform across all modelled countries, given the limited availability of country- and commodity-specific emission intensity data.</p> <p>Limitation: Assuming uniform emission intensities leads to an overestimation of economic impacts for countries with relatively less carbon intensive means of production, and vice versa.</p>
Initial MFN tariffs and ad valorem equivalent carbon tariffs	<p>Assumption: Initial tariffs are expressed as bilateral Most Favoured Nation (MFN) tariff lines. Preferential tariff lines on volume restricted quotas are not accounted for.</p> <p>Carbon tariffs are expressed as 'value added' equivalent tariffs. The commodity-specific GHG intensity and the country-pair-specific transport intensity (as a function of the maritime route transport distance and a uniform 'per kg', 'per km' transport emission intensity) are used to derive the 'per kg' absolute carbon cost. This is converted into its 'value added' equivalent following Bacchetta et al. (2018), i.e. the carbon tariff. The carbon tariff is introduced into the model as a</p>

	<p>percentage point increase on top of the initial bilateral MFN tariff, following Zheng et al. (2018).</p> <p>Limitation: For countries with high initial MFN tariffs, the percentage point addition of the carbon tariff leads to very high final tariff values (significantly above 100%). This renders economic impacts difficult to interpret at high carbon prices. We set a tariff ceiling of 300% to avoid overly unrealistic tariff levels. 300% represents a tariff level that is not unprecedented for peak tariff lines in agriculture (Stewart, 2021). However, it is uncertain whether countries would impose high carbon tariffs on top of existing tariff lines from one year to the next; it is more likely that either a grace period, a gradual introduction, or a carbon pricing response from the exporting country will precede the introduction of the carbon tariff. As such it is unlikely that the total tariff would rise to high levels such as 300%.</p>
Non-tariff barriers or export taxes/subsidies are not modelled	<p>Assumption: Non-tariff barriers (NTBs) as well as export taxes and subsidies, remain constant.</p> <p>Limitation: Non-tariff barriers (NTBs), such as certification requirements, are not accounted for. These are likely to become increasingly relevant as countries impose more stringent domestic environmental requirements in addition to carbon pricing schemes. For the purpose of this study, we assume NTBs remain constant.</p> <p>Export taxes and subsidies are also relevant, specifically in the context of the Argentine agriculture sector. We assume existing export taxes imposed on the modelled commodities remain constant. Fixing export taxes or subsidies in modelled countries does not affect estimated economic impacts, except in the analysis of net welfare effects where tariff revenues are accounted for.</p>
Uniform carbon price application	<p>Assumption: The carbon tariff is calculated based on a carbon price that applies uniformly across all countries.</p> <p>Limitation: The model neglects any existing carbon pricing schemes in countries other than those of the European Union. We are not aware of any existing carbon pricing schemes applied to agriculture sectors in the modelled countries.</p>
Carbon price assumptions	<p>Assumption: Economic impacts are modelled for a carbon price range of up to USD 100 per tonne of CO₂eq. In depth results presented in Section 5 assume a carbon price of USD 50 per tonne of CO₂eq.</p> <p>Limitation: The uncertainty regarding an applicable and realistic carbon price remains a limitation of the ex-ante analysis.</p>
Aggregation of impacts	<p>Assumption: Aggregated total impacts are proxied as the sum of commodity-level impacts at a given carbon price.</p> <p>Limitation: Economic impacts are modelled at the commodity-level, keeping outputs in all other commodities constant. It is likely that a</p>

	carbon tariff would shift production patterns in exporting countries. It is also possible that importers substitute between different commodities as a result of the introduction of the carbon tariff. These feedbacks or interlinkages are not accounted for when commodity-level impacts are aggregated.
Input-Output analysis	<p>Assumption: Argentina's Input-Output table, although depicting an industry representation derived from pre-2005 (at the onset of Argentina's debt restructuring following the country's great depression), can still provide insights into the domestic impact of demand shocks to the agriculture sector.</p> <p>Limitation: The modernisation and intensification, as well as the growth of the sector since the early 2000s is not necessarily reflected in the industry representation offered by the latest Input-Output tables. Impacts on employment may be overestimated, given the high level of automation in the sector today.</p>

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