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Article

Uruguay's banking system exposure to transition risk

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ABSTRACT

The uncertainty implied in the transition to a low carbon economy introduces new challenges to central banks to forecast potential output, the output gap and inflation. It also poses significant challenges in terms of financial stability, to the extent that banks' loan portfolios could be highly exposed to vulnerable sectors. We present and apply two methodologies, one emissions-based and the other sector-based, to measure Uruguay's exposure to transition risk in terms of product, exports and credit. The results account for a relevant exposition, both from the perspective of the banking system and at a macro level. This reaffirm the necessity of integrating transition risk into the analyses and forecasts. Furthermore, there is a continued need to progress along pathways that evaluate and quantify this risk at both macroeconomic and financial levels.

1. Introduction

Economies face two types of risks associated with climate change¹: physical risks and transition risks. Following BIS definitions (BCBS, 2021), physical risks refer to economic costs and financial losses resulting from the increasing severity and frequency of extreme weather events (acute physical risks); longer-term gradual shifts of the climate (chronic physical risks) and indirect effects of climate. Meanwhile, transition risks are related to the process of adjustment towards a low-carbon economy, which can be costly for households, firms and the financial sector.

In this document, we focus on assessing the exposure of Uruguayan banks through corporate lending to economic activity sectors most vulnerable to transition risks, along with their macroeconomic relevance.²

Transition risks can materialize through various channels, such as the imposition of carbon taxes; the inability of carbon-intensive companies to adopt new, lower-emission technologies; the introduction of export barriers to products with a high carbon footprint; changes in consumer preferences, and other factors. These risks can affect the financial sector, including banks, by altering the creditworthiness of borrowers and the value of assets in their loan portfolios.

Climate change transition risks in Uruguay are closely tied to its heavy dependence on agroindustrial production, particularly food exports. The Uruguayan government is actively working to reduce Greenhouse Gas (GHG) emissions and adapt to climate change. Failure to meet these targets could potentially expose the country to trade barriers. Key measures that are already being implemented include the transformation of the energy matrix to renewable sources, mainstreaming climate-smart agriculture,

[☆] The views expressed herein are those of the authors and do not necessarily represent the opinion of the institutions with which they are affiliated.

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¹ Article 1 of the United Nations Framework Convention on Climate Change (United Nations, 1992) defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

² While the assessment of physical risk exposure is fundamental for Uruguay due to, among other issues, the economy's dependence on the primary sector and the high proportion of the population living in coastal zones, we currently lack sufficient data on the geographic distribution of assets within the financial system to assess this type of risk.

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promoting e-mobility, and implementing a carbon tax focused on carbon dioxide (CO₂) emissions from fuel combustion.³ Uruguay's Sovereign Sustainability-Linked Bond (SSLB), issued in 2022, reflects its commitment to environmental benchmarks under the Paris Agreement.⁴

Uruguay's vulnerability to climate change, could also be affected by global measures. EU regulations, like the Deforestation Regulation introduced in June 2023,⁵ may impact the agricultural sector, presenting challenges for banks with exposure to related industries. The ongoing transitional phase of the EU's Carbon Border Adjustment Mechanism (CBAM)⁶ could increase carbon costs for Uruguay's exports. The US green industrial policy, initiated in August 2022,⁷ may also affect industries in Uruguay, especially those targeted by the measure. Banks should assess these evolving risks within the framework of international trade regulations.

The uncertainty involved in the transition to a low carbon economy poses significant challenges to central banks in terms of financial stability, as banks' loan portfolios could be highly exposed to sectors vulnerable to the consequences of climate risks. Specifically, the most polluting sectors could experience increases in both their financing costs and default rates. According to [Seltzer et al. \(2020\)](#) and [Delis et al. \(2019\)](#), the 2015 Paris Agreement led to a rise in the cost of credit for companies operating in more polluting sectors. Meanwhile, [Huang et al. \(2021\)](#) found that after the implementation of the Clear Air Action of 2013 in China, default rates and financing costs increased for the most polluting companies. Using data from Mexico, [Roncoroni et al. \(2021\)](#) discovered that while direct exposure of the financial system to Climate Policy Relevant Sectors (CPRS)⁸ is small, financial contagion effects can affect financial stability under disorderly transition scenarios and certain market conditions.

Furthermore, the inherent unpredictability concerning future paths and changes in relative prices, sectoral restructuring, and other effects, also introduces new challenges for central banks in forecasting potential output, output gap and inflation when designing monetary policy. As the Central Bank of Uruguay (BCU) is at an early stage of development in incorporating climate risk into monetary policy and financial stability analysis, this document could serve as a starting point for the development of lines of work on this subject.

In this paper, we employ two approaches to map and classify economic activities based on their vulnerability to transition risks: an emissions-based approach and a sector-based approach to measure Uruguay's exposure to transition risk in terms of product, exports and credit. Both approaches are based on exercises that have been conducted by other central banks and regulatory authorities, which we discuss in Section 2. The main similarity with them is that they rely on backward-looking metrics, unlike other papers that present a forward looking approach. For example, [Jung et al. \(2023\)](#) evaluates the impact of different policies that could be implemented to promote the transition to a net-zero economy at the industry level and their effect on banks in the US. This suggests a potential avenue for future research in Uruguay.

We find a relevant exposition to sectors identified as vulnerable to transition risks, both from the banking system perspective and at the macroeconomic level. The sectors most exposed to this risk make up a range of 30% (emissions approach) to 65% (sector approach) of total corporate credit. In terms of Gross Domestic Product (GDP), the most vulnerable sectors represent roughly 14% (emissions approach) to 40% (sector approach). Likewise, the country's dependence on exports from these sectors is very high, accounting for between 70% (emissions approach) and 90% (sector approach) of total goods exports.

The rest of this document is organized as follows. Section 2 presents a brief literature review and what has been done by other central banks and agencies. Section 3 provides a description of the Uruguayan emissions profile. Section 4 outlines the approaches used to map sectors that are most vulnerable to transition risk. Section 5 presents the results. Finally, Section 6 concludes.

2. Related literature

In recent years, central banks in Latin America have incorporated analyses of the financial system's exposure to transition and physical risks into their financial stability reports. Specifically focusing on transition risks, we outline the reports from selected countries below.

In the first-half Financial Stability Report of 2022, the Central Bank of Chile measured the exposure of the main financial agents to sectors with a high carbon footprint. The carbon footprint is estimated in [Avilés-Lucero et al. \(2021\)](#) based on supply and use tables. They find that 42% of the commercial portfolio of banks are allocated to companies in emission-intensive sectors.

The Financial Stability Report of November 2022 from the Central Bank of Brazil evaluated the credit portfolio exposure of the financial system to transition risk. They associated each economic activity sector with the respective potential for exposure to transition risk using information from sectoral GHG emission estimates (for scope 1 emissions) and from the national energy balance (for scope 2 emissions).⁹ They found that approximately 8% of the credit portfolio corresponds to borrowers who may be affected by transition risks.

Since 2021, the Central Bank of Mexico has been presenting the exposure of the bank's credit portfolio to companies vulnerable to transition risks in their Financial Stability Report. Their approach considers sectors with high direct emissions (related to scope

³ The carbon tax was established on January 1st, 2022, through Presidential Decree No. 441/021.

⁴ For further details on this subject, [IMF \(2023\)](#) provides valuable insights into Uruguay's efforts to address climate change.

⁵ Regulation (EU) 2023/1115 of the European Parliament and of the Council of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation <https://eur-lex.europa.eu/eli/reg/2023/1115/oj>.

⁶ https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en#legislative-documents.

⁷ <https://www.energy.gov/lpo/inflation-reduction-act-2022>.

⁸ Classification developed by [Battiston et al. \(2017, 2022\)](#).

⁹ See Table in [Appendix A.2](#) with the definitions of scope 1, 2 and 3 emissions according to the GHG Protocol.

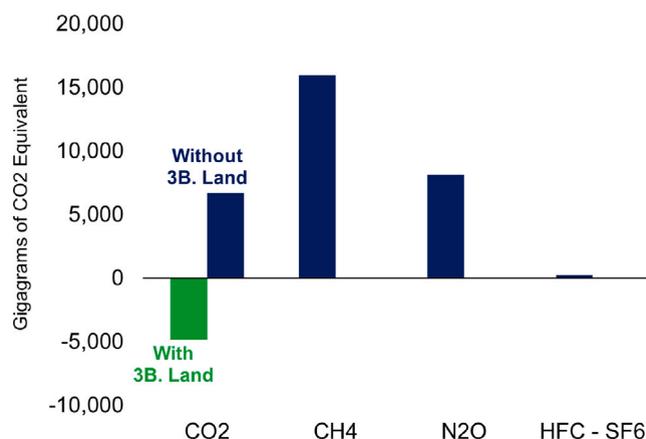


Fig. 1. Uruguay's greenhouse emissions by gas 2019. Notes: The figure describes Uruguay's emissions profile for the year 2019 in gigagrams of CO₂-eq. (GWP_{100AR2}). For CO₂, emissions are reported both with and without the land-use category. When this category is included, net emissions are negative. This is explained by the fact that CO₂ absorption through land use more than offsets the gross emissions of this gas. Source: Own elaboration based on the National Inventory of Greenhouse Gases.

1), sectors indirectly exposed through input use (related to scopes 2 and 3), and sectors exposed to demand shocks because their demand depends on sectors with high emissions (direct and indirect). According to the June 2021 report, almost 25% of the credit to companies at the beginning of that year corresponded to sectors with high direct and indirect emissions. The percentage rises to 35% when sectors exposed to demand shocks are included.

In Europe, the European Banking Authority (EBA, 2020), employs both an emission-based and a sector-based approach to assess the exposure to transition risk of a sample of 29 banks from the European Union. For the emission-based approach, they have information on GHG at the firm level for 30% of credit to entities that are not small and medium-sized enterprises (SMEs) and are classified as non-financial obligors domiciled in European Union countries, with the remainder allocated using the average emissions of the sector. Banks' exposures are classified according to GHG emission intensity ranges defined based on the distribution of individual firms' emission data. Approximately 35% of exposures are assigned to firms classified as medium/high, high, and very high CO₂ intensity. They also apply a sector-based approach using the classification introduced by Battiston et al. (2017) and find that 55% of the total exposure is allocated to CPRS.

Sever and Perez-Archila (2021) uses the mapping between sector-level GHG emissions and companies to conduct a stress test exercise. They associate GHG emissions in Colombia with economic activity and economic output at the sector level estimating the rate of emissions per output. The stress-test exercise imposes new liabilities on firms' balance sheets under various carbon tax scenarios, revealing that agriculture, manufacturing, electricity, wholesale and retail trade, and transportation are the most relevant sectors for the transmission of this risk to the banking sector.

3. Uruguay's greenhouse gas emissions profile

According to the National Inventory of Greenhouse Gases (INGEI, by its Spanish acronym) compiled by the Ministry of Environment (ME), Uruguay's GHG emissions in 2019 reached 60,510 gigagrams of CO₂ equivalent (CO₂-eq).¹⁰ However, when removals (of CO₂) are taken into account,¹¹ net emissions decrease to 19,463 gigagrams of CO₂-eq (i.e. net emissions account for around one-third of total emissions). This represented only 0.03% of global anthropogenic GHG emissions in 2019 (UNEP and UNEP-CCC, 2020). Although emissions of this gas related to land use are also relevant, in general for this category removals have exceeded emissions. Due to the specificities in land use, we conduct the following analysis excluding this category, meaning that neither emissions nor removals from this category are considered.

Total emissions, excluding the land use category were 31,020 Gg CO₂-eq. in 2019. Approximately half of these emissions correspond to methane (CH₄). Globally, CH₄ is the second most abundant anthropogenic GHG after CO₂. While Uruguay contributes to less than 1% of global emissions of this gas, it is one of the main emitters of methane per capita (World Bank, 2020). This is directly related to the relevance of the livestock activity for Uruguay. In second place, nitrous oxide (N₂O) account for 26% of total emissions (in part also related to livestock activity); carbon dioxide (CO₂) emissions account for 22%; and fluorinated gases emissions, despite their high global warming potential, represent only 1% of total national emissions (Fig. 1).

According to the methodology proposed by the Intergovernmental Panel on Climate Change (IPCC), sectors of activity are classified into four broad categories: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land

¹⁰ Metric measure used to compare the emissions from various GHG gases on the basis of their Global Warming Potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential.

¹¹ CO₂ removals are mainly explained by increases in carbon stocks due to biomass growth in forest plantation and native forest areas.

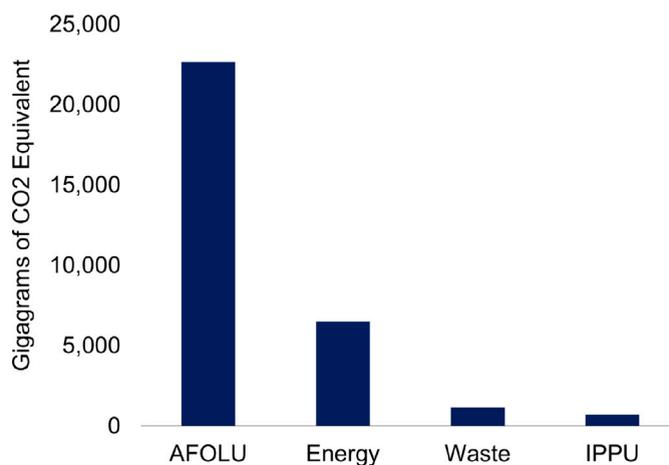


Fig. 2. Uruguay's greenhouse gas emissions by sector 2019 (without Land). Notes: The figure describes Uruguay's emissions by sector of activity, according to the methodology proposed by the IPCC, for the year 2019 in gigagrams of CO₂-eq. (GWP_{100AR2}). Sectors of activity are classified into four broad categories: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), and Waste.
Source: Own elaboration based on the National Inventory of Greenhouse Gases.

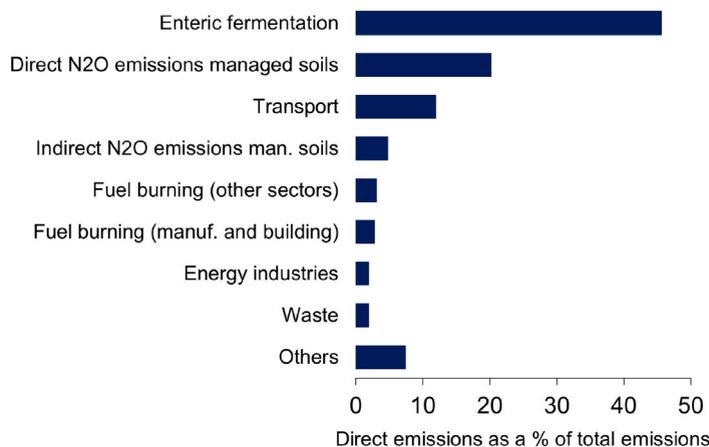


Fig. 3. Uruguay's greenhouse gas emissions by category 2019 (without Land). Notes: The figure describes Uruguay's emissions by category of activity. Enteric fermentation and Direct/Indirect N₂O emissions from managed soils correspond to AFOLU sector. Transport, Sectors fuel burning and Energy industries correspond to Energy sector.

Source: Own elaboration based on the National Inventory of Greenhouse Gases.

Use (AFOLU), and Waste.¹² One of the most notorious characteristics of Uruguay's GHG inventory is the significant contribution of emissions from AFOLU (Fig. 2). The two categories with the highest GHG emissions in Uruguay are linked to livestock activity and correspond to this sector (Fig. 3): enteric fermentation of livestock (corresponding to CH₄) and, secondly, direct N₂O emissions from managed soils (most of which correspond to emissions from the deposition of urine and feces from cattle in grazing areas).

One important aspect to consider is that CH₄ emissions from livestock are part of what is known as the biogenic carbon cycle (Werth, 2020; Lanfranco et al., 2023): carbon is captured by plants through photosynthesis and later consumed by ruminants. On average, after 12 years, CH₄ is transformed into CO₂ through natural combustion. This situation differs from the fossil fuel extraction and burning industries, where the exchange of carbon between the atmosphere and geological reservoirs lasts for 1000 years or more. Despite this, GWP of CH₄ is higher than that of CO₂. Besides, some authors argue that the GWP measure overestimates and unfairly penalizes the effect of short-lived GHGs (such as CH₄) on global temperature (Allen et al., 2018; Lanfranco et al., 2023; Rocha, 2022). The GWP₁₀₀ metric does not account for the removal of short lived gases from the atmosphere, it assumes that all GHGs remain stagnant in the atmosphere, which is not the case for CH₄.

¹² See Table in Appendix A.1 with a description of sectors in which GHG emissions are disaggregated.

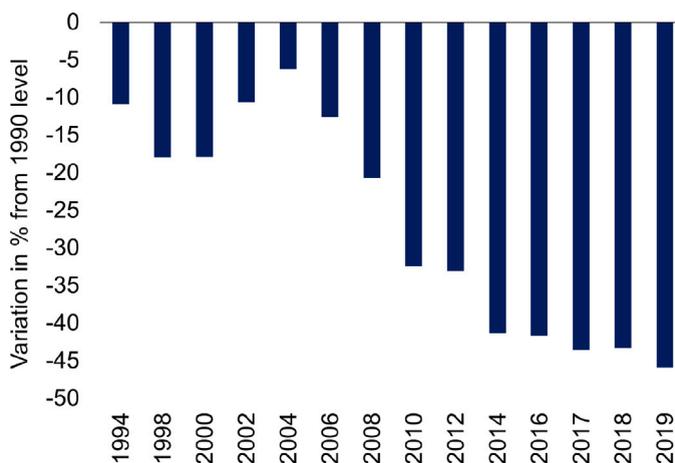


Fig. 4. Uruguay's ratio of greenhouse gas emissions (without Land) to real GDP change compared to 1990. Notes: The figure illustrates the evolution of Uruguay's emissions-to-GDP ratio from 1994 to 2019, relative to the 1990 level.

Source: Own elaboration based on the National Inventory of Greenhouse Gases and the Central Bank of Uruguay.

It is worth noting that although Uruguay represents a negligible percentage of global GHG emissions, policies have been implemented in the country to promote development with the lowest possible emissions intensity. As a result, between 1990 and 2019 the ratio of emissions to GDP fell 46% (Fig. 4).

4. Methodology

A first step towards integrating climate risk into the analysis and design of monetary policy and financial stability is the identification of sectors most vulnerable to such risks. As mentioned earlier, this document will primary focus on identifying sectors with the highest level of transition risk in Uruguay. To achieve this, we will use as a reference the exercises conducted by other central banks and regulatory agencies described in Section 2. These exercises involve two different approaches to map and classify economic activities based on their level of transition risk. In a subsequent stage, we link the results obtained to the classification of activity sectors used in National Accounts, foreign trade statistics, and the Credit Registry sector classification.¹³ These linkages enable a comprehensive understanding of emissions in relation to GDP, exports and banking credit.

4.1. Emissions-based approach

This approach focuses on evaluating the level of GHG emissions from operations of a business or activity sector. In this exercise, we classify sectors of activity according to a set of risk indicators constructed based on their emissions contribution and their emissions intensity. For the calculations, we considered direct emissions through scope 1.¹⁴ Similarly, we conducted the same exercise to additionally include emissions from scope 2¹⁵ and the results remained unchanged. This is because the GHG emissions from scope 2 that can be sectorally assigned are minimal in comparison to those directly emitted through scope 1.¹⁶

We constructed two indicators for each sector of activity: Emissions per product (EP) and Gross emissions (GE). The EP indicator reflects the emissions intensity of each sector, thereby assessing its efficiency in terms of its GHG emissions. It is a useful tool to track and compare the environmental performance of different sectors. The GE indicator reflects the sector's contribution to total emissions. This indicator provides a more accurate understanding of the sources of emissions and enables countries to compare their emissions profile with other jurisdictions:

$$EP = \frac{\text{Emissions}}{\text{Production Value (constant prices)}} \quad (1)$$

$$GE = \frac{\text{Emissions}}{\text{Total Emissions}} \quad (2)$$

Constructing the EP indicator requires mapping emissions data by sector with production value data. We obtained detailed sector-specific breakdowns of GHG emissions data from the INGEI, following the IPCC classification outlined in Appendix A.1.

¹³ Sectors of activity in National Accounts are classified according an adaptation of International Standard Industrial Classification (ISIC) Rev.4, while external trade statistics use Central Product Classification (CPC) and Credit Registry use ISIC Rev.3 classification.

¹⁴ We use data from the National Inventory of Greenhouse Gases (INGEI) to compute scope 1 emissions.

¹⁵ We use data from the National Energy Balance (BEN) of the Ministry of Industry, Energy, and Mining to compute scope 2 emissions.

¹⁶ Scope 2 emissions could be considered only for the IPPU sector, as the data aggregation level does not allow for further sectoral breakdown.

Simultaneously, for computing production value, we use data from National Accounts. Since the IPCC classification does not precisely align with that of National Accounts, primarily due to differences in data aggregation, assigning the totality of emissions to an economic activity sector was not possible. For example, emissions from the Waste category were not considered due to insufficient information for assignment to specific economic activities. Despite these omissions, it is still possible to account for more than 85% of the total GHG emissions in Uruguay between 2016 and 2019.

We use the average values from the years 2016 to 2019 to compute the indices, subsequently linearizing them to assume values between 0 and 1 based on their positions in the sample distribution. Finally, we aggregate them with equal weighting to construct a transition risk (TR) indicator. Based on the value of the TR indicator, we classify sectors into different risk categories: low-risk if the value is below the median, medium-risk if it is between the median and the third quartile of the distribution, and high-risk if it exceeds the third quartile level.

4.2. Sector-based approach

We adopt the Climate Policy Relevant Sectors (CPRS) approach introduced by Battiston et al. (2017, 2022). This methodology aims to identify the economic sectors that are relevant in terms of climate policies and allows for a climate-relevant classification at different levels of granularity. CPRS are defined as economic activities that could be affected either positively or negatively in a disorderly transition to a “green economy” and have been identified according to (1) their contribution to GHG emissions (2) their sensitivity to climate policy or regulatory change (3) their role in the energy value chain and (4) their business model (input substitutability). The authors remap all the economic activities from the 4-digit Nomenclature of Economic Activities (NACE) Rev2 classification into the following CPRS: 1-Fossil-fuel, 2-Utility, 3-Energy-intensive, 4-Buildings, 5-Transportation, 6-Agriculture, 7-Finance, 8-Scientific R&D and 9-Others. This enables users to group a large number of activity codes into few categories of climate transition risk. Sectors included in categories 1 to 6 are considered the ones most likely to be affected in a disorderly low-carbon transition. The CPRS classification is considered a benchmark for evaluating the financial risks associated with climate change, and various global financial institutions have adopted it to analyze the potential impact of climate transition risk on their portfolios.

Since National Accounts statistics in Uruguay are typically categorized using adaptations from ISIC codes, in this exercise, we must establish a connection between this classification and the NACE code.

4.3. Limitations

Both the emission-based and sector-based approaches, use data at the activity sector level. However, even within the same sector, there may be firms employing different technologies—such as electric and fuel-powered car manufacturing—that are impacted in distinct ways by the transition to a low-emission economy. For public policy, it would be very useful to work towards building a data base for Uruguay of companies with emissions at the firm level.

Regarding the CPRS methodology, Category 9-Others includes several activities from the agroindustry sector, which have significant backward linkages with primary activities counted among the relevant sectors. In our perspective, given that these industries’ production relies almost entirely on agricultural inputs and some are classified within the medium and high-risk sectors in the emissions approach, they should be considered part of the categories exposed to transition risk. This is why we calculate an extended indicator in Section 5, incorporating to the CPRS-6 sectors the following industries from the 9-Others category: meat, fish, dairy and rice and flour mills. Another drawback is that this approach does not deliver a numerical risk exposure by sector, as in the emissions approach. In that case, sectors with the highest transition risk index (based on emissions intensity and the share of total emissions) are identified as the most vulnerable ones.

5. Results

5.1. Emissions-based approach

Table 1 reports the EP, GE and TR indicators scaled between 0 and 1. The first panel of the table shows the sectors classified as high risk, the second part shows those classified as medium risk and the third part lists those classified as low risk. By considering only the EP indicator, the Refinery would be placed in the low-risk category, as its index value is below the median. Similarly, using the GE index the Paper and Pulp sector would be classified as low-risk. Calculating the simple average of these indicators yields a more conservative result, allowing both sectors to be included in the TR index.¹⁷ This is crucial, as climate policies often target sectors with high EP and/or high GE values.

The contribution of high-risk sectors to Uruguay’s GDP has fluctuated around 8% in recent years, jumping to 10% in 2021. When taking into account sectors classified as medium risk, this percentage increases to 12%–14% (Fig. 5). In both categories, the participation of sectors linked to primary activities stands out.

More than half of the goods exports correspond to high and medium risk sectors. High risk sectors accounted for almost 40% of goods exports between 2016 and 2022. When medium risk sectors are added this share amounts to almost 70% (Fig. 6).

¹⁷ Although the aggregate indicator was reported as an average, different weightings were tested to see if the results varied significantly. To the extent that a greater weight is given to the EP indicator, the refinery sector tends to fall outside the classification of medium-risk sectors, becoming a low-risk sector. Something similar occurs with the Paper and Pulp sector when a greater weight is given to the GE indicator.

Table 1
Transition risk index.
Source: Own elaboration.

	EP	GE	TR
Cattle and other livestock	1,00	1,00	1,00
Ground transportation	0,69	0,92	0,81
Cement	0,92	0,69	0,81
Other crops	0,77	0,77	0,77
Dairy cattle	0,85	0,62	0,73
Rice	0,54	0,85	0,69
Refinery	0,46	0,54	0,50
Paper and pulp	0,62	0,38	0,50
Fishery	0,38	0,46	0,42
Maritime transportation	0,31	0,23	0,27
Construction	0,00	0,31	0,15
Rail transportation	0,23	0,00	0,12
Air transportation	0,15	0,08	0,11
Chemical industry	0,08	0,15	0,11

Notes: Indexes in red correspond to values above the third quartile of the distribution, while indexes in orange correspond to values between the median and the third quartile. Indexes in green correspond to values below the median. Sectors are ranked in descending order based on the TR Index, with the highest values (in red) indicating high-risk sectors, middle values (in orange) indicating medium-risk sectors, and the lowest values (in green) indicating low-risk sectors.

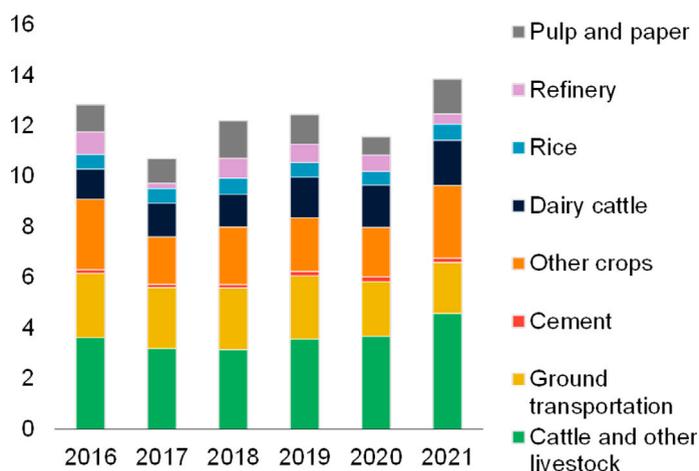


Fig. 5. GDP distribution by sector — emissions approach (for medium and high risk sectors, % of total GDP). Notes: The figure shows, for 2016 to 2021, the share in GDP of sectors that were classified as medium or high risk by the emissions approach. From bottom to top in the bars of the graph the first 4 sectors were classified as high risk and the next 4 as medium risk.

Source: Own elaboration based on BCU.

In particular, beef industry is vital to Uruguay's economy, accounting for nearly 25% of its goods exports, with China (almost 60%), the United States, and the European Union being the main destinations. Potential non-tariff barriers based on environmental costs of these product pose a risk to Uruguay's macroeconomic and financial stability.

Some elements attenuate this result. Firstly, as mentioned in Section 3, emissions from livestock activity are part of the biogenic carbon cycle and there is an ongoing discussion on how the GWP metric treats short-lived gases such as methane. Second, livestock farming in Uruguay has characteristics that set it apart from the rest of the world. The production system is based mainly on animals that live outdoors and are fed on natural pastures (grass-fed) and follows a mandatory traceability system since 2006.

The banking sector is exposed directly to transition risk through credit granted to companies belonging to sectors with higher GHG emissions.¹⁸ Credit to companies in Uruguay represents around 60% of the total granted by the banking system to the private resident non-financial sector.¹⁹ Using the emissions approach, it was possible to classify approximately 40% of the firms into the

¹⁸ The banking sector plays a central role in financial intermediation in Uruguay, given the underdeveloped nature of the capital market. Banks provide 94% of credit granted by regulated financial intermediaries to the non-financial sector.

¹⁹ Credit to the private resident non-financial sector represents more than 90% of the credit granted by the banking sector.

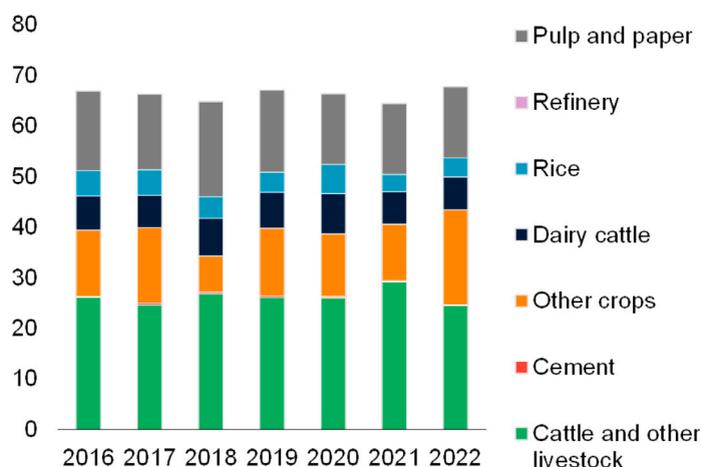


Fig. 6. Goods exports distribution by sector — emissions approach (for medium and high risk sectors, % of total goods exports). Notes: The figure shows, for 2016 to 2022, the share in goods exports of sectors that were classified as medium or high risk by the emissions approach. From bottom to top in the bars of the graph the first 3 sectors were classified as high risk (ground transportation is not included because those are services exports) and the next 4 as medium risk.

Source: Own elaboration based on BCU.

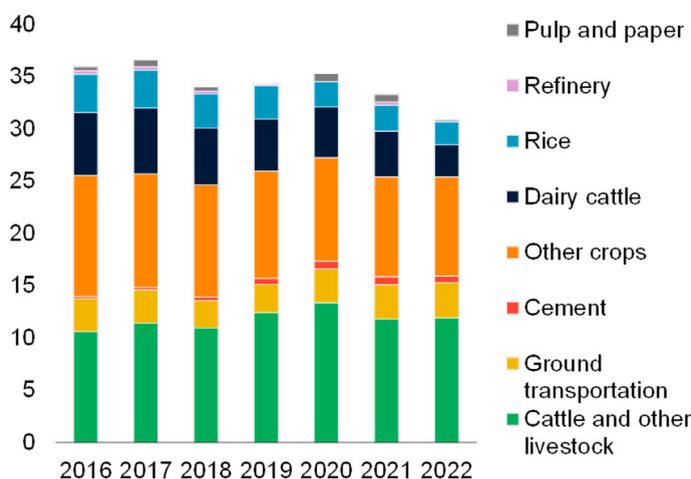


Fig. 7. Credit distribution by sector — emissions approach (for medium and high risk sectors, % of total credit to firms). Notes: The figure shows, for 2016 to 2022, the share in banking credit to resident private firms of sectors that were classified as medium or high risk by the emissions approach. From bottom to top in the bars of the graph the first 4 sectors were classified as high risk and the next 4 as medium risk.

Source: Own elaboration based on BCU.

different risk categories (low, medium and high). The rest were not classified, but given that, as discussed in Section 4, we considered most of the emissions, it would be reasonable to assume that they are sectors with a reduced (at least directly) transition risk.

Specifically, one third of the unclassified credit corresponds to the trade sector which, as discussed in Section 4, was not included in the indicator due to lack of disaggregated information on its GHG emissions. It is followed in importance by some industries (in particular, beverage and plastics processing) and real estate and business activities.

Between 30% and 35% of credit to resident private firms corresponds to companies operating in sectors categorized as high or medium risk²⁰ (Fig. 7). In terms of trend, between 2016 and 2022 there was a slight reduction in the share of lending to sectors classified as medium risk, mainly due to a fall in lending to the dairy cattle sector. Within the most risky sectors in terms of transition, credit to firms belonging to beef and dairy cattle, crops and transportation sectors stands out.

²⁰ Credit information is available at the banking system level disaggregated by ISIC Rev.3 4-digit sector. Appendix A.4 shows which ISIC Rev.3 category was assigned to each of the sectors of activity for which the TR indicator was constructed.

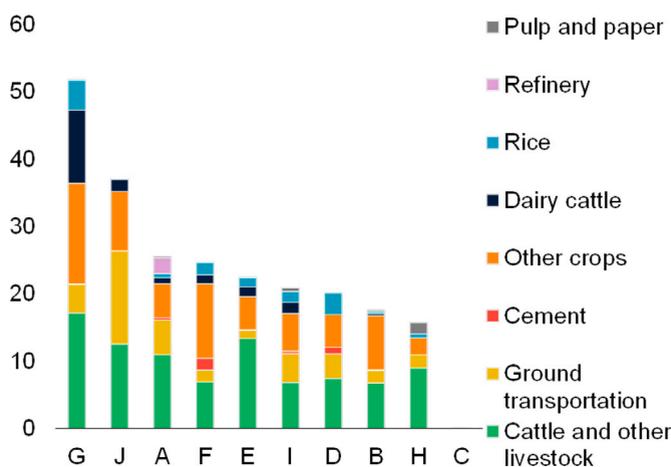


Fig. 8. Credit distribution by risk level and bank (% of credit to firms, Dec-22). Notes: The figure shows, for December 2022, for each commercial bank in Uruguay, the share in credit to resident private firms of the sectors that were classified as medium or high risk by the emissions approach. From the bottom to the top of the bars in the graph the first 4 sectors were classified as high risk and the next 4 as medium risk. Source: Own elaboration based on BCU.

Table 2

Credit to debtors with a compromised or irrecoverable capacity to pay (% of credit to firms for each group/sector, Dec-22).

Source: Own elaboration based on BCU.

Group/sector	Share of sector-credit
High-medium	14
Cement	63
Pulp and paper	34
Ground transportation	31
Dairy cattle	24
Other crops	12
Rice	8
Cattle and other livestock	6
Refinery	1
Rest	7

Notes: The table shows the share of debtors with compromised or irrecoverable capacity to pay in sectoral credit.

Based on data from the Credit Registry, we measured the bank-level share of exposure to firms in high and medium risk sectors, considering the main debtor firms²¹ (from the resident private sector) of the 10 commercial banks that are part of the Uruguayan banking system. Two of the institutions have a significant exposure to sectors classified as high or medium risk. In one of them, these sectors account for around 50% of its credit to resident private firms (Fig. 8).

Loans in sectors classified as high or medium risk have worse ratings than other loans to resident private sector companies (Table 2). 14% of credit to firms in high or medium risk transition sectors are rated as payment compromised, highly compromised or unrecoverable against 7% for the rest of the credit to firms. Within the medium and high risk sectors cement, paper and pulp, ground transportation and dairy cattle have the highest proportion of worst rated debtors. However, as can be seen in Fig. 7, the weight of total credit to companies in the cement and paper and pulp sectors (which have the higher share of poorly rated loans) is very small, less than 1% overall.

5.2. Sector-based approach

According to this approach, CRPS-6 categories represent approximately 40% of GDP. Given the limitations previously mentioned, when we include the agroindustry sectors (which in the CPRS methodology are within 9-Others) that were classified as medium or high risk in the emissions approach, the share increases by just over 2% (Fig. 9). Regarding goods exports, the CPRS-6 sectors account for a 60% share over the 2016–2022 period. However, when we use the extended indicator – specifically incorporating certain agroindustries –, it reaches almost the totality of exports (Fig. 10).

²¹ For the smaller banks all debtors are included. For the rest of the institutions, loans of more than 590 thousand Uruguayan pesos (approximately 15 thousand dollars) are considered.

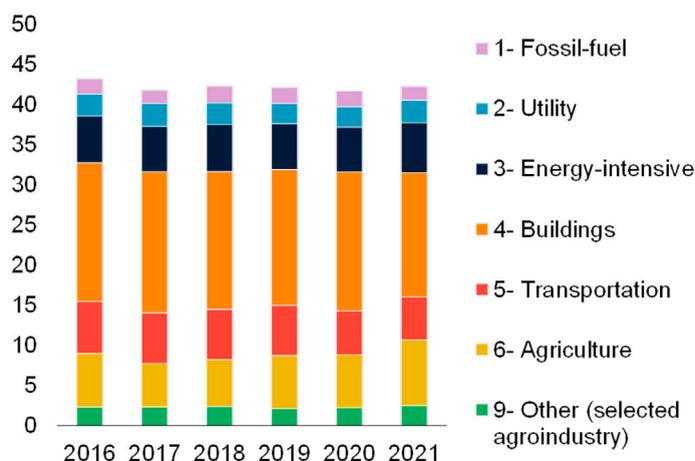


Fig. 9. GDP distribution by sector — sector approach (% of total GDP). Notes: The figure shows, for 2016 to 2021, the share in GDP of sectors that belong to CPRS-6 or selected agroindustries from the Other category.

Source: Own elaboration based on BCU.

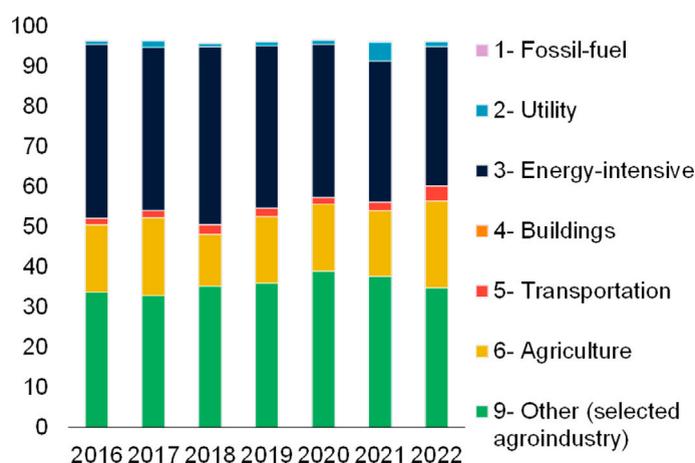


Fig. 10. Goods exports distribution by sector — sector approach (% of total goods exports). Notes: The figure shows, for 2016 to 2022, the share in goods exports of sectors that belong to CPRS-6 or selected agroindustries from the Other category.

Source: Own elaboration based on BCU.

According to the sector-based approach, the exposure of the banking system to sectors included in CPRS-6 is sensibly larger than the one computed using the emissions approach (Fig. 11). Between 2017 and 2022 approximately 57% of credit to resident private firms was allocated to companies operating in CPRS-6. If additionally we consider the selected agroindustry sectors of 9-Others category, this percentage rises to an average of 65% during the period. At the sub-sector level, Agriculture stands out, followed by the categories Energy-intensive, Buildings and Transportation.

In terms of macroeconomic importance as well as credit exposure, the sector-based approach yields higher values than the emissions-based approach. This is related to the fact that the CPRS approach classifies the entire universe of economic activities, while the emissions approach fails to classify all activities due to lack of granular information on emissions.²² In addition, the criteria to consider that a sector belongs to the CPRS-6 group are broader than just considering the emissions of the sector (see Section 4).

We evaluate commercial banks' exposure to credits extended to the CPRS-6 sectors and selected agroindustries on an individual basis using Credit Registry data (Fig. 12). As in the emissions approach, Bank G has the highest exposure (approximately 70% as of December 2022). However, the ranking for the rest of the banks changes, in some cases significantly, concerning the emissions approach. Three fundamental factors explain the difference in the ranking of the two approaches. First, the energy-intensive sector of the CPRS approach is relevant for most banks, but many activities within this sector could not be classified according to the

²² See Table in Appendix A.3 with the mapping between CPRS-6 sectors and the emissions-based classification.

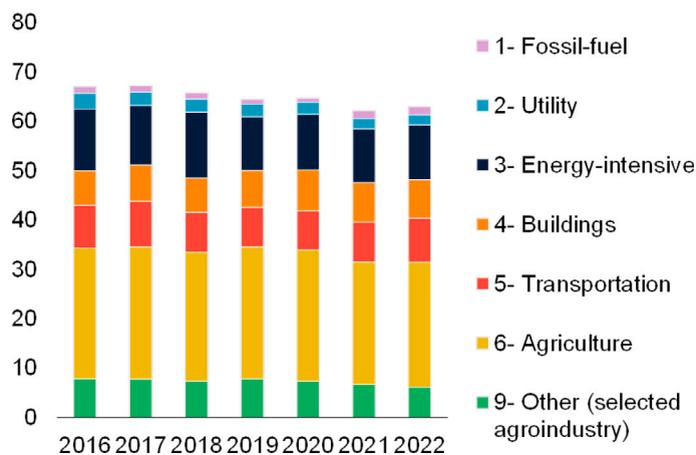


Fig. 11. Credit distribution by sector — sector approach (% of total credit to firms). Notes: The figure shows, for 2016 to 2022, the share in banking credit to resident private firms of sectors that belong to CPRS-6 and the selected agroindustries from the category Others.
Source: Own elaboration based on BCU.

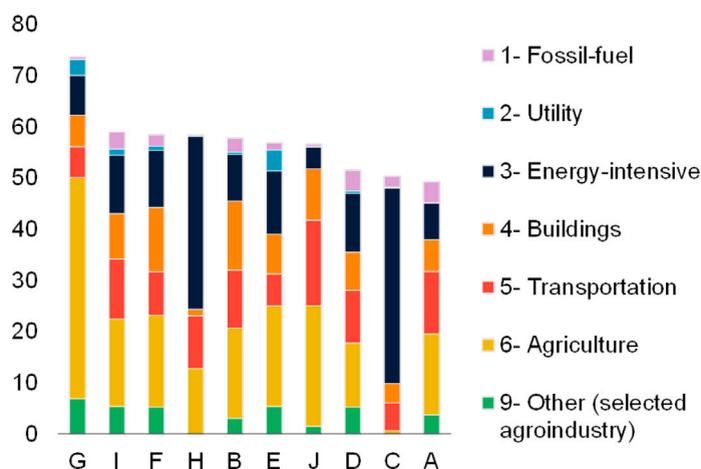


Fig. 12. Credit distribution by CPRS and bank (% of credit to firms, Dec-22). Notes: The figure shows, for December 2022, for each commercial bank in Uruguay, the share in credit to resident private firms of sectors that belong to CPRS-6 and the selected agroindustries from the category Others.
Source: Own elaboration based on BCU.

emissions approach; some of those that were classified were categorized as low risk.²³ Second, the construction sector is included in the CPRS-6 group, but in the emissions approach it is classified as low risk. Third, the transport sector in the emissions approach refers only to ground transport services, while in the CPRS classification, it is broader and encompasses other activities, such as manufacturing and services like motor vehicle sales.

This serves to illustrate the main conceptual differences between the two approaches that were mentioned above. The sector approach is broader than the emissions approach in two aspects: it encompasses all sectors of activity and takes into account additional elements beyond GHG emissions.

In terms of ratings, the findings are similar to the ones obtained using the emissions based approach: loans within CPRS-6 sectors and selected agroindustries have worse ratings compared to other loans given to resident private sector companies (Table 3). For firms within CPRS-6 sectors and selected agroindustries from the 9-Others category, 11% of the credit is categorized as compromised payment, highly compromised, or unrecoverable. For the remaining credit granted to firms this share is 6%.

²³ Specifically, with data as of December 2022, only 47% of the lending to the energy-intensive sector could be classified by the emissions approach (activities related to cement, chemicals, and pulp and paper). The chemical industry, the most relevant, is classified as low risk in the emissions approach and is therefore not included in the banks' exposure ranking.

Table 3

Credit to debtors with a compromised or irrecoverable capacity to pay (% of credit to firms for each sector, Dec-22).

Source: Own elaboration based on BCU.

CPRS	Share of sector-credit
CPRS-6 + Others (selected agroind.)	11
1- Fossil-fuel	3
2- Utility	3
3- Energy-intensive	8
4- Buildings	13
5- Transportation	17
6- Agriculture etc.	8
9- Other (selected agroind.)	18
Rest	6
7- Finance	0
8- Scientific R&D	25
9- Other (w/o selected agroind.)	7
No classified	3

Notes: The table shows the share of debtors with compromised or irrecoverable capacity to pay in sectoral credit.

6. Final comments

In this document, we present and apply two methodologies, one emissions-based and the other sector-based, to measure Uruguay's exposure to the risk of transition to a low-emissions economy in terms of product, exports and credit.

The results account for a relevant exposition to transition risks, both from the banking system perspective and at the macroeconomic level. The sectors most exposed to this risk make up a range of 30% (GHG) to 65% (CPRS) of total corporate credit. Furthermore, the credit ratings for these loans are below the economy's average, which would intensify the level of exposure even more. It is noteworthy that both methodologies indicate that the same financial institution carries the higher degree of exposure compared to the rest of the system. In terms of their macroeconomic importance, in relation to the GDP, the most vulnerable sectors constitute roughly 14% (GHG) to 40% (CPRS). Likewise, the country's dependence on exports from these sectors is very high, accounting for between 70% (GHG) and 90% (CPRS) of total goods exports.

The results obtained might be regarded as a "worst-case" scenario, particularly when considering that one of the sectors carrying a higher transition risk is livestock farming. Since the GHG emissions linked to this activity are part of the biogenic carbon cycle, the environmental impact of these emissions may be relativized. Nevertheless, this does not undermine the importance of implementing technological advancements to reduce methane emissions. This is especially important given the substantial role that livestock farming plays in Uruguay and in light of the fact that other nations are already taking proactive measures in this direction.

To conclude, the findings of this study reaffirm the necessity of integrating transition risk into the analyses and forecasts conducted by the BCU. There is a continued need to make progress in evaluating and quantifying this risk at both macroeconomic and financial levels.

Glossary

AFOLU Agriculture, Forestry and Other Land Use
BCU Central Bank of Uruguay
BEN National Energy Balance
CH₄ Methane
CO₂ Carbon dioxide
CPC Central Product Classification
CPRS Climate Policy Relevant Sectors
EP Emissions per product
GDP Gross Domestic Product
GE Gross emissions
GHG Greenhouse Gas
GWP Global Warming Potential
INGEI National Inventory of Greenhouse Gases
IPCC Intergovernmental Panel on Climate Change
IPPU Industrial Processes and Product Use
ISIC International Standard Industrial Classification
N₂O Nitrous oxide
NACE Nomenclature of Economic Activities

Table 4

Sectors of national inventory of greenhouse gases.

Source: Intergovernmental Panel on Climate Change.

Energy	Emissions generated by the burning of fossil fuels (oil derivatives and natural gas) and fugitive emissions from fossil fuels.
Industrial processes and product use (IPPU)	Emissions from industrial processes, from the use of GHGs in products and from non-energy uses of carbon contained in fossil fuels. Emissions from energy consumption during the industrial process are considered within the Energy Sector.
Agriculture, Forestry and Other Land Use (AFOLU)	Emissions generated in agricultural activities and practices, as well as CO ₂ emissions and removals from land use and land use changes.
Waste	Emissions generated by the disposal of solid waste, the treatment of domestic and industrial effluents, and the incineration of waste

Table 5

Scope 1, 2 and 3 emissions of greenhouse gases.

Source: Greenhouse Gas Protocol.

Scope 1	Emissions from sources that an organization owns or controls directly.
Scope 2	Emissions that a company causes indirectly and come from where the energy it purchases and uses is produced. For example, the emissions caused when generating the electricity that the firm uses in its building would fall into this category.
Scope 3	Emissions that are not produced by the company itself and are not the result of activities from assets owned or controlled by them, but by those that it is indirectly responsible for up and down its value chain. Scope 3 emissions include all sources not within the scope 1 and 2 boundaries.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

A.1. Definitions: sectors of INGEI

See [Table 4](#).

A.2. Definitions: scope 1, 2 and 3 emissions

See [Table 5](#).

A.3. Mapping between CPRS-6 and selected agroindustries to activity sectors and GHG classification

See [Table 6](#).

Table 6
Mapping between CPRS-6 and selected agroindustries to activity sectors and GHG classification.

CPRS	Activity sector — Uruguay national accounts	GHG sector	GHG Classif.
1-Fossil-fuel	Mining and quarrying	–	–
	Manufacture of coke and petroleum refining products	Refinery	Medium-risk
	Manufacture of gas, distribution of gaseous fuels by pipelines; supply of steam and air conditioning.	–	–
	Wholesale trade of solid, liquid and gaseous fuels and related products; retail trade of fuels for motor vehicles in specialized stores. Does not include purchase and sale or re-exports.	–	–
2-Utility	Generation, transmission and distribution of electric power.	–	–
	Water collection, treatment and distribution.	–	–
	Sewage disposal; waste collection and material recovery; decontamination activities and other waste management services.	–	–
3-Energy-intensive	Manufacture of vegetable and animal oils except corn oil	–	–
	Manufacture of starches, starch products and corn oil; manufacture of prepared animal feeds	–	–
	Manufacture of cocoa, chocolates and other food products n.e.c.; manufacture of prepared meals and dishes; manufacture of syrups, concentrates and sugars	–	–
	Distilling, rectifying and blending of alcoholic beverages; manufacture of tobacco products	–	–
	Manufacture of wine	–	–
	Manufacture of malted and malt beverages	–	–
	Manufacture of textile products	–	–
	Manufacture of garments of all kinds of materials; manufacture of leather goods and knitted and crocheted goods	–	–
	Manufacture of leather and related products	–	–
	Manufacture of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	–	–
	Manufacture of paper and paper products	Paper and pulp	Medium-risk
	Manufacture of fertilizers and nitrogen compounds; manufacture of pesticides and other chemicals for agricultural and livestock use	Chemical industry	Low-risk
	Manufacture of basic chemicals and biofuels; manufacture of plastics and synthetic rubber	Chemical industry	Low-risk
	Manufacture of cleaning and toiletry products	Chemical industry	Low-risk
	Manufacture of paints, varnishes and similar coating products, printing inks and mastics; manufacture of other chemical products n.e.c.; manufacture of man-made fibers	Chemical industry	Low-risk
	Manufacture of pharmaceuticals, medicinal chemicals and botanicals for pharmaceutical use	Chemical industry	Low-risk
	Manufacture of rubber and plastic products	–	–
	Manufacture of cement, lime and plaster; manufacture of articles of concrete, lime and plaster; cutting, shaping and finishing of stone; manufacture of other non-metallic mineral products n.e.c.	Cement	High-risk
	Manufacture of glass and glass products; manufacture of refractory, clay, ceramics and porcelain products	–	–
	Manufacture of basic metals	–	–
	Manufacture of fabricated metal products except machinery and equipment	–	–
	Manufacture of computer, electronic and optical products; manufacture of electrical equipment; manufacture of machinery and equipment n.e.c.	–	–
	Manufacture of medical and dental instruments and supplies	–	–
Manufacture of jewelry and related articles, musical instruments, sporting goods, toys; other manufacturing industries n.e.c.	–	–	
4-Buildings	Manufacture of furniture	–	–
	Construction of buildings and other specialized construction activities	Construction	Low-risk
	Other constructions	Construction	Low-risk
	Accommodation	–	–
	Real estate activities carried out with owned or leased property	–	–
Real estate activities carried out for remuneration or on a contractual basis	–	–	

(continued on next page)

Table 6 (continued).

5-Transportation	Manufacture of motor vehicles, trailers and semi-trailers	–	–
	Manufacture of other transport equipment; repair and installation of machinery and equipment	–	–
	Wholesale and retail trade of motor vehicles, excluding purchase and sale and re-exports.	–	–
	Maintenance and repair of motor vehicles and motorcycles; wholesale and retail trade of parts and accessories for motor vehicles and motorcycles. Does not include sale and purchase or re-exports.	–	–
	Freight transportation by land	Ground transportation	High-risk
	Passenger transportation by land	Ground transportation	High-risk
	Non-land transportation	Maritime/rail/air transportation	Low-risk
	Complementary transportation activities	–	–
	Postal and courier activities	–	–
	Rental and leasing activities	–	–
6-Agriculture	Rice cultivation; agricultural services applied to rice cultivation; plant propagation	Rice	Medium-risk
	Cultivation of leafy and/or fruit-bearing vegetables, roots and tubers; services applied to these crops; plant propagation	Other crops	High-risk
	Soybean cultivation; agricultural services applied to soybean cultivation; plant propagation	Other crops	High-risk
	Wheat cultivation; agricultural services applied to wheat cultivation; plant propagation	Other crops	High-risk
	Barley cultivation; agricultural services applied to barley cultivation; plant propagation	Other crops	High-risk
	Other cultivation of cereals and other crops n.e.c.; agricultural services applied to these crops; plant propagation	Other crops	High-risk
	Crops of fruit trees, grapes, and plants whose leaves or fruits are used for the preparation of beverages or spices; agricultural services applied to these crops; plant propagation	Other crops	High-risk
	Production of milk and dairy products processed on the premises; livestock services applied to milk production	Dairy cattle	Medium-risk
	Cattle, sheep, goat and horse breeding, except milk production; livestock services applied to this activity	Cattle and other livestock	High-risk
	Raising of other animals; processing of animal products n.e.c.; hunting and related services; production of fine furs by trapping and trapping activities; services incidental thereto	Cattle and other livestock	High-risk
	Forestry, logging and related service activities	–	–
	Fishing, exploitation of fish hatcheries; fishing-related service activities	Fishery	Low-risk
	Others (selected agroind.)	Processing and preserving of meat and meat products except poultry and swine meat	Cattle and other livestock
Processing and preservation of poultry and pork meat; processing of cold cuts and sausages		Cattle and other livestock	High-risk
Fish, crustaceans and shellfish processing and preservation		Fishery	Low-risk
Dairy products processing		Dairy cattle	Medium-risk
Processing of rice milling products and processing of rice oil		Rice	Medium-risk
Processing of milling products of wheat and other cereals except rice	Other crops	High-risk	

A.4. Mapping between ISIC Rev.3 sectors to activity sectors

For each sector of activity for which the TR indicator was calculated under the emissions approach, it is presented which ISIC Rev.3 sectors at the 4 digit level (classification used in Uruguay for bank loans) are assigned.

Cattle and other livestock

- Livestock farming (excluding dairy);
- Livestock services (excluding veterinary activities);
- Production, processing, and preservation of meat and meat products.

Ground transportation

- Other types of regular passenger transportation by land;

- Other types of non-regular passenger transportation by land;
- Road freight transportation.

Cement

- Manufacture of cement, lime, and gypsum;
- Manufacture of concrete, cement, and gypsum products.

Other crops

- Wheat;
- Oilseeds;
- Barley;
- Cultivation of vegetables and legumes, horticultural specialties, and nursery products;
- Fruit growing (excluding viticulture), plants whose leaves are used for beverages and spices;
- Viticulture;
- Other crops;
- Combined crop farming and animal husbandry (mixed farming);
- Agricultural services;
- Processing of milling products. Flour mills.

Dairy cattle

- Dairy farming;
- Production of dairy products.

Rice

- Rice;
- Processing of milling products. Rice mills.

Refinery

- Manufacture of petroleum refining products.

Paper and pulp

- Manufacture of wood pulp, paper, and paperboard.

Fishery

- Fishing, fish farming and fish hatcheries; service activities related to fishing;
- Processing and preservation of fish and fish products.

Maritime transportation

- Maritime and coastal shipping;
- Inland waterway transport.

Construction

- Construction of complete buildings or parts of buildings; civil engineering works.

Rail transportation

- Railway transport.

Air transportation

- Regular air transport;
- Non-regular air transport.

Chemical industry

- Manufacture of basic chemicals, excluding fertilizers and nitrogen compounds;
- Manufacture of fertilizers and nitrogen compounds;
- Manufacture of pesticides and other agrochemical products;
- Manufacture of paints, varnishes, and similar coating products, printing inks, and putties;
- Manufacture of pharmaceuticals, medicinal chemicals, and botanical products;
- Manufacture of soaps, detergents, cleaning and polishing preparations, perfumes, and toilet preparations;
- Manufacture of other chemical products not elsewhere classified.

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