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European Roundtable on Climate Change and Sustainable Transition

Report

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Chile Country Case Study

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The views expressed are attributable only to the authors in a personal capacity and not to any institution with which they are associated, or the funders and supporters of this project.

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Executive Summary

This report presents the results from the ERCST country case study on Chile that assesses the trans-border impacts from the implementation of climate change mitigation policies (also known as response measures) on Chile. Domestic, out-of-jurisdiction and international response measures could have socio-economic impacts in Chile.

This report is part of the "Reporting on RM under Biennial Update Reporting" project, in which a methodology was developed ("Response Measures – Country case study methodology") for reporting on the impacts of response measures under Biennial Update Reporting (BUR) and Biennial Transparency Reporting (BTR). This case study is meant to test the methodology, and to showcase how it could be used in practice.

The main objective of this project is to support non-Annex I Parties to the UNFCCC in their efforts fulfilling their mandate to report on the impacts of the implementation of response measures in Biennial Update Reports, by offering a concrete example of the type of assessment that might be conducted to underpin that reporting. The project also aims to help those countries in future as they transition to requirements to submit Biennial Transparency Reports.

The methodology seeks to aid in identifying both the positive as well as negative, intended and unintended impacts of domestic and international climate change mitigation policies and projects, concentrating on the three pillars of sustainable development: the economic, environmental and social dimensions. This will be achieved by identifying key vulnerable sectors, relevant response measures and analysing impacts.

The identification of key sectors and relevant response measures, and assessing their impacts is a laborious process. However it can be simplified to be more useful for countries with less capacity to perform such a more exhaustive and comprehensive exercise. There are three main ways to simplify this methodology: (1) limit the number of sectors that are deemed vulnerable, for example by focusing on the top 3 or 5 sectors. (2) limit the number of response measures analysed, for example focusing on the top 5 or top 10 response measures per sector. (3) Limit the data collection and analysis step, and rely on stakeholder input to complement the analysis and ensure relevant sectors and policies are included in the country case study.

This approach is very much a bottom-up approach on how to do a country case study, and essentially tries to connect impacts with individual response measures. The vulnerable sectors are identified, and are then linked to relevant domestic and international measures. An alternative methodology which may make this reporting less complex and more realistic would be take a more macro-approach: model what a 1,5°C world would look like, which mitigation policies would need to be

implemented in various countries and regions and then assess the impacts of those policies on a country.

The case study, and the methodology it follows which shall be outlined below, are not intended to analyse the merit of the policies and measures that are being implemented, or their effectiveness and efficiency, but will focus on their socio-economic impacts, and measures to alleviate any negative impacts in the period of transition.

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The basic premise of this research project is that we need to move faster and deeper. For the transition to a low-carbon or climate neutral society to take place, impacts of response measures need to be understood and addressed. Otherwise the lack of information and analysis of impacts and tools to mitigate negative impacts can act as a brake on ambitious climate action and risk reducing buy-in from important stakeholders. This case study and the overall project's focus should be seen in that light: increasing understanding to strengthen the case for climate mitigation action.

This case study and the "Methodology description – Chile country case study" document have been developed by the European Roundtable of Climate change and Sustainable Transition (ERCST), an independent think tank based in Brussels, Belgium.

1. Introduction

Climate change is an urgent challenge facing all of humanity, and it is currently being tackled through a broad set of approaches, including the implementation of policies and measures aimed at mitigating greenhouse gas (GHG) emissions. These climate change mitigation policies (also known as 'Response Measures') are necessary to force a global transition to low carbon and carbon neutral societies and economies. In the UNFCCC definition, response measures refer to transfer impacts. This paper will refer to measures that are domestic as well as out of jurisdiction.

In order to ensure continued momentum and progression towards climate pathways in line with these degree goals outlined in the Paris Agreement, it is extremely important to pay close attention to the way in which the transition to a low-GHG economy is managed.

This transition is critical, and is a very ambitious undertaking. The way in which it is managed will have significant impacts on everyday life and societies in general. It should be undertaken in a sustainable way, by moving at the commensurate speed on the environmental, social and economic axes – this includes understanding and addressing the negative and unintended impacts of climate mitigation policies.

Response measures have significant impacts, both within the jurisdiction implementing them and cross-border in other jurisdictions. These impacts will increase as climate mitigation efforts intensify the coming years and decades. These impacts can undermine the case for and the speed of the transition, therefore they need to be acknowledged and addressed. Otherwise the lack of information and analysis of impacts and tools to mitigate negative impacts can act as a brake on ambitious climate action and risk reducing buy-in from important stakeholders.

This is not to be interpreted or construed as encouraging a lack of mitigation action. On the contrary, it must be seen as providing a way forward that will ensure that action can be undertaken with the full support of all stakeholders. Otherwise the lack of information and analysis of impacts and tools to mitigate negative impacts can act as a brake on ambitious climate action and risk reducing buy-in from important stakeholders.

Note that it is the unintended negative impacts of policies that are the most critical to understand, quantify and address. Taking fossil fuel subsidy reform as an example, an *intended negative* impact is to make consuming fossil fuels more expensive in order to disincentivize the burning them. An *intended positive* impact could be savings for the government budget as costly fossil fuel subsidies are decreased. Both these impacts are intended goals of the policy. However, and *unintended negative* impact could be increased energy poverty or increased costs of transportation for low-

income families with significant repercussions on their quality of life. These unintended negative impacts should be the focus of any assessment of response measures and their impacts.

One of the components that have been introduced under the UNFCCC process is the reporting of mitigation policies and their impacts. This document outlines the methodology developed and tested by ERCST in line with the Biennial Update Reports (BUR) process under the UNFCCC, which allows for the reporting of economic and social consequences of response measures by non-Annex I Parties (UNFCCC, 2011a). It also incorporates the available guidance for the transition from BUR to Biennial Transparency Reports (BTR), allowing for the methodology to be adapted to the upcoming BTR reporting process that should be followed by all parties starting in 2024.

Note that there no obligation for Parties to report on the impacts of response measures in their BURs, but there is an opportunity to do so.

So far, a methodology for identifying adverse impacts of international/out-of-jurisdiction has not been developed. Highlighting this gap, and seeking to provide a template for filling it in, is an important outcome of this project, as addressing impacts in an efficient and optimal manner is heavily dependent on identifying and quantifying them.

The methodology seeks to aid in the identification and assessment of the impacts of three types of response measures:

(1) domestic response measures in the jurisdiction under review (e.g. in the Chile country case study: Chilean climate mitigation measures);
(2) domestic measures in other jurisdictions (e.g. in the Chile country case study: climate mitigation measures in countries other than Chile) and;
(3) international mitigation measures (e.g. in the Chile country case study: policies implemented under the International Civil Aviation Organisation (ICAO) or International Maritime Organization (IMO)).

The first type of policies will be referred to as ‘domestic policies’ throughout the methodology. The second and third types of policies will be referred to collectively as ‘international’ or ‘out-of-jurisdiction’ policies.

It is not feasible to assess the potential impacts of all global climate change measures on all sectors of the Chilean economy. Therefore, a large part of the methodology is focused on sorting through economic sectors and response measures as to enable the analysis to focus on the sectors and policies that are most significant. The methodology to report on socio-economic impacts of response measures follows nine steps (detailed in the “Methodology description – Chile country case study” document), which seek to:

- identify sectors vulnerable to the impacts of domestic/international response measures,
- list relevant response measures,
- quantify the impacts of those response measures, and
- highlight approaches to mitigate negative and unintended impacts

The methodology can also be a valuable tool for drafting ex-ante reports to address and manage the unintended risk of possible adverse impacts coming from future response measures, allowing for the implementation of tools to manage the risk at an earlier stage, and even the prevention of such impacts. It can form the basis for ex-ante impact identification, with an emphasis being placed on stakeholder consultations throughout the process from the main sectors of the economy.

Chile was chosen for this country case study for a variety of reasons. Not only as it was set to host COP25 in Santiago de Chile, but because the country has seen significant economic development in the previous decades, with strong institutions. In addition, it has some history implementing climate change mitigation policies and has recently raised the ambition of its climate policies significantly. Last but not least, government actors and business stakeholders were interested in cooperating with the research team to build this case study.

This case study on reporting on socio-economic impacts of response measures follows the nine steps detailed in the methodology report. The key issues addressed for Chile are:

- identify sectors vulnerable to the impacts of domestic/international response measures,
- list relevant domestic and international response measures,
- quantify the impacts of those response measures, and
- highlight approaches to mitigate negative and unintended impacts

2. Background

Mitigation policies and actions are being taken by Parties under the Paris Agreement (PA) to limit climate change and its impacts. These policies, known as 'response measures' under the UNFCCC, can have impacts beyond reducing greenhouse gas (GHG) emissions, both in the jurisdiction implementing them and across borders. These impacts can be positive, or negative and intended or unintended, and be social, economic or environmental in nature.

To achieve the 2 °C goal of the Paris Agreement, and even more to limit global heating to 1.5 °C, the effective and sustainable mitigation of GHG emissions needs to be enhanced and efforts increased. The increased stringency of response measures in the future could exacerbate their impacts. The aim of policy makers should be to minimize the unintended negative impacts, and maximize the positive impacts.

Response measures give rise to a large variety of concerns, including competitiveness concerns, budgetary impacts, job losses, transitioning of sectors etc. Understanding these concerns is fundamental when assessing the sustainability of the transition to a low GHG global economy, as stakeholders with concerns that are not taken into account can potentially slow down a sustainable transition. Buy-in from stakeholders is necessary for a rapid and deep transition, and for this reason, environmental, social and economic impacts need to be assessed, analyzed, reported and addressed.

Yet, while there has been considerable debate on how to achieve this, as yet no agreed guidelines or methods for identifying and quantifying these impacts have been outlined. This case study and the related "Methodology description – Chile country case study" document aim to partially fill this current gap.

Non-Annex I Parties (mostly developing countries) have the possibility (UNFCCC, 2011b) to report on any socio-economic impacts of response measures in other jurisdictions in their Biennial Update Reports (BUR). This methodology is meant to help those countries report on impacts of response measures under the BURs. Therefore, the methodology is geared towards country-level assessments of response measures.

The mandate and guidelines for the BURs reports are to be found in decision 2/CP.17 (UNFCCC, 2011a), with Annex III stipulating that the objectives of the BUR guidelines include "… [facilitating] reporting by non-Annex I Parties, to the extent possible, on any economic and social consequences of response measures" (UNFCCC, 2011a – Para 11-13). The BURs can also be used to highlight needs Parties may have, and support they have received.

From 2024 onwards, BUR reporting will be replaced by Biennial Transparency Reporting (BTR), based on guidance elaborated in the Transparency Framework. How reporting requirements will change in detail is as yet not entirely clear. However, two sections of the guidance in the Transparency Framework are relevant with regard to response measures – paragraphs 78 and 90. The first BTR report submission deadline is set to take place on December 31, 2024, with subsequent review of the submitted BTR occurring within the two years prior to the next submission. Parties should submit a new BTR every four years from 2024 onwards (UNFCCC, 2019a).

Under paragraph 78 Parties are allowed to report on how socio-economic impacts of adaptation and/or economic diversification actions with mitigation co-benefits are addressed (UNFCCC, 2018a – Para 78). It should be noted that reporting on measures to address the impacts is different

from reporting solely on the impacts of response measures, which is the current focus of this methodology.

Paragraph 90 states that "Each Party is encouraged to provide detailed information, to the extent possible, on the assessment of economic and social impacts of response measures."(UNFCCC, 2018a – Para 90). It is, however, unclear how broad the scope of this assessment should be: does it include the domestic impacts of domestic mitigation measures, the impacts of domestic measures in other jurisdictions or does it only cover the domestic impacts of mitigation measures in other jurisdictions and at the international level.

One interpretation could be that countries are supposed to report on the impacts their mitigation policies are having on other countries. This would be a further differentiation from the focus of this methodology. For this reason, in preparation for this transition from BUR reporting to BTR reporting, this methodology for reporting on the impacts of response measures includes assessing the impacts of domestic response measures as well.

This case study report follows the nine steps of the methodology developed by the research team. Some of the steps are grouped together as this report concentrates on the results of implementing the methodology, instead of presenting a step-by-step guidance on how to use the methodology.

To see an extensive **step-by-step guide**, please refer to the "Methodology description – Chile country case study" document.

For some sections of this report, it was necessary to split up the discussion on domestic and international response measures.

In those sections the report will first look at identifying and reporting on **international response measures**. This includes mitigation policies enacted at the international level (e.g. CORSIA for international aviation) and mitigation policies enacted in other jurisdictions (e.g. renewable energy support programs in other countries). This assessment of international response measures builds upon the BUR reporting requirements.

After that, the same structure will be applied to identify and report **on domestic response measures** (e.g. coal phase out measures in the country itself).

3. Project overview

3.1. Project Objectives

The main aim of the study is to test the ERCST methodology which assesses and analyses the adverse, and unintended impacts of existing, and emerging, climate change mitigation measures

and policies, coming from both domestic and international jurisdictions. The project objectives therefore include the following:

1. To design and create a methodology on response measures (RM) under BUR reporting, which can then be used under BTR reporting after 2024.
2. To test this methodology through a country case study. A major aspect of the test is to see whether all the necessary data to implement the methodology is available and is feasible to access.
3. Highlight relevant challenges, and potential solutions, in both 1 and 2. These challenges are discussed in the methodology document.
4. Engage in discussions on the main findings of the project, both within the country where the methodology is tested (Chile) and in meetings with relevant high-level policy makers and negotiators on response measures.

3.2.Steps

The methodology seeks to identify and quantify the adverse impacts from domestic, out-of-jurisdiction and international response measures on sectors of the economy that are deemed vulnerable to the impacts of response measures. In addition, potential tools, and lack thereof, to address these impacts at the domestic and international level are discussed.

The methodology follows nine steps, that will be the core of the remained of this methodology. Each step will be described and discussed in detail, highlighting challenges the project team encountered when testing the methodology throughout the Chile country case study. The nine steps are:

Step 1: Describe the country and its key characteristics

Step 2: Identify the top sectors in terms of value added

Step 3 (a): Further limit the list of sectors potentially vulnerable to international response measures

Step 3 (b); Further limit the list of sectors potentially vulnerable to domestic response measures

Step 4 (a) Identify sectors vulnerable to international response measures, using two methods

Step 4 (b): Identify sectors vulnerable to domestic response measures, using two methods

Step 5: Employ stakeholder input to identify vulnerable sectors that might have been missed in step 4.

Step 6 (a): Identify the international response measures relevant for sectors identified in step 4(a).

A. Identify main export partners of the vulnerable sectors
B. Search national and international databases
C. Filter the results

Step 6 (b): Identify the domestic response measures relevant for sectors identified in step 4(b).

A. Search national and international databases
B. Filter the results

Step 7: Employ stakeholder input to identify response measures that might have been missed in step 6 (a) and 6 (b).

Step 8 (a): Assess the impacts of international response measures

Step 8 (b): Assess the impacts of domestic response measures

Step 9: Look at possible domestic and international tools and support which may be needed to address the impacts.

As mentioned above, it is not feasible to assess the potential impacts of all global climate change measures on all sectors in an economy. Steps 2 to 5 focus on identifying the sectors that should be considered vulnerable to the impacts of response measures. Steps 6 and 7 focus on identifying the relevant response measures for those sectors.

The nine Steps will not be expanded upon further in this country case study report but are discussed in detail in the "Methodology description – Chile country case study" document.

This approach is very much a bottom-up approach on how to do a country case study, and essentially tries to connect impacts with individual response measures. The vulnerable sectors are identified, and are then linked to relevant domestic and international measures. An alternative methodology which may make this reporting less complex and more realistic would be take a more macro-approach: model what a 1,5°C world would look like, which mitigation policies would need to be implemented in various countries and regions and then assess the impacts of those policies on a country.

3.3. Report of the country case study

This country case study report outlines what the final product of implementing the methodology could look like by testing it on Chile.

This paper combines the nine steps of the methodology into five chapters:

1. *Chile Country profile*

This chapter presents an overview of Chile, focusing on geography, main sectors of the economy and recent economic developments.

2. *Identification of vulnerable sectors*

In this chapter the sectors deemed most vulnerable to the impacts of response measures are presented, with a brief discussion on how these sectors were identified. Two lists of sectors are presented:

- one list contains the sectors deemed vulnerable with regard to ***international*** response measures,
- a second list contains those sectors deemed vulnerable with regard to ***domestic*** measures.

3. *Identification of relevant response measures*

Here an overview is presented of the relevant response measures that have the potential to impact the identified sectors. Again, two lists are presented:

- one list of ***international*** climate mitigation measures that are relevant to the sectors considered vulnerable to international response measures,
- a second list of ***domestic*** climate mitigation measures that are relevant to the sectors considered vulnerable to domestic response measures.

4. *Assessment of impacts of response measures*

This chapter contains the results of the limited quantitative analysis of the potential impacts of response measures performed by the research team, and the results of the qualitative analysis. Again, this assessment is done separately for international and domestic response measures.

5. *Tools to address impacts*

In the final chapter, an overview is presented of the domestic tools and international cooperative approaches that can be used to help Chile address and mitigate the impacts of response measures.

4. Chile Country Profile

4.1. General Profile and Geography

The Republic of Chile is a representative democratic republic, with the President acting as both the Head of State and Head of Government. Sebastian Pinera is the current president, having won elections in December 2017. Chile is considered as one of South America's most stable and affluent nations. In May 2010, it became the first South American country to join the OECD (2019a). In March 2018, Chile signed the Comprehensive and Progressive Trans-Pacific Partnership (CPTPP, 2019).

Chile's elongated shape, measuring 4,300 km long and on average only 175 km wide, gives rise to many climatic variations across its territory. In the North it contains the world's driest desert, the Atacama, which transitions to a Mediterranean climate in the centre of the country, and then to a snow-prone Alpine climate in the South, with glaciers, fjords and lakes. Land use is primarily dominated by agriculture and forestry.

Chile's population was estimated at around 18.4 million in 2017 (Statista, 2019a). The population growth rate has been decreasing over the last few years (Statista, 2019b). This is mainly due to a declining fertility rate: from 1.96 children per woman in 2006, to 1.77 in 2016 (Statista, 2019c).

The largest population densities are found in the middle of the country, around the capital Santiago de Chile. In this region approximately 90% of the population lives. The north and south are relatively underpopulated.

Chile borders three countries, Argentina, Bolivia, and Peru and the South Pacific Ocean. The Pacific islands Juan Fernandez, Salas y Gomez, Desventuradas, and the Easter Islands are also a part of its territory.

Chile is home to multiple ethnicities, including people of European and indigenous ancestry. The main spoken language is Spanish, along with a multitude of indigenous languages.

4.2. Overview of the Chilean economy

The services sector accounts for the largest share of Chile's economy in the previous decade. It represented just over 50% of GDP in 2017. Tourism expenditure alone has increased rapidly in Chile, going from 1.4 bn USD in 2007, to over double that amount within 10 years, to nearly 3 bn USD in 2017 (World Bank, 2019a).

Industry represented roughly 30% of GDP in 2017. Agriculture accounts for a relatively minor share of GDP (just under 4% in 2017) (Statista, 2019d).

Employment by each of these three segments of the Chile economy roughly reflects their respective shares of GDP. Agriculture accounts for 9.15% of total employment in 2018, industry 22.75% and services over 68.1% in 2017 (Statista, 2019e).

GDP per capita was estimated at 24,122 USD/capita in 2017, showing strong growth from 18,129 USD/capita in 2010. Real GDP growth has fluctuated in recent years, decreasing from 5.8% annually in 2010, to 1.5% in 2017, (OECD, 2019b) and increasing to 4% in 2018 (World Bank, 2019b). Inflation was approximately 2.3 percent in 2018 compared to 2017 (Statista, 2019f).

Chile is by far the world's largest copper exporter, exporting roughly 5.8 million tonnes in 2018 with the second top exporter – Peru – exporting less than half that amount (approx. 2.4 million tons in 2018) (Statista, 2019g). Copper is Chile's top export product, accounting for approximately 48% of total export value (Chile, 2019a), and almost a quarter of government revenue (CIA, 2019).

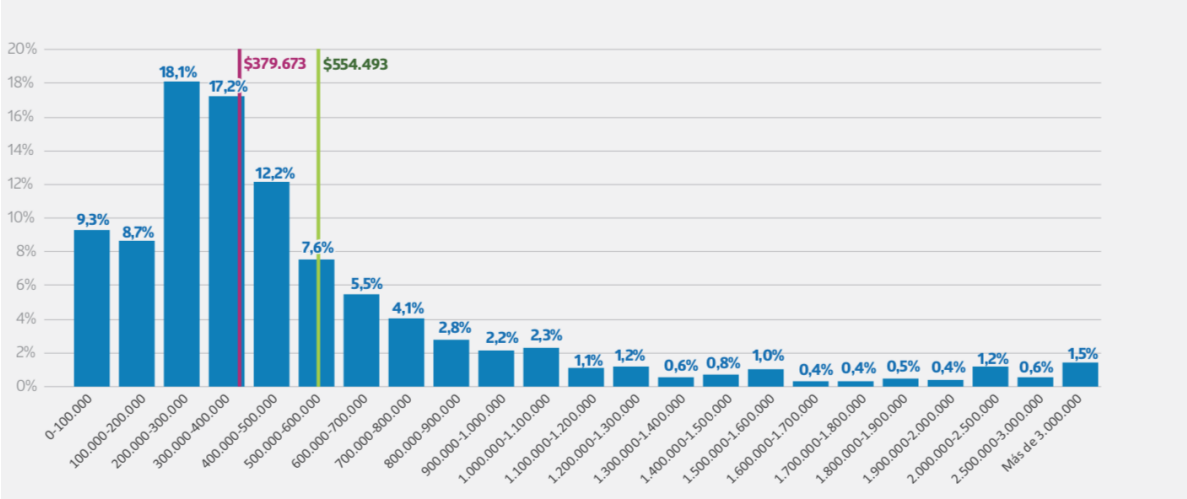
Other major Chilean export products are wood pulp, wine, grapes, salmon, and cherries. However, when taken together, these products only comprise roughly 14% of total exports (Chile, 2019a), which further emphasises the significance of the copper sector to the Chilean economy.

4.3. Economic performance

Since the 1980s, Chile has experienced steady growth and poverty reduction. The percentage of the population considered below national poverty lines decreased considerable from 25.3% in 2009 to 8.6% in 2017 (World Bank, 2019c). Unemployment halved between 1986 (14% of total labour force) and 2018 (7%) (OECD, 2019c).

However, Chile has high income inequality with 71% of employees receiving an income of less than or equal to the national average income in 2017 (see Figure 1) (Instituto Nacional de Estadíticas, 2018). Chile's Gini coefficient, although remaining high, has been improving recently, decreasing from 49 in 2009 to 46.6 in 2017 (World Bank, 2019d).

Figure 1: Income levels for Chilean employees - percentage of employees for various income levels.



Source: Instituto Nacional de Estadíticas (2018)

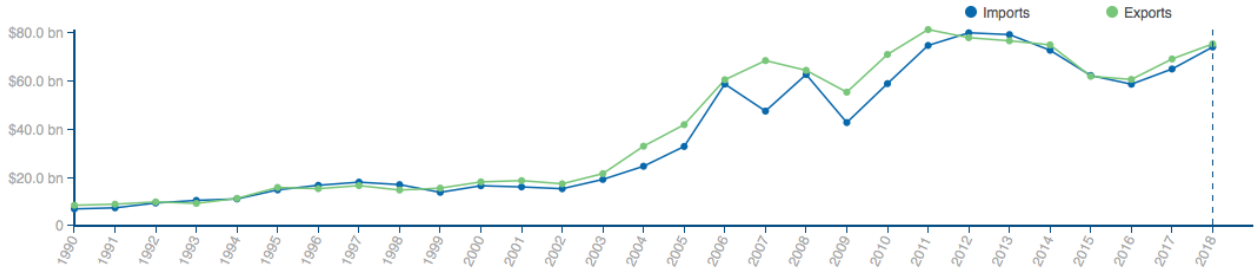
Note: The blue bars represent percentages of total employees (left axis), the purple line represents the national median income, and the yellow axis average national income.

Chile has a market-oriented economy characterized by a high level of foreign trade and a reputation for strong financial institutions and sound policy. It has a high credit rating, receiving a stable rating of A1 in 2018 according to Moody's (Trading Economics, 2019).

From 2003 to 2013, growth rate was approximately 5% per year, despite a slight downturn in 2009 due to the global financial crisis (World Bank, 2019d). Growth slowed to below 2% in the past few years, but has picked up again to 4% in 2018 (World Bank, 2019e). The average inflation rate was at approximately 2.3% in 2018 compared to 2017, dropping considerably since the high rate of roughly 8% in 2008, with projections for under or equal to 3% inflation up to 2024 (Statista, 2019h). Efforts to diversify its economic base beyond copper could help stabilize the economy further in the future (Statista, 2019i).

Chile's trade balance, however, has fluctuated significantly over the past decade (UN Comtrade, 2019). It was negative in 2012 and 2013, with a trade balance of roughly USD -2bn. In 2015, the trade balance dipped again at USD -353.7m, but in 2016, the trade balance returned to a surplus, valued at USD 2bn, decreasing slightly to USD 1.3bn in 2018 (UN Comtrade, 2019).

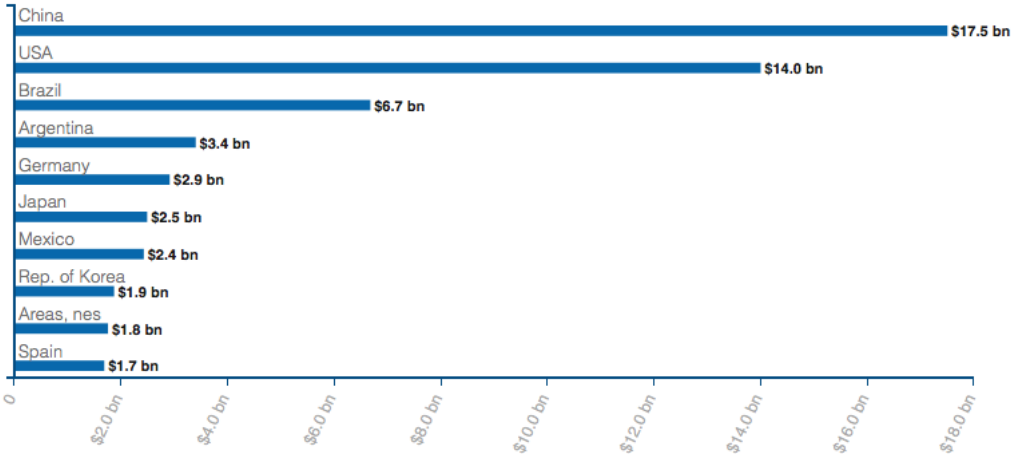
Figure 2: values of Chilean exports and imports (1990-2018)



Source: UN Comtrade (2019)

Chile has seen enormous increases in both exports and imports in the past 40 years, with total imports and exports around USD 9 bn in 1990, increasing more or less in step to nearly USD 75bn by 2018. China and the United States are Chile's most important trade partners, with China accounting for 23.6% of total imports, and the U.S. accounting for 18.9% of total imports, followed by Brazil, Argentina and Germany, (Figure 3).

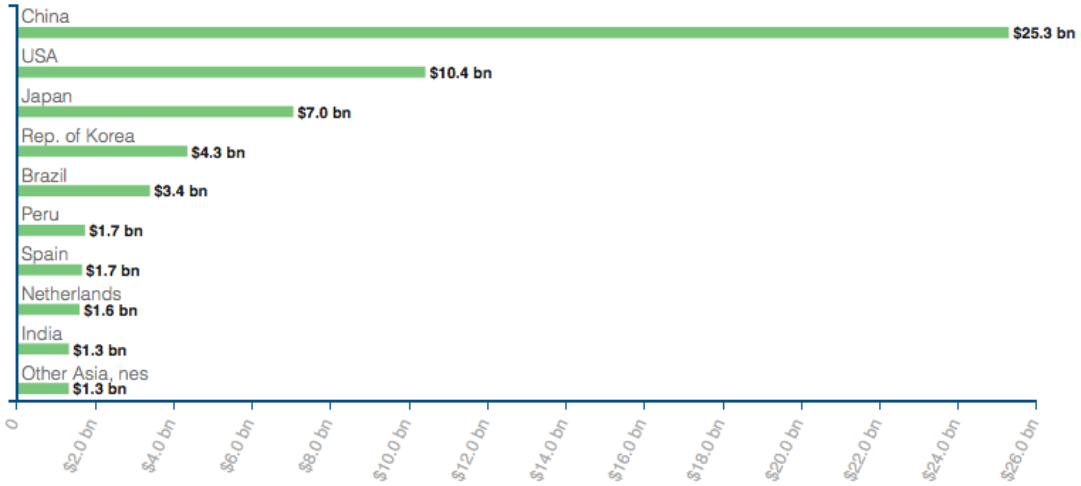
Figure 3: Top 10 import markets for goods for Chile (2018)



Source: UN Comtrade (2019)

With respect to exports, China accounted for 33.5% of total exports and the U.S. at 13.8%, followed by Japan, Republic of Korea and Brazil (see Figure 4 below)

Figure 4: Top 10 export markets for goods for Chile (2018)



Source: UN Comtrade (2019)

5. Identification of vulnerable sectors

This chapter covers the identification and selection of sectors which could be considered most vulnerable to response measures. First, those sectors deemed vulnerable to international response measures are covered, then those sectors deemed vulnerable to domestic response measures.

A detailed overview of the sector selection can be found in the methodology document, with only the most relevant issues covered in this country case study.

The sector classification used by Chile is the International Standard Industrial Classification of All Economic Activities (ISIC Rev. 4), at a fine level of disaggregation (4-digit, in the case of ISIC). Throughout this case study, sectors will be defined using this classification system.

Table 1: Overview of ISIC structure

Sector	Agriculture
Section	A, Agriculture, hunting and forestry
Division	01, Crop and animal production, hunting and related service activities
Group	011, Growing of non-perennial crops
Class	0111, Growing of cereals (except rice), leguminous crops and oil seeds

Source: United Nations (2008), International Standard Industrial Classification of All Economic Activities (ISIC), Rev. 4, ST/ESA/STAT/SER.M/4/Rev.4.

First, only sectors with major contributions to Chile's GDP were deemed relevant. The top 100 sectors in terms of value added were therefore selected for the initial list. This data was gathered using the 2016 Annual National Accounts of the Central Bank of Chile. A wide range of sectors were identified, from manufacturing to legal and accounting activities. The full list of sectors can be found in Annex 1.

Note that smaller sectors can be equally or even more vulnerable to the impacts of domestic and international response measures than larger sectors of the economy. However, the impacts for smaller sectors will be less urgent for the overall economy and country, and it might be possible to deal with them at a lower level of governance. Different tools from those used to address the impacts for major exporting and/or employing sectors of the economy might be necessary to address the impacts of response measures on smaller sectors.

Up to this point, the tracks for sectors deemed vulnerable to international and domestic response measures are identical. However, now the analysis will start differentiating between the two tracks.

5.1.Identification of sectors deemed vulnerable to *international* measures

The identification of sectors deemed vulnerable to international measures involved further narrowing down the list of top **100 sectors** in terms of value added identified above. For this reason, two additional filters were applied:

1. Is the sector internationally traded?
2. Does the sector have significant greenhouse gas emissions?

If a sector is not internationally traded and/or does not have significant GHG emissions, it should be taken off our list of potentially vulnerable sectors. More detail on this process can be found in the "Methodology Description – Chile Country Case Study" document. This reduced the list of potentially vulnerable sectors further down to **31 sectors.**

Two methods were proposed in order to filter and identify the sectors that are both vulnerable to response measures and are significant to the national economy: **Method 1**, the Threshold Method, and **Method 2**, the Weighted Scoring Method.

The two methods were chosen in order to allow room for testing, comparing and modifying the two approaches, which can reveal whether one is better suited for identifying vulnerable sectors than the other.

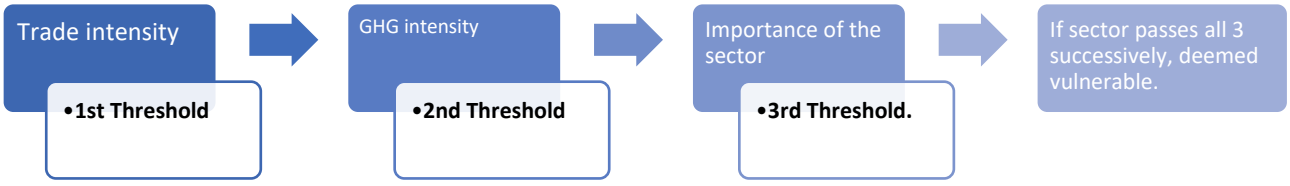
In the end, we cannot make a strong conclusion on which method is preferable. The results of both methods depend solely on either the thresholds or the weights that are set. Both methods are valid, and are equally subjective. The main way to limit subjectivity is to combine a set of scenarios with different thresholds and/or weights to add robustness to the sector identification process. We would advise anyone following the methodology to therefore also implement a scenario analysis.

5.1.1. Method 1: threshold method

Method 1 involves iterating the sector through three threshold conditions, set in series. This means that the three thresholds have equal weight. For a sector to be classified as vulnerable to the impacts of response measures, it had to pass each of the thresholds.

The three thresholds are defined as: (1) trade intensity, (2) GHG intensity or energy cost over value added (choice between the two is dependent on available data), and (3) importance of the sector for the economy, expressed as sectoral value added as a percentage of GDP. The first two are proxies for vulnerability, and the third is a proxy for sectoral significance for the country's economy.

Figure 5: Threshold Method



Source: Authors' own elaboration

The threshold method was included by the research team as it could potentially provide a way to limit the research burden related to data gathering from the outset. Sectors are dropped from the list because from the very beginning if they do not meet the first threshold, and therefore do not need to be included in the data gathering exercise for the next threshold.

5.1.1.1. Threshold 1: trade exposure

The first threshold test looked at the trade exposure of the sectors by calculating the level of trade intensity. This was calculated through the following formula:

$$Trade\ intensity\ (\%) = \frac{\text{exports}}{\text{domestic production}}$$

Exports are expressed as the total value of exports from the sector. Domestic production is defined as the value of the gross domestic production of the sector. The higher the trade intensity, the higher the vulnerability of the sector. Higher trade intensity means more exposure to not only foreign competition, but also international and out-of-jurisdiction climate measures.

The level of the threshold is a subjective choice to be made. As will be discussed later, the research team tested several levels of thresholds in the Chile case study to limit subjectivity.

5.1.1.2. Threshold 2: GHG intensity

The second threshold looks at GHG intensity, expressed as GHG intensity of value added, or the energy costs over unit of value added. The best indicator for potential vulnerability to climate measures is GHG intensity of value added, but a second different possible way for defining the threshold is included in this methodology.

Data on sectoral GHG emissions was not available for Chile on a sufficiently disaggregated level (e.g. Class or ISIC 4-digit level). In the end, less disaggregated data was used as a proxy. For example, as data on GHG emissions for the entire agriculture sector was only available at section level, this was used as a proxy for all agricultural sectors under analysis (be it divisions, groups or classes).

$$GHG\ intensity\ (grams\ of\ CO2e/USD) = \frac{\text{GHG emissions}}{\text{Value added}}$$

5.1.1.3. Threshold 3: Importance of the sector

The last and third threshold focused on the importance of the sector in the economy of the country. This was calculated by looking at the value added of the sector as percentage of national GDP.

$$Importance\ of\ sector\ (\%) = \frac{\text{Value added sector}}{\text{National GDP}}$$

5.1.2. Method 2: weighted scoring method

The weighted scoring method provides a systematic process for selecting the vulnerable sectors based on the same three criteria seen above: trade intensity, GHG intensity and sectoral importance. All three were defined in the same manner as under the Threshold Method outlined above.

Whereas in Method 1 these criteria were categorised as thresholds, in this Method the criteria are weighted. The sum of the three criteria multiplied by their respective weight must be above a fixed cut-off score if the sector is to be deemed vulnerable to the impacts of response measures.

Multiple different sets of weights were applied to the three variables, with Trade intensity and GHG intensity receiving higher weights than the importance of the sector.

Table 2: Weighted Scoring Method for International Track

Trade intensity (trade intensity: exports/domestic production). Scored zero to 100, derived by multiplying number by 4, cap at 40.	40%
GHG intensity (grams of $C0_2e$/ USD value added). Scored zero to 40, using logarithmic scale that is capped at 40. Sectors with GHG intensity of 0,5 or higher score 40.	40%
National sectoral significance: value added relative to GDP. Scored zero to 100, derived by multiplying number by 2000, cap at 20.	20%

Source: Authors' own elaboration

These three rows describe a way which to employ the raw data for trade intensity, GHG per unit of value added, and value added relative to GDP and "normalize" it to a set of values between 1 and 100. The manipulations differ as the raw data differs in characteristics. The manipulations are not ideal and were adapted subject to the discretion of the research team in order to best fit the purposes of this study.

5.1.3. Combining methods 1 and 2 to provide robustness

To limit the subjectivity of the two methods, the research team decided to use additional robustness checks during the sector selection. Four scenarios for setting thresholds and scores were defined, and used under each Method:

- Scenario 1: sector GDP contribution less important
- Scenario 2: GHG intensity less important
- Scenario 3: Trade intensity less important
- Scenario 4: GDP contribution, GHG intensity and trade intensity equally important

In scenario 1, less weight was attributed to the national sectoral significance. In scenario 2, the GHG intensity was given less weight. For scenario 3, trade intensity was assigned less weight, and in the last scenario, each criterion was assigned the weights set out in the previous section (baseline scenario).

This defined a total of eight tests (four scenarios for two different methods) which presented us more confidence in the sector selection as a variety of weights and scores were used. The sectors which passed 6 or more scenarios out of 8 were deemed to be vulnerable to the impacts of international response measures.

To summarize the results of the elimination of sectors:

- 100 sectors with the highest value added were initially listed,
- 60 are internationally traded (40 were discarded),
- 31 had significant GHG emissions, and were then run through the 8 scenario tests.
- 5 sectors were found to have passed 7-8 of the scenario tests, and 4 of the sectors passed 6 scenario tests.

This meant that out of the narrowed down list of 31 sectors from the previous steps, 9 were found to have passed the final filters, as shown in Table 3. The tourism sector was added through a qualitative assessment.

Table 3: Top 10 Vulnerable Sectors to International response measures[1]

ISIC code	Sector Description
0729	'Mining of copper'
0122-0126	'Cultivation of other fruit' (e.g. tropical and subtropical fruits, citrus fruits, pome fruits and stone fruits, other tree and bush fruits and nuts, oleaginous fruits)
17	'Manufacture of paper and paper products'
2011	'Manufacture of basic chemicals'
19	'Manufacture of coke and refined petroleum products'
0121	'Cultivation of grapes'
1102	'Manufacturing of wines'
032	'Aquaculture'
031	'Fishing'
WTO 1.33 and 1.36	Tourism

Source: Authors' own elaboration

The robustness checks included through the running of the eight scenarios was the subject of an effort to proceed as objectively as possible with the sector selection. However, the scenarios (and therefore the sector selection) remains a largely subjective exercise.

5.2. Identification of sectors deemed vulnerable to *domestic* measures

The identification of sectors deemed vulnerable to domestic measures involved further narrowing down the list of top 100 sectors in terms of value added identified above. This process closely followed the steps set out above for identification of sectors deemed vulnerable to domestic impacts – with several key differences:

(1) Only one additional initial filter was applied: Does the sector have significant greenhouse gas emissions?
Whether or not the sector is internationally traded, is less relevant for identifying the sectors which could be vulnerable to *domestic* response measures. Both sectors that are and are not traded, can be impacted by domestic climate mitigation measures. This reduced the list of potentially vulnerable sectors further down to 34 sectors.

[1] The listing order of the sectors does not bear any relevance to the level of vulnerability of the sector.

(2) Only two threshold tests were used in Method 1: threshold method: GHG intensity and importance of the sector. These criteria were defined in the same manner as during the identification of sectors vulnerable to international response measure

(3) Only two variables were also used and weighted for Method 2: weighted scoring method: GHG intensity and importance of the sector. These criteria were defined in the same manner as during the identification of sectors vulnerable to international response measure, but weighted differently (as the total of the weights needs to add up to 100%, and there is one less variable).

Method 1 and Method 2 were again combined into a scenario analysis. Due to changes in the use of both methods, only three scenarios were used, as the criteria for trade intensity was left out for the selection of sectors vulnerable to domestic response measures.

- **Scenario 1:** Sectoral GDP contribution less important
- **Scenario 2:** GHG intensity less important
- **Scenario 3:** GDP contribution and GHG intensity equally important

This created a total of six tests (three scenarios, two methods) for the 34 sectors still on the list of sectors potentially vulnerable to the impacts of domestic response measures. Sectors that passed four or more out of six tests were considered vulnerable to the impacts of domestic response measures. Just as in the international track, a list of nine sectors (Table 4) were found to be the most vulnerable to the impacts of domestic response measures, and the tourism sector was added through a qualitative assessment.

Table 4: Top 10 Vulnerable Sectors to Domestic response measures [2]

Sector Code	Sector Description
3510	Electric power generation
4923	Freight transport by road
17	Manufacture of paper and paper products
51	Air transport
19	Manufacture of coke and refined petroleum products
2011	Manufacture of basic chemicals
0729	Mining of copper
1020	Processing and preserving of fish, crustaceans and molluscs
0122-0126	Cultivation of other fruit
WTO 1.33 & 1.36*	Tourism

Source: Authors' own elaboration

There is a large overlap between the lists of sectors deemed vulnerable to the impacts of domestic or international response measures. "Mining of copper", "Cultivation of other fruit", "Manufacturing of coke and refined petroleum products", "Manufacturing of paper and paper products", "Manufacturing of basic chemicals" and "Tourism" are all on both lists, with the latter also being added following qualitative analysis.

It should be noted that the domestic list also contains a number of sectors that are major GHG sources, including power generation, and road and air transport.

5.3.Conclusions on sector selection

There are now two lists of 10 sectors available, one deemed vulnerable to the impacts of international measures, and another one deemed vulnerable to the impacts of domestic measures. The research team did not aim to have an equal number of sectors in both lists.

Both lists overlap to a large extent, and contain the major sectors of the Chilean economy, and major GHG emitters. The main difference is the inclusion of a number of non-traded sectors in the

[2] The listing order of the sectors does not bear any relevance to the level of vulnerability of the sector.

list of sectors vulnerable to domestic measures, most importantly the electric power generation sector (ISIC 3510).

Following the identification of the top 10 sectors vulnerable to domestic and international response measures, a stakeholder consultation was organised. For the international track, questions centred on asking for feedback on the list of sectors vulnerable to international RM and whether or not anything had been missed. For the domestic track, feedback was asked about the list of vulnerable sectors to domestic response measures.

In this manner, stakeholder consultations were used to supplement Methods 1 and 2, capturing any vulnerable sectors that the methodologies may have missed, or, inversely, whether too many sectors had been incorrectly listed as being vulnerable to response measures. Opening the discussion of the two methods to the relevant stakeholders allowed for feedback on whether the methods are a suitable representation of the vulnerable sectors which may/have already experienced adverse impacts, and on how to improve the methods.

The input from the stakeholder consultations did not differ from the outcomes of the desk research, therefore the lists of sectors did not need to be amended. Rather the stakeholders agreed with the identified sectors. This does not mean that the stakeholder consultation was not useful, rather it provided a critical sanity test and ensured that the conclusions of the desk research were validated.

6. Identification of response measures

In order to assess their impacts, the most relevant response measures (both domestic and international) need to be identified.

The mapping of policies is a labour intensive task, necessitating significant amounts of desk research and interaction with stakeholders. Existing policy measures, as well as policy measures which are under proposal and have a high probability of being implemented are included.

Drivers behind these measures and policies may be environmental (concerns about climate change and its impacts or other environmental issues such as air pollution), political (energy security, international pressure, political vision), social (poverty alleviation, combatting energy poverty or public pressure for a less GHG intensive society) or economic (new potential economic and market opportunities by developing cleaner technologies).

The international and domestic response measures were identified through two separate, but very similar, procedures.

6.1. Identifying international Response Measures

In this step the main international mitigation policies were mapped and listed. These international response measures can be implemented either on an international level (for example by ICAO and IMO), or in other jurisdictions (e.g. not in Chile).

The international response measures were identified following a three-part procedure:

A. Identify main export partners of the vulnerable sectors
B. Search national and international databases
C. Filter the results

In Part A the main trading partners for the vulnerable sectors are identified, enabling us to understand in which countries the response measures need to be implemented before they can be relevant for those sectors deemed vulnerable.

In Part B response measures in the main trading partners are identified and mapped through extensive desk research.

In Part C the goal is to filter the response measures that should be considered, by looking at the types of measures and impacts.

6.1.1. Part A: identifying main export partners of the vulnerable sectors

Using the UN Comtrade Database, the five main trading partners for each of the identified 10 sectors were identified. This meant reviewing all the export partners for all the HS codes covered by each of the sectors. More detail on this process can be found in the "Methodology description – Chile country case study" document.

Table 5 below gives an overview of the results of this process for one sector (Manufacturing of paper and paper products). The full table covering all ten sectors can be found in Annex 2.

Table 5: Top Export Partners for one of the 10 Vulnerable Sectors

ISIC Rev 4 Code	Product Description	HS 2007 Code	Product Description	2018 Top 5 Export Partners: Value (USD)*	
				Country	Total value
17	Manufacture of paper and paper products	470100-590500	Paper products	China	1,998,820,149
				Netherlands	229,812,390
				Rep. of Korea	216,929,369
				Other Asia, nes	81,894,432
				Japan	75,946,474

Source: Authors' elaboration on UN Comtrade (2019)

Note: Over 200 HS Codes are included in ISIC Rev 4 Code 17. We looked at the top 10 (covering just over 98% of the exports from this sector). These top 10 HS codes include: multiply paper and paperboard, unbleached sack craft paper, newsprint, self-adhesive paper and paperboard. These four HS codes account for nearly 95% of exports from this sector in Chile

For the tourism sector detailed country-level data on arrivals to Chile was not readily available or accessible for the research team. Therefore, data was collected using the WTO codes 1.33 & 1.36, which gave an overview of the departure regions for tourists arriving in Chile. The majority of tourists arrived in Chile from the Americas, along with a smaller potion arriving from Europe. Therefore, policies potentially impacting the tourism sector (through aviation or maritime transportation) in countries in those two continents were considered in the following phases.

As there were large overlaps between trading partners of the various sectors, only 15 countries were in the end relevant. One of those needed to be dropped due to differences in definitions between various sources ("Other Asia, nes").

Table 6: 15 Trade Partners in order of Total Trade Value for Top Vulnerable Sectors

Country	Aggregated Values for Export Destinations 2018 (USD) for Top 10 Vulnerable Sectors
China	14,486,603,546
Japan	6,253,164,157
USA	5,299,014,054
Rep. Of Korea	1,962,565,993
Brazil	1,406,007,337
India	952,045,620
Russian Federation	888,362,650
Spain	885,972,263
The Netherlands	631,193,035
United Kingdom	381,441,011
Belgium	265,529,424
Colombia	93,378,332
Other Asia, nes	81,894,432
Peru	601,729
Argentina	506,318

Source: Author's elaboration on UN Comtrade (2019)

This gives a clear overview of which countries and jurisdictions are the main areas of concern when searching for the international out-of-jurisdiction response measures. The top 5 in this list already account for over 87% of the value of exports in this table: China, Japan, USA, Republic of Korea and Brazil.

"Other Asia, nes" had to be dropped from the analysis, as the definitions for this region vary significantly between the UN Comtrade database and the various databases used to map climate measures themselves. This left 14 countries to look at for compiling the list of international response measures.

6.1.2. Part B: Search national and international databases

To have an extensive list of potentially relevant international response measures, a series of databases were mined to map every possible relevant international response measure. The research team identified 13 databases[3] as sources of climate mitigation measures.

1. European Environmental Agency database on climate change mitigation policies and measures in Europe
2. OECD Database on Policy Instruments for the Environment
3. UNFCCC NDCs registry and IGES NDC database
4. ICAP Carbon market database
5. World Trade Organisation Environmental Database
6. International Energy Agency/IRENA Joint Policies and Measures database
7. Food and Agriculture Organisation FAOLEX Database
8. International Trade Centre Sustainable and Standards Map
9. International Civil Aviation Organisation Policy Factsheets
10. International Maritime Organisation Policy Factsheets
11. London School of Economics and Political Sciences Climate Change Laws of the World database
12. UNFCCC Response Measures Synthesis Report
13. International Energy Agency Building Energy Efficiency Policies Database

Note that many of these databases are not limited to climate change mitigation measures. This allows researcher to also map policies that are not directly related to climate mitigation, and those that are more indirectly climate change related for example as they have climate mitigation co-benefits.

A country reducing fossil fuel subsidies or increasing taxes on fossil fuels might not always list these measures as climate policies, but as fiscal policies as they can help decrease public spending or increase government revenue.

These databases were scanned for national and international direct and indirect climate change policies that could be relevant for the identified Chilean sectors.

Each database had differently structured search functions. Certain databases were less relevant than others for our search, as they are not directly related to the vulnerable sectors identified in

[3] See bibliography for an overview of the sources for the 13 databases.

the previous step, like the IEA Building Energy Efficiency Policy Database. However, these sources could still be relevant for assessing other countries. For the OECD database, the research team searched by sector and country. The majority of the identified response measures were sourced from this database.

The EEA database specifically dealt with European mitigation policies. The research team was able to filter the relevant measures and policies by specifying which sector to focus on. For the European export partners (Spain, United Kingdom, Belgium and the Netherlands) this database was very useful.

An excel sheet for every country was built, and populated with policies from each of the databases while going through them. These country sheets contained possibly relevant response measures that could be relevant for all sectors, not just the sectors that each country was a major trade partner for. This was done to simplify to the database mining exercise.

There were multiple duplications between databases, countries and sectors, as the same policy would be listed in multiple databases, implemented in multiple countries (i.e. EU Directive or Regulation), and would be applicable for multiple sectors, such as the Directive 2009/28/EC on the Promotion of Electricity Produced from Renewable Energy Sources.

This initial search cast a wide net and for most countries a large number of possible measures were initially identified, as can be seen in Table 7 below.

Table 7: Preliminary numbers of potentially relevant international climate change policies that could impact sectors deemed most vulnerable

Country	Number of potentially relevant climate change policies
China	2,332
Japan	441
USA	3,304
Rep. Of Korea	516
Brazil	1,901
India	567
Russian Federation	3,745
Spain	2,352
Netherlands	453
United Kingdom	2,646
Belgium	1,497
Colombia	1,706
Peru	3,059
Argentina	2,128
International Organizations (ICAO and IMO)	3

Source: Authors' elaboration on 13 databases for potentially relevant policies

6.1.3. Part C: Filtering results

This extensive list of all potential direct and indirect climate change policies that could have impacted the 10 sectors (over 26,000 policies) clearly needed to be narrowed down significantly in order to be able to assess their impacts.

In order to begin narrowing down this extensive list, further criteria were applied. This process was extremely labour-intensive and consisted of members of the research team manually assessing every policy in the initial list to see if it fit the bill. The criteria to narrow down the list included:

- The measures and policies need to be related to the exporting sector, either by impacting direct competitors (producing similar products or substitutes) or by directly impacting the exporter (for example through changes in cost of transportation or need for exporters to comply with monitoring and reporting obligations).
- Policies should be direct or indirect climate change mitigation policies.
- Duplicates should be removed.

By narrowing down this initial list, the remaining response measures identified were ensured to be climate change related, that could have impacts on the identified Chilean sectors of the economy. See Table 8 below:

Table 8: Final numbers of potentially relevant international climate change policies that could impact sectors deemed most vulnerable

Country	Number of potentially relevant climate change policies
China	39
Japan	7
USA	44
Rep. Of Korea	13
Brazil	5
India	27
Russian Federation	0
Spain	13
Netherlands	4
United Kingdom	16
Belgium	4
Colombia	2
Peru	8
Argentina	19
International Organizations (ICAO and IMO)	3

Source: Authors' elaboration on 13 databases for potentially relevant policies

These measures were then assessed in more detail and organised by the vulnerable sector(s) they were considered to have a potential impact on. Often, a measure enacted in one of the 14 trading partners was found to have a possible impact on more than one vulnerable sector.

When looking at the response measures which could have an impact on "Mining of Copper" (ISIC Rev 0729), a total of 39 were found from the top 5 trading partners:

- China – 13, including the "China National Plan for Tackling Climate Change (2014-2020)" and the "Industrial Green Development Plan (2016-2020)"
- Japan – 1, grants and direct payments scheme to renewable energy producers
- Republic of Korea – 7, including the "Enforcement Decree of the Framework Act on Low Carbon, Green Growth (Presidential Decree No. 22124 of 2010)".
- India – 9, including the "Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017".
- Spain – 8, including "Directive 2009/28/EC on the Promotion of Electricity Produced from Renewable Energy Sources".

The full list of policies identified for the five main trading partners for each of the 10 sectors identified is included in Annex 3.

Out of these policies, two were chosen for quantitative assessment:

- IMO carbon tax for international shipping
- CORSIA under ICAO for international aviation

These results were then reviewed by local Chilean stakeholders through a stakeholder consultation in Santiago de Chile in August 2019. Meetings were held to engage with stakeholders from academia, private and public sector. This was done through workshops where the methodology and the main findings were presented, followed by requests for input and feedback, as well as inviting stakeholders to identify other policies (out-of-jurisdiction and international) and other potential negative impacts on their sector.

While the issue of response measures was not a high priority for many stakeholders, most concern among Chilean business stakeholders was about two policies: one that has not been implemented yet and is still in the design phase (CORSIA) and one policy that has been discussed by various stakeholders globally, but is not actually high on the political agenda (IMO speed reduction). There was limited interest in policies originating in other jurisdictions.

During this stakeholder consultation, no policies were raised that the research team had missed. Therefore, the list was not altered.

6.2. Identifying domestic response measures

For compiling the list of domestic response measures, the previous procedure was modified, as again the aspect of trade is not relevant. For this reason, there was no need to follow the first step and find the top 5 export partners for the identified vulnerable sectors to domestic response measures. This resulted in an adapted two-part procedure:

A. Search national and international databases
B. Filter the results

To compile lists of relevant domestic direct and indirect climate change policies, there are less sources that needed to be drawn from – only one jurisdiction (instead of all major trading partners) is pertinent. These sources included:

- The Chilean Nationally Determined Contribution under the Paris Agreement (Chile, 2015),
- The websites and policy databases of the relevant line ministries (climate change, environment, agriculture and energy),
- Chile's latest BUR under the UNFCCC (Chile, 2018),
- The London School of Economics and Political Sciences Climate Change Laws of the World database, and
- The OECD Database on Policy Instruments for the Environment.

This research led to a list of preliminary measures, sorted by sector for each of the ten sectors deemed vulnerable to domestic response measures. These were then narrowed down by labour intensive policy-by-policy check using several criteria, including:

- Deleting duplications
- Policies are direct or indirect climate change policies
- Policies need to be enacted in the 10 sectors identified as vulnerable, or in a closely related sector

The remaining response measures identified were therefore ensured to be both climate change and sector related, that could then potentially have an impact on the identified Chilean sectors of the economy. See Table 9 below for the list of policies identified for the Electric power generation sector (ISIC 3510). The full list of all policies identified for all ten sectors can be found in Annex 4.

Table 9: List of domestic response measures by list of top vulnerable sectors

Code	Sector	Name of policy or measure
3510	Electric power generation	National climate change plan 2017-2022
		Carbon neutrality pledge
		National energy agenda (Energia 2050)
		Law 19.657
		Law 19.940
		Law 20.780
		Law 20.698
		Law 20.571
		Law 20.257 (NCRE Act)
		Law 20.365
		Solar Strategic Program
		Energy roadmap 2018-2022 (Ruta energetica 2018-2022)
		Coal phase out
		Net billing law
		Energy Efficiency Action Plan (PAE2020)
		Energy Efficiency program in public buildings (PEEP)
		Energy Strategy 2015
		Renewable energies for self-consumption
		Mitigation plan for the energy sector

Source: Authors' own elaboration

6.3. Stakeholder Consultation

These results were checked with local Chilean stakeholders through a stakeholder consultation in Santiago de Chile in August 2019. Meetings were held to engage with stakeholders from academia, private and public sector. This was done through workshops where the methodology and the main findings were presented, followed by requests for input and feedback, as well as inviting stakeholders to identify other Chilean policies and other potentially negative impacts on their sector.

During this stakeholder consultation, no policies were raised that the research team had missed. Therefore, the list was not altered.

7. Impacts of response measures

The previous steps focused on identifying vulnerable sectors and relevant response measures. This step concentrates on analyzing the possible impacts of the mapped response measures on the identified vulnerable sectors.

Policies can have both positive and negative impacts, for example, a shift to renewable energy away from fossil fuels could have negative impacts on fossil fuel exporters, but positive impacts for countries exporting raw materials and technologies necessary for deploying renewable energy systems and batteries. Chile, as a major exporter of copper and lithium, could see potentially strong positive impacts from a global transition to renewable energy for that reason.

It is up to a country's discretion whether to include positive as well as negative impacts when using this methodology for BUR reporting. An overview of potential positive and negative impacts can be seen below in Table 10.

Table 10: Overview of possible positive and negative impacts of types of response measures

Type of response measures	Impacts in country undertaking the response measure	Possible impacts in other countries
Carbon taxes	decreased demand for carbon-emitting goods; increased demand for low-carbon emitting goods	- Negative effects: fossil fuel producers. + Positive effects: low-carbon goods (e.g., renewable energy/EV components)
Subsidies		
… for low-carbon transport	decreased demand for goods associated with internal combustion engines.	- Negative effects: producers of fossil fuels, lead. + Positive effects: producers of EVs, cobalt, lithium, vanadium.
… for low-carbon energy production	decreased demand for thermal fuels	- Negative effects: coal, natural gas, oil producers. + Positive effects: low-carbon energy technology (e.g., PV solar cells)
… removal of, for fossil fuel production	decreased production of fossil fuels	- Negative effects: fossil fuel consumers. + Positive effects: fossil fuel producers.
… removal of, for fossil fuel consumption	decreased consumption of fossil fuels	- Negative effects: fossil fuel producers. + Positive effects: fossil fuel consumers.
… for energy efficiency in buildings	decreased energy consumption	Effects depend on fuel source used in implementing country buildings. If fossil fuels used: - Negative effects on producers; + Positive effects on consumers.
Green procurement		
of energy	decreased demand for thermal fuels, increased demand for low-carbon energy technologies	- Negative effects: coal, natural gas producers. + Positive effects: coal and natural gas consumers (price decrease), producers of alternative energy tech.

of automobiles	decreased demand for goods associated with internal combustion engines.	- Negative effects: fossil fuel producers. + Positive effects: cobalt, lithium, vanadium producers, EV producers.
Cap and trade schemes	decreased demand for carbon-intensive goods; increased demand for low-carbon goods	- Negative effects: fossil fuel producers. + Positive effects: renewable energy/low-carbon transport tech producers; fossil fuel consumers.
Liberalization of trade in environmental goods	boost in consumption of green goods	+ Positive effects: producers of covered environmental goods
Border carbon adjustment	decreased demand for high-carbon goods (aluminum, steel, cement, plastics, pulp & paper); increased demand for substitutes.	Depends on carbon intensity, and regime details, but likely: - Negative effects: aluminum, steel, cement, plastics, pulp & paper. + Positive effects for low-carbon producers.
Standards and labelling requirements		
for agricultural goods, involving GHG emissions	depends on details of the scheme, but likely loss of market share for non-certified air-freighted goods, inter alia.	Depends on details of the scheme, but possible: - Negative effects for producers of perishable fruits such as berries, high-value horticulture
mandatory efficiency performance standards for consumer goods, industrial equipment	restricts the market to high-efficiency products; reduces demand for fuel	- Negative effects: fossil fuel producers; producers of low-efficiency consumer goods and industrial equipment. + Positive effects: fossil fuel consumers; producers of high-efficiency goods/equipment
International aviation levies	n/a - international	- Negative effects: flight-based tourism sectors (e.g., hotels, restaurants); producers of air-freighted (perishable) goods.
International maritime levies	n/a - international	- Negative effects: increased costs of imports and exports using maritime transport

Source: Authors' own elaboration

Assessing these impacts can be done using both quantitative and qualitative tools.

Robust quantitative tools – such as modelling – have the advantage of providing more insight into the expected types of sizes of the impacts of response measures. They can help quantify the impacts somewhat. However, they are more time consuming and costly to implement. Implementing robust and comprehensive modelling exercises can involve significant budgets, specialized staff and long timeframes in order to build or adapt models to specific local circumstances.

Ideally, a quantitative assessment would be performed for each identified international response measures – focused on the sectors identified before and their role in the overall economy. This assessment should be done before a response measure is implemented (ex-ante) as well as after the functioning of the response measure has started (ex-post). This allows for the predictions obtained through modelling to be tested against real observed impacts.

This is however infeasible to do, not only because of the vast number of potentially impacting response measures, but also because it is very challenging to isolate the impacts of individual policies on global trade, investment and production decisions in the country being assessed.

The goal of the quantitative assessment should be to analyse the consequences of policy-shocks on the economy and trade flows. Using a general equilibrium model can aid in achieving this. This type of analysis looks at the economic system as a whole, whereby the system is recognised as a network with all parts being mutually dependent and in constant interaction. Therefore, any change in the demand or supply of a commodity or its production will set in motion a chain reaction. A change in one sector will reverberate across the wider economy – be it positively or negatively.

A qualitative assessment can also be useful. It can start discussions and highlight areas of concern that might need to be assessed in more detail. This can enable researchers to focus the limited time and budget they have for modelling on the most pressing areas. Qualitative assessments can also help raise understanding of the broader issues at play, and engagement with key stakeholders.

Qualitative assessments can be used to supplement quantitative assessments, by concentrating on a basic description of vulnerability and possible impacts, the causal chain transferring impacts and the main expected positive or negative, intended or unintended impacts. The following section will go into a description into the quantitative and qualitative assessment.

In total four policies were assessed through a quantitative approach: two international policies and two domestic policies. These are:

- IMO carbon tax for international shipping (international policy)
- ICAO CORSIA scheme for international aviation (international policy)
- Chilean coal phase out (domestic policy)
- Chilean national CO2 tax for stationary installations (domestic policy)

Both for domestic and international policies, a limited example qualitative assessment is provided below.

7.1.International Response Measures Assessment

7.1.1. Quantitative assessment of international response measures

The intent of the case study was to test the methodology and methods for assessing impacts. Therefore, the research team did quantify the possible impacts from of a limited number of international policies. Two international policies were chosen for quantitative assessment, other policies were assessed through qualitative tools.

The project's modelling was conducted by Professor Raul O'Ryan from the Adolfo Ibañez University in Chile. Two main international measures were assessed, introduced by two international organisations, the international maritime organisation (IMO) and the international civil aviation organisation (ICAO).

For the quantitative assessment, the ECOGEM CHILE 2 CGE model was used. The model is a multi-sector, recursive-dynamic model based on the OECD GREEN model (Château et al., 2014 and O'Ryan, 2005). It covers the following components: productive sectors or activities, occupational categories, income groups for households, public spending categories, final demand spending, trade partners and different pollution types.

The model is based on the most recent integrated economic data available for Chile, namely the 2013 Social Accounting Matrix (SAM). This describes the circular flow of income and spending in a national economy. Table 11 presents a summary of the characteristics and description of the ECOGEM-Chile 2 model in its current state relevant for this study.

Table 11: Characteristics of the ECOGEM 2 model

Characteristics	Description
Sectors and activities	60 sectors: 26 productive sectors, 7 energy generation sectors (solar, wind, hydroelectricity, coal, oil, gas, and biomass), 27 services (including water, health, transportation among others).
Occupational categories	12 categories: high-, medium- and low-skill disaggregation by gender (Male/Female) and by place (Urban/Rural).
Household income groups	10 deciles: income groups.
Trade partners	35 trade partners: Brazil, USA, China and others and groups of countries or regions (rest of Asia or America and others).
Public finances	Breakdown of taxes and transfers: direct and indirect taxes to businesses, direct taxes on households (income), labor tax, tariffs, VAT and government transfers to households from/to abroad.
Pollution	4 airborne pollutants: Chile's own emission factors have been estimated by sectoral production and final consumption.

Source: elaboration by Prof. O'Ryan

In this model optimization behavior in the production sector is based on cost minimization, where each sector minimizes its costs for each level of production. The following figure presents the nested production structure used that includes various levels.

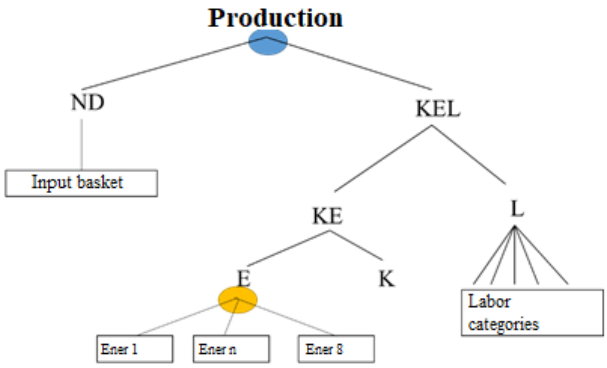
In the tree's first level, a constant elasticity of substitution (CES) function[4] is used to choose between a non-energy-producing intermediate input basket (ND) and a basket (KEL) of inputs that contains production factors – capital (K) and labor (L) – and energy producing inputs (E). It is assumed that there is no substitution between the inputs in the non-energy-producing intermediate input basket ND, i.e. the production is of fixed factors.[5]

[4] This means that the inputs in each branch are substitutes with an exogenous constant elasticity of substitution parameter.

[5] Technically, this means that a Leontief-type function is used.

On the factor side, the capital-energy basket is separated from labor using a CES function, and then energy and capital are split through a new CES function. In this version of the model four electricity generation sectors and four energy sectors are included. This allows for substitution among these sectors to occur, as a result, say, of a tax on emissions of more polluting sectors. See Figure 6 for this overview.

Figure 6: nested production structure used for modelling



Source: Elaboration by Prof. O'Ryan

In the model, households use their income for consumption and savings. Household decisions are modeled assuming a choice is made between consumption and saving in each period.[6] Each household maximizes utility subject to its budget constraint. The final demand is composed of intermediate demands, household demands and the rest, which include investment, government consumption, and trade margins. These are modeled through fixed shares of the total final demand.

To consider business relations with trade partners, imports and exports are modeled. The commodities are differentiated with respect to their destination (sales to the domestic markets or exports) and to their origin (domestically produced commodities or imports). The domestically produced commodity is sold either in the domestic market or the foreign market. Domestic demand originates from domestic and foreign sources.

[6] Technically this is done using an Extended Linear Expenditure System (ELES) utility function. The function used assumes myopic behaviour, so saving enters the utility function, but its determination is based only on contemporary prices (where the price of saving is assumed to be the consumer price index).

These goods are assumed to be imperfect substitutes allowing a break down between demanded goods by place of origin, for example locally produces and imported cars. [7] This allows considering a composite good, i.e. "cars". This composite good is either used as an input into the production process of domestically produced commodities or sold for final demand including private consumption, government consumption and investment.

In addition, to consider the existence of multiple business partners, the model includes two nested CES levels : at the first level, agents choose the optimal combination between nationally produced goods and an imported good; at the second level, agents choose the origin from which they import goods as a function of prices and degree of substitution between regions.

Equilibrium is imposed in all relevant markets. In the labor market, labor supply and demand are made equal for each occupational category. As for the capital market, it is assumed that there is only one type of capital, which can be more or less mobile among the productive sectors. The mobility of capital between sectors is adjusted based on the specific elasticities. The model considers three macroeconomic closures that must always be met: the closure condition for public finances, the external closure (current account of the balance of payments, which includes the equilibrium of the trade balance) and the saving and the investment equality.

The dynamics in the model are obtained solving the equilibrium for each period and connecting period t with t+1 through capital accumulation (i.e investment). Capital is allocated among sectors using the relative rates of return. Consequently, any shock to the economy will change the baseline, affecting the total amount of savings in the economy and thus total investment. It will thus change relative rates of return for each sector, so some sectors will receive more investment vis a vis the baseline, and others less, affecting their production. This in turn affects the labor market, i.e. wages and total amount of labor by labor category and economic sector. Household income will also change as will government revenues.

The main characteristics of the ECOGEM-Chile model are therefore,

(1) A small country model. Consequently, the country is a price taker and any export production will be bought at these prices.
(2) Based on the latest input output matrix for 2013. This is the basis of the Social Accounting Matrix used.
(3) Competitive markets are assumed in each productive sector. Prices and quantities are determined endogenously to clear markets, denoting the models Walrasian nature.

[7] Technically, this implies that trade is modeled using the so-called Armington assumption.

(4) Real term model. Does not include monetary aspects.
(5) Demand functions are based on a process of maximization of utility by consumers. Supply functions assume a maximization of profits by producers.

Key model elasticities are presented in Annex 5, along with GDP growth and depreciation rates, population growth and labor productivity are exogenous for the baseline scenario.

The main goal of the modelling exercise was to show how the impacts of international response measures could be modelled, not to do an exhaustive and comprehensive assessment.

1) Results of quantitative assessment of international policies in Chile country case study

Using the ECOGEM 2 model two main international measures were assessed, belonging to the international maritime organisation (IMO) and the international civil aviation organisation (ICAO).

1. IMO: Possible introduction of a CO2 Tax
2. ICAO: Upcoming introduction of CORSIA

The former has been under discussion for some years in various fora, but as yet there is no clarity on whether and when it might be implemented. The latter is set to be implemented, with the pilot phase is due to start in 2021.

1) IMO: Possible introduction of a CO2 Tax

The ECOGEM 2 model for Chile was adapted by Professor O'Ryan. For the type of model used, any cost increase for a sector needed to be translated into a production cost increase. Ideally, for every major exported product in every sector under assessment the actual potential increased transportation costs due to an IMO CO2 tax would be calculated in detail. This could be done through the following steps:

- Assessing to which countries the products are being transported
- Assessing through which means of shipping each product is transported (Panamax or smaller, bulk carriers, container ships, etc.)
- Calculating the transport costs per unit/tonne of product
- The cost increase per unit or tonne of product due to a CO2 tax on international shipping
- The price elasticity of each product, and the availability of substitutes

This could allow for an approximation of the actual loss of exports and cost increases for each of the products. This translation of an IMO CO2 tax into percentage production cost increases for all countries and all sectors under assessment is a task beyond the budgetary capacity and time constraints the research team is working under.

The IMO tax on CO2 was therefore translated into a production cost increase through a simplified approach. To mimic real life, several checks and variations were introduced in the model:

a) The model was adapted to be able to differentiate in cost increases between various countries and regions. Four countries and regions were defined: Brazil, China, USA, Rest of World (RoW – in practice this mostly represents EU countries). These four regions received a 'distance-weight' where the distance of the country from Chile was included as a factor behind the production cost increases. Brazil, as the closest country received a distance-weight of one, the USA as the second closest country received a distance-weight of two, China and RoW as the most distant regions received distance-weights of 4.
b) Three possible price levels of the IMO tax were modeled: 15, 30 or 50 USD/tonne of CO2. Lloyd's register and UMAS (2017) stated on this highest price level that most shipping companies would be willing to pay 50 USD/tonne of CO2. This way a robustness check is implemented that allows for some comparison between various potential price levels.
c) The nine sectors potentially impacted by the IMO tax (tourism was left out, as an IMO CO2 tax would mostly impact large shipping vessels) were divided in two groups: bulk carried products (copper ore, paper and paper products, coke and petroleum refined goods) and high value goods in terms of density (for example, wines, frozen fish, fresh fruit). The first group was deemed to be significantly more impacted by an IMO CO2 tax than the second group due to differences in transportation costs.

Research by Ricardo- AEA (2018) on impacts of CO2 taxation for shipping indicates that bulk goods (such as iron ore) could see an impact between 0,1% and 4% in terms of transport cost increases, where 0,1-0,3% was the range for a low CO2 tax on shipping, and 3-4% the range for a high tax on CO2. For higher value goods (apparel) this transport cost was estimated at between 0% (low tax) and 0,1% (high tax).

The three price ranges used in our analysis are all three closer to the low range used in the Ricardo-AEA paper. Therefore, the base level for the production cost increase due to a CO2 tax on shipping was set at 0,1%-0,33% for bulk goods, and 0,05%-0,17% for higher value goods. These base ranges were then adapted to reflect the distance-weights and the nature of the main products exported by each of the nine sectors.

These percentages estimating roughly production cost increase related to an IMO CO2 tax were fed into the model.

The international CO2 tax on maritime transport is assumed to increase transport prices for Chilean export products, consequently reducing the final price exporters receive for their products[8]. The impacts of this shock are assessed relative to the ECOGEM-Chile baseline.

This baseline reflects the expected changes in electricity generation shares up to 2050. The assumptions used for average GDP yearly growth rate, population growth, labor force and labor productivity growth rates and net foreign savings as a share of GDP can be found in Annex 5. With this data the model was run, and the CGE baseline for the implementation of an IMO CO2 tax was created.

Macroeconomic impacts

The IMO carbon tax in essence reduces the export prices received by producers by increasing transport costs. Sectors with strong international competition and a low level of product differentiation (such as most commodities) this implies that producers need to match their delivery price with those of other exporters, or risk losing market share. As a result, exporters receive a lower price for their products, impacting negatively and reducing slightly GDP.

The expected overall GDP reduction is limited in for all three potential IMO carbon tax price levels, in 2020 between 0,004% for a 15 USD/tonne tax to 0,012% for 50 USD/tonne. The modeling does indicate that the impacts could increase over time, reaching between 0,01% for a 15 USD/tonne tax and 0,017% for 50 USD/tonne by 2050. Overall, however, this impact should be considered limited.

Table 12: Modelling results - reduction in GDP due to Shipping Tax (%)

	2020	2030	2040	2050
Higher tax rate (50 USD/tonne)	-0.012%	-0.024%	-0.031%	-0.037%
Medium tax rate (30 USD/tonne)	-0.007%	-0.015%	-0.019%	-0.023%
Lower tax rate (15 USD/tonne)	-0.004%	-0.007%	-0.009%	-0.011%

Source: Elaboration by Prof. O'Ryan

[8] The impacts on import prices and consequently inputs to production and consumer goods are not assessed in this exercise.

An interesting extra impact is the depreciation of the Chilean exchange rates: higher export prices and/or lower exports lead to less foreign exchange flowing into the country leading to a depreciation. Again, these impacts should be considered minor, and can be seen in the following table:

Table 13: Modelling results - increase in exchange rates due to shipping Tax (%)

	2020	2030	2040	2050
Higher tax rate (50 USD/tonne)	0.123%	0.103%	0.095%	0.087%
Medium tax rate (30 USD/tonne)	0.075%	0.062%	0.058%	0.053%
Lower tax rate (15 USD/tonne)	0.037%	0.031%	0.029%	0.026%

Source: Elaboration by Prof. O'Ryan

Sectoral Impacts

The impacts on different sectors of the Chilean economy vary across types of sectors.

Among the export sectors identified in Step 4(a), some sectors (copper (ISIC 0729), manufacturing of paper and paper products (ISIC 17), manufacturing of wines (ISIC 1102)) see low negative impacts. The copper sector sees production decrease by 0,213% compared to the baseline scenario in case of a 50 USD/tonne IMO carbon tax. For the manufacturing of wines, the impact is expected to be even smaller (-0,005% decrease in production compared to baseline in 2050 with 50 USD/tonne IMO carbon tax).

Other sectors, such as the agricultural sectors and aquaculture see a limited increase in production levels (respectively +0,017% and +0,043% in 2050 compared to baseline with 50 USD/tonne IMO carbon tax).

There are also expected impacts in sectors that are not directly impacted by the IMO CO2 tax, mostly due to lower copper production and the depreciation of the Chilean peso. These impacts are also minor.

- Small increases in power production through hydro and solar (respectively +0,170% and +0,122% in 2050 compared to baseline with 50 USD/tonne IMO carbon tax).
- Small decreases in power production using petrol and coal (respectively -0,158% and -0,126% in 2050 compared to baseline with 50 USD/tonne IMO carbon tax).

When looking at the impacts of the lower ranges of the potential IMO carbon tax (15USD/tonne and 30 USD/tonne) the impacts are even lower.

Effects on Income

The impact on income is very small in all periods for all income deciles. The minor decreases in household income are due to the minor decrease in GDP discussed previously. In particular the lowest decile is barely impacted (-0,006% in 2050 compared to baseline with 50 USD/tonne IMO carbon tax. For 15 USD/tonne tax: -0,002% in 2050).

The four highest deciles are impacted the most (-0,020% to -0,021% in 2050 compared to baseline with 50 USD/tonne IMO carbon tax. For 15 USD/tonne tax: -0,006% in 2050)

The main goal of the modelling exercise was to show how the impacts of international response measures could be modelled, not to do an exhaustive and comprehensive assessment. Therefore, the decision was made not to invest too much in the preparatory work behind this step. Therefore, for the IMO CO2 tax 'back of the envelope' calculations on cost elasticities for various products and regions were fed into the modelling to show case how such a modelling exercise could work.

Ideally, additional studies would be carried out which will try to get actual figures and estimates on how an IMO CO2 tax could impact the price of shipping for the various goods exported by each of the vulnerable sectors. Studies have already been carried out on the potential impact of a tax on aviation as will be looked at below.

2) ICAO: Upcoming introduction of CORSIA

The second international policy that was modelled was ICAO's international market-based measure, CORSIA, of which the pilot phase will begin in 2021. This aviation policy was seen as a major concern for the Chilean tourism sector due to many of its visiting tourists relying on flights to reach Chile.

CORSIA would lead to increased operational costs for airlines, who would pass these costs on to customers through increased airfares. These increased ticket prices could then disincentivize tourism to Chile – impacting the various services tourists use and reducing revenue for the Chilean tourism sector.

In the general equilibrium model that the research team and its partners used, ECOGEM 2, the tourism sector is not defined as a separate sector in Chile. Rather tourism-related activities (such as hotels, travel agencies, restaurants etc.) are included in other service sectors. This made it

challenging to model the impacts of CORSIA on the tourism sector and the Chilean economy through the model used for the IMO CO2 tax and the domestic policies.

The team instead used non-dynamic estimates and calculations to estimate impacts. The impacts of the policy on ticket price were estimated by drawing on estimated price impacts of including aviation in the EU ETS. CE Delft (2007) estimated the impacts of a €15 and a €45/tonne C02 carbon price, and used several scenarios for regime design. We chose the 100% auctioning model with 100% cost pass through, on the assumption that any international levy will not involve free allocation.

To translate this into impacts, we used the price elasticity for demand for air travel estimated in another analysis of EU options for taxing aviation Scheelhaase and Grimme, (2007), with an assumed breakdown among business class and economy travellers, and short- medium- and long-haul flights. This, coupled with information on foreign non-business arrivals in Chile by air, from the World Tourism Organization (2018) gave us numbers of reduced visits in response to ticket price increases (See Annex 6).

These were then multiplied by weighted average figures from the Statistics of Ministerio de Economía de Chile for length of stay, and expenditure, to derive lost spending, or direct impacts. We derived indirect impacts by disaggregating that spending into the main categories charged in Chile by foreign credit cards, and adapted those categories to fit the 2017 input-output matrix for Chile. The multipliers in that matrix gave us direct and indirect impacts across a number of sectors of the Chilean economy.

There are many assumptions and imperfect proxies underlying that chain of calculations, meaning the final figures are indicative, rather than definitive, but they give an illustrative order of magnitude to help policymakers think about the impacts in question.

Effects on tourism sector

The main effect on the tourism sector is the reduced income for the sector due to a decrease in the number of visitors. Visitors who would not come to Chile would of course no longer spend money there on restaurants, food and beverages, transport, entertainment etc.

The reduction in the number of visitors was estimated exogenously, as described above. Depending on the price increase for each fare, between several hundred (15 EUR price increase) and a few thousand business travellers (30 EUR price increase) would not fly to Chile. The numbers of people coming to Chile for personal reasons (including tourism) would drop by between 2000

(short trip, 15 EUR fare increase) and 15000 (medium trip, 30 EUR fare increase). Again, these are very much indicative numbers. The full estimations can be found in Annex 6.

Using estimates of reductions in visitors and figures from the Chilean Ministry of Economy on average length of stay and average spending per type of trip (see Annex 6), we can estimate the potential reduction in total spending by visitors to Chile if CORSIA would add 15 or 30 EUR to ticket prices. These estimates show that these results could be significant.

Table 14: Estimated reduction in total spending due to 15 EUR price increase of fares

EUR 15							
	Long Trip		Medium Trip		Short Trip		Total
	business	personal	business	personal	business	personal	
Reduction in passengers	318	2,804	455	3,696	529	1,978	**9,780**
Reduction in spending (USD)	511,195	3,315,847	623,708	4,116,311	470,052	1,022,852	**10,059,965**
Reduction in total spending by passengers (thousand million pesos)	0.35	2.24	0.42	2.79	0.32	0.69	**6.81**

Source: Authors' own elaboration

Table 15: Estimated reduction in total spending due to 30 EUR price increase of fares

EUR 30							
	Long Trip		Medium Trip		Short Trip		Total
	business	personal	business	personal	business	personal	
Reduction in passengers	1,718	11,471	2,456	15,120	2,859	8,093	**41,717**
Reduction in spending (USD)	2,761,739	13,564,935	3,366,653	16,839,456	2,540,414	4,185,004	**43,258,200**
Reduction in total spending by passengers (thousand million pesos)	1.87	9.18	2.28	11.40	1.72	2.83	**29.28**

Source: Authors' own elaboration

We derived indirect impacts by disaggregating that spending into the main categories charged in Chile by foreign credit cards (see Annex 6), and adapted those categories to fit the 2017 input-

output matrix for Chile. The multipliers in that matrix gave us direct and indirect impacts across a number of sectors of the Chilean economy.

Direct impacts of reduced spending from travellers.

The main direct impacts are to be found in reduced spending by travellers in the retail sector (-3,1 billion Chilean pesos for 15 EUR fare increase and -13,3 billion Chilean pesos for 30 EUR fare increase), hotels, (resp. -1,4 and -6,2 billion Chilean pesos) air transport (resp. -0,7 and -3,1 billion Chilean pesos), restaurants (resp. -0,6 and -2,7 billion Chilean pesos) and entertainment and recreational activities (resp. -0,5 and -2,4 billion Chilean pesos).

The total of the direct effects across the 60 sectors in the model is a decrease in spending of 6,81 billion Chilean pesos (EUR 15 fare increase) and 29,28 billion Chilean pesos (30 EUR fare increase).

Indirect impacts of reduced spending from travellers.

There are minor indirect impacts on other sectors, especially due to multiplicative effects. If hotels see their turnover reduced, they might hire less staff. This would have the multiplicator effect that there is less hotel staff spending their own wages throughout the Chilean economy.

These indirect impacts are however minor in the case of a 15 EUR increase in ticket fares. This quantitative approach indicates that spending would decrease on Real estate activities (-0,56 billion Chilean pesos), Administrative and support activities (-0,37 billion Chilean pesos), and Wholesale trade (-0,37 billion Chilean pesos). The total of the indirect effects across the 60 sectors in the model is a decrease in spending of 4,58 billion Chilean pesos in the case of a 15 EUR fare increase.

In case of a 30 EUR fare increase, the indirect impacts are, however, more significant. This quantitative approach indicates that spending would decrease on Real estate activities (-2,4 billion Chilean pesos), Administrative and support activities (-1,6 billion Chilean pesos), and Wholesale trade (-1,6 billion Chilean pesos). The total of the indirect effects across the 60 sectors in the model is a decrease in spending of 19,71 billion Chilean pesos in the case of a 30 EUR fare increase.

7.1.2. Qualitative assessment of international response measures

The qualitative assessment of the impacts of the implementation of response measures, as carried out in the Chile country case study, follows many of the same steps followed in the quantitative

assessment. In fact, the methodology is identical until the step at which the analysis assesses the impacts of the identified response measures on the vulnerable sectors of the economy (Step 8).

At this point, the qualitative assessment seeks to identify the full range of impacts that might ensue from the implementation of the existing or possible response measures. That full range could include both positive and negative impacts, and it would include impacts in three categories: social (for example, job losses/gains, retraining, indigenous rights, democratic aspects), economic (for example, changes in trade flows or production, growth/reduction in different sectors, competitiveness), and environmental impacts (for example, water use and pollution, biodiversity, air quality, deforestation, land use change, GHG emission reductions).

But in contrast to the quantitative approach, it seeks to assess these impacts based on a survey of the relevant literature, usually arriving at predictions of the vector of impacts, but not the magnitude.

While it is incapable of predicting magnitude of impacts, and unable to match general equilibrium models in understanding ripple effects throughout the economy (such as exchange rate impacts, downstream impacts), the qualitative approach is a useful complement to a quantitative analysis, since it can predict effects that are not easily identified in modelling results.

Social impacts are particularly difficult for modelling to predict, other than income effects. Regional impacts are also difficult, particularly when they are modulated by regionally specific circumstances (e.g., over-dependence on a particular economic activity). It is also difficult for models to predict second and third-order impacts, such as the environmental impacts arising from socio-economic changes (e.g., decreased pressure on biodiversity as a result of poverty alleviation).

Ideally, a qualitative assessment would consider those sorts of impacts for each of the identified response measures – those measures that major trading partners have taken with potential impacts on the sectors identified as vulnerable through the previous stages of the methodology.

Pragmatically, the assessment should instead concentrate on a more limited number of cases, focusing on those with the greatest potential impacts on the most significant sectors. What follows is a brief illustration of how such an analysis would be carried out, building on the work described above in identifying vulnerable sectors and significant response measures. It focuses on two cases: the impacts of possible IMO mandated reductions in shipping speed on export of fruit, and the impact of support measures for electric vehicles on export of copper.

A. IMO mandated reductions in shipping speed

The second most significant vulnerable sector identified in the Chilean case study is edible fruits and nuts, of which grapes are a significant part. A scan of the types of measures that might impact this sector (see Table 12: Overview of possible positive and negative impacts of types of response measures) turns up such response measures as carbon-based standards and labelling of agricultural goods, and climate-related international restrictions or levies on air and maritime transport. The response measures identified in our scan does include the latter type of measure, and three of them were assessed by quantitative analysis: CORSIA, a maritime carbon tax, and restrictions in maritime shipping speeds. To illustrate the type of analysis covered by a qualitative approach, we will assess the last of these.

One of the candidate short-term measures listed in the IMO's adopted Strategy on Reduction of GHG Emissions, which aims to reduce total GHG emissions from shipping by 50% by 2050 compared to 2008, is: "Consider and analyse the use of speed optimization and speed reduction as a measure" (IMO, 2018). Indeed, Faber et al (2017) estimate that a speed reduction of just 10% would reduce those emissions by 13% - a significant distance toward the ultimate goal.

The final measure itself is not yet decided, and it is not certain that it will be, but it remains a one of the most likely options, given its strong emissions reduction potential, and the lack of need for costly and time-consuming capital investments (CSC, 2017). For the sake of the analysis a single rate could be chosen, such as 10%, or several scenarios could be used.

Environmental impacts would primarily consist of the estimated reduction in GHG emissions, and the reduction in climate change impacts this might imply for Chile. The 13% figure cited above is one such estimate, and the authors also provide estimates for 20% and 30% speed reduction scenarios. Another environmental impact is reduced whale strikes. Leaper (2019) estimates that a 10% reduction in speed across the global fleet would result in 50% fewer whale strikes. He also notes that a 10% reduction in speed would reduce the total sound energy from shipping—an important problem for many marine mammals—by 40%. Chile hosts an annual migration of blue, humpback and grey whales moving along its coast heading south to feed, so these impacts would be nationally important.

Economic impacts: Our consultations with Chilean exporters leads us to believe that a slower global fleet may also make some markets for perishable fruit – specifically the Chinese market – much less viable. A full analysis would estimate the number of extra days shipping involved with various scenarios of slow-down, and assess whether that implied not just increased costs, but actually a full loss of market for specific exports, and would assess direct and indirect costs of such

a loss to the Chilean economy. It would also assess the possibilities for crop switching, or switching mode of transport.

Social impacts: Following on the economic analysis above, it would be important to understand better whose jobs might be lost (i.e., in what region/sub-sector) in fruit production, and how many.

B. Support measures for electric vehicles

Only one sector was ranked more significant in our analysis, and that was copper ores and concentrates. This is Chile's largest single sector in terms of value added. A scan of the possible response measures that might affect this sector turns up a wide variety of support measures for electric vehicles, primarily including subsidies to consumers. These sorts of measures are important for fostering wider and more rapid dissemination of electric vehicles. Bloomberg (2019) charts a rise in sales from a few thousand in 2010 to 2 million in 2018, and predicts exponential growth in future sales, rising to 10 million by 2025 and 56 million by 2040. This kind of increase in sales has important implications for demand for copper, since the average EV uses roughly 80 kg of copper, or four times as much as a comparable internal combustion vehicle. By one estimate, characterized as conservative in its assumptions of EV uptake, copper demand would increase 10 – 15% by 2030 as a result (CRU, cited in Jamasmie, 2018).

As an aside, it is worth noting that demand for lithium, used in EV batteries and found in abundance in northern Chile, is estimated to increase over the same period by 80% (ibid). A full qualitative analysis would consider this dynamic, lithium being the highest value component of the fifth most significant sector identified: "Basic chemicals, except fertilizers and nitrogen compounds."

Environmental impacts: Copper extraction and processing is an energy- and water-intensive process, and increased demand for copper would entail more of these sorts of impacts in the Chilean context. A full qualitative analysis would estimate the impacts of increased demand in terms of energy use, resulting air pollution and GHG emissions, and increased water use, especially in water-scarce locations in the Northern high desert.

Economic impacts. Calculating these would involve first estimating the impacts of subsidies on demand for EVs. Jenn et al (2018) estimate in the US context that each $1,000 in subsidy for an electric vehicle equates to a 2.6% increase in sales. The next calculation would involve translating that into global increases in demand for copper, and scaling that down to a picture of the impact for Chile, a world leader in copper responsible for roughly a quarter of global production.

Social impacts. The social accounting matrix for Chile could then be used to show the increase in direct and indirect employment that could be expected as a result of increased demand for copper.

The two cases above illustrate a range of assessment possibilities, showing both positive and negative impacts of measures adopted at national and international levels, applied to actual and possible response measures. While a full qualitative assessment of these and other impacts is beyond the scope of the present exercise, this brief discussion is intended to show the basic methodology that would be used in a more in-depth assessment of the impacts of the implementation of response measures for Chile.

7.2. Domestic Response Measures Assessment

In this step, the domestic impacts of domestic response measures are assessed. The same discussion and caveats with respect to quantitative versus qualitative analysis as the assessment of the potential impacts of international response measures are valid here, and will not be repeated again. Instead, the focus in this section will be on how impacts of domestic policies were assessed in this country case study.

7.2.1. Quantitative assessment of domestic response measures

1. Domestic coal phase out

The Chilean government announced a coal phase out by 2040 in June 2019 (Bloomberg Environment, 2019), which would put the country firmly on the path towards carbon neutrality. This example was chosen for the modeling exercise as it is a major climate mitigation policy, that was recently announced, and could have significant positive and negative impacts across the Chilean economy.

In order to assess the economic, social and environmental impacts of any policy, the modelling team compared the baseline values of the variables of interest with the values of these same variables after the shock is imposed. Consequently, what is relevant is the magnitude and direction (increase or decrease) of the change in each of the variables.

To assess the impacts of a coal phase out throughout the generation sectors we first define an initial baseline trajectory for electricity generation and then apply the shock. The current version of the CGE model cannot endogenously impose a coal phase out shock. For this reason, it was necessary to impose the shock exogenously. This requires first defining a baseline model that replicates the expected shares of each generating source.

For the shock it was necessary to run a simulation imposing the new generation shares for coal phase out. The impacts of these generation shares on the economy are then assessed.

To construct the GCE baseline scenario, it is necessary to make assumptions on the evolution of the electricity generating sector as well as key macroeconomic parameters. Over the last few years, electricity generation from Non-Conventional Renewable Energy (NCRE) sources has grown extraordinarily fast. Five years ago, the share of NCRE in total installed power capacity accounted for only 5%, whereas it has reached 22% in September of 2019. This structural change in the electricity sector is expected to continue in the future. To incorporate this structural change into the ECOGEM baseline CGE model – and consequently adequately capture the expected energy matrix in the next decades – it is necessary to have a scenario for the development of the power generating sectors in Chile.

The energy scenario used is based on the prospective long-term energy planning scenarios built by the Chilean Energy Ministry (2017) using a bottom-up modelling approach up to 2046. In that exercise, five scenarios (A through E) were assessed, considering different assumptions on energy prices, technology costs and penetration, and social and environmental acceptability.

For this modelling effort Scenario C was chosen, which is closest to what experts and officials from the Energy Ministry currently think will be the energy shares in the future. This scenario assumes the following characteristics for key factors that determine power demand and shares for each generation source.

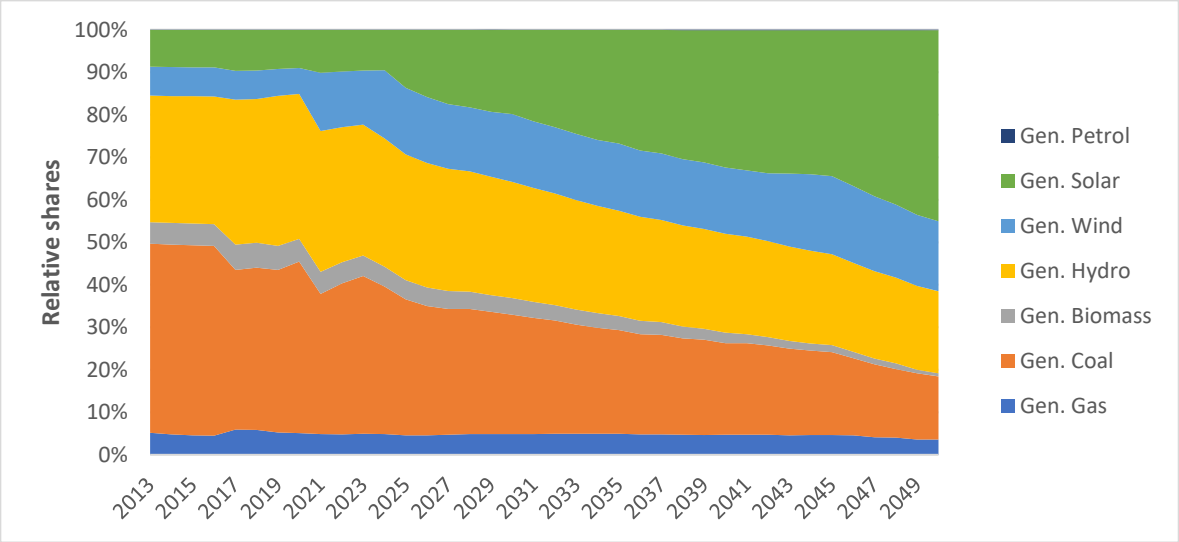
Table 16: overview of Scenario C from Chilean Ministry of Energy long-term energy planning scenarios

FACTORS	EXPECTED VALUE
Social acceptability of projects	Low
Energy demand	Medium
Technological change in battery storage	Current
Inclusion of environmental externalities	Current
Investment costs for renewable technologies	Medium
Fossil fuel prices	Low

Source: Chilean Energy Ministry (2017)

These factors determine electricity demand and shares. Coal is expected to fall from a 38% share in electricity generation in 2019 to 20% in 2040 and 15% in 2050, whereas solar and wind increase from a 15% share in 2019 to over 60% in 2050 (see Figure 7).

Figure 7: Baseline electricity generation shares for various technologies

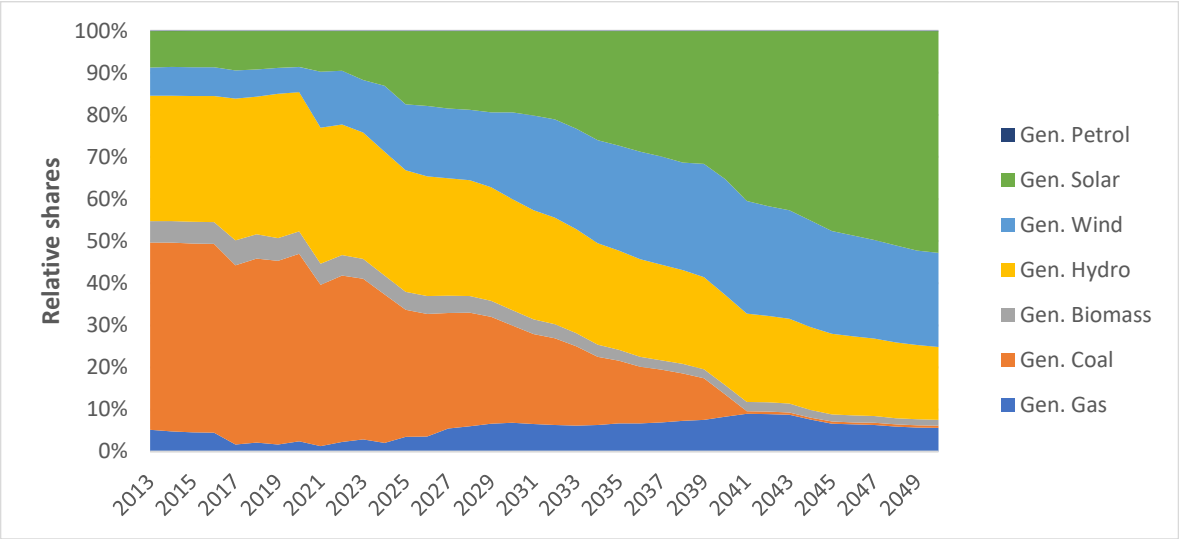


Source: Elaboration by Prof. O'Ryan

Following the shares proposed in that scenario, as well as the total energy generation each year, the yearly shares presented in the next figure were imposed on the ECOGEM model for the seven electricity generating technologies. Technically this requires two steps. First changing the endogenous AEP parameter in the model that determines the share of each electricity sector input used by each economic sector, to the shares that are required by the external energy scenario. Total electricity demand is then adjusted to the total value required according to the external model using the capital efficiency parameter of each generating sector λ_k.

Finally, as discussed above, to construct the CGE baseline scenario the assumptions presented in Annex 5 have been made on average GDP yearly growth rate, population growth, labor force and labor productivity growth rates. With this data we run the model and obtain the CGE baseline.

Figure 8: Electricity generation shares for various technologies – with coal phase out



Source: Elaboration by Prof. O'Ryan

Note: For technical reasons coal generation is not reduced to zero, but comes very close to zero.

The main impacts of the modelling of the coal phase out, and the changes in sources of electricity are presented below.

Economic and environmental impacts

Imposing the coal phase out increases the price of electricity. Therefore, the economy becomes more inefficient, reducing GDP slightly across all periods compared to the baseline scenario. The impact on GDP is higher when the policy is initially applied and less after 2040.

Table 17: Modelling results – impacts on GDP of coal phase out

	2020	2030	2040	2050
Change in GDP	-0,13%	-0,13%	-0,12%	-0,05%

Source: Elaboration by Prof. O'Ryan

However, the coal phase out has a significant impact on GHG emissions. This reduction is significant, and adds almost 8% in 2040 to the baseline scenario.

Table 18: Modelling results – impacts on GDP of coal phase out

	2020	2030	2040	2050
Change in CO2 emissions	0,88%	-2,37%	-7,78%	-7,18%

Source: Elaboration by Prof. O'Ryan

Sectoral Impacts

The modelled coal phase out has a variety of impacts across sectors of the Chilean economy. As expected, the small coal production sector and coal generation sectors are very negatively affected.

Also, sectors very dependent on electricity decrease their production, notably the copper and mining sectors. Wind and solar electricity make up for most of the loss in coal generation. Other non-energy economic sectors benefit, for example fishing.

The sectors with the largest relative change include sectors with very low production in the baseline (minor absolute changes result in large relative changes), such as coal production, biomass generation and gas generation.

Table 19: Modelling results – sectoral impacts of coal phase out, showing percentage increase/decrease in production in a number of sectors relative to the baseline scenario.

Sector	2020	2030	2040	2050
Agriculture (including grapes and other fruits) (ISIC 0121-0126)	0,07%	-0,01%	-0,04%	0,04%
Aquaculture (ISIC 032)	0,01%	-0,07%	-0,13%	-0,02%
Fishing (ISIC 031)	0,09%	-0,03%	-0,09%	0,03%
Coal production	2,45%	-8,92%	-31,28%	-33,51%
Copper (ISIC 0729)	-0,46%	-0,42%	-0,47%	-0,34%
Paper products	-0,28%	-0,19%	-0,09%	-0,01%
Gas generation	-48,17%	66,86%	105,53%	84,60%
Coal generation	-0,46%	-21,93%	-71,12%	-95,79%
Biomass generation	-7,48%	-10,87%	-8,30%	63,04%
Hydro generation	-10,18%	-10,06%	-13,58%	-16,02%
Wind generation	-9,44%	20,67%	66,82%	28,46%
Solar generation	-11,97%	-9,96%	1,18%	9,24%
Petrol generation	-3,50%	-3,57%	-3,23%	-2,90%

Source: Elaboration by Prof. O'Ryan

Effects on Income

Income falls in all periods for all income deciles as a direct consequence of the fall in GDP. The impacts however are somewhat lower for the lowest decile (hh1) and the highest decile (hh10).

Table 20: Modelling results – household income impacts of coal phase out for 10 deciles, showing percentage decrease relative to the baseline scenario.

Deciles	2020	2030	2040	2050
hh1	-0,05%	-0,07%	-0,12%	-0,08%
hh2	-0,10%	-0,15%	-0,26%	-0,17%
hh3	-0,12%	-0,17%	-0,29%	-0,18%
hh4	-0,13%	-0,18%	-0,30%	-0,19%
hh5	-0,13%	-0,19%	-0,31%	-0,19%
hh6	-0,13%	-0,19%	-0,30%	-0,19%
hh7	-0,13%	-0,18%	-0,29%	-0,18%
hh8	-0,13%	-0,17%	-0,25%	-0,16%
hh9	-0,13%	-0,16%	-0,22%	-0,14%
hh10	-0,12%	-0,14%	-0,18%	-0,12%

Source: Elaboration by Prof. O'Ryan

2. Domestic CO2 tax

Law 20.780 in 2014 implemented a CO2 tax of 5 USD/tonne of CO2 emitted by large stationary sources in Chile (Chile, 2014). Installations with a thermal power greater than 50 MW in the power and industry sectors are covered by the tax.

However, independent research has indicated that the level of the tax is insufficiently high to incentivize significant GHG mitigation action by the operators of these installations. Mardones and Flores (2017) conclude that in its current form the CO2 tax serves more to raise tax revenue rather than incentivize emission reductions.

Therefore, in light of Chile's pledge of carbon neutrality by 2050 it seems possible the level of the CO2 tax will be revisited. The research team chose to therefore focus on levels the current tax could be increased to, with three possible levels (15, 30 and 50 USD/tonne of CO2) chosen to provide some robustness checks and the ability to compare the potential outcomes of three possible price levels.

Ideally, each of the identified response measures in all of the sectors deemed vulnerable would have been assessed on a quantitative basis. assessment would have been undertaken for each of the identified domestic response measures again using quantitative analysis through ex post empirical work by concentrating on the data series of the economic activity of the sector before, and after the operationalization of the domestic response measure, in order to measure the possible national impacts.

For carrying an assessment, again the same model was used. The scenario simulated a tax on all CO2 emissions, that will increase the relative cost of using more polluting energy sources. The model endogenously finds a new equilibrium where the sectors that use polluting sources substitute away from them, or reduce their production. The impact will be determined by the importance of the cost of the different types of energy and the substitution elasticity associated to the energy sources. The model imposes the tax on all CO2 emissions from a variety of sectors, not only those covered by the currently implemented CO2 tax.

To assess the economic, social and environmental impacts of this tax, the results were compared with the results of the baseline. In this baseline, there is a CO2 tax that started in 2018, with a value of 5 USD per ton of emitted CO2.

As in the previous exercise, it was necessary first to create a baseline that replicates the expected shares from the Energy Ministry's Scenario C discussed above. However, this must be done without having to impose these shares exogenously, as in the case of coal phase-out. This allowed the shares to adjust endogenously as a tax on CO2 is applied. This was done by exogenously imposing capital efficiency values by trial and error to the energy generating sectors, as in the case of the IMO tax.

A tax with values of 10, 30 and 50 USD per ton of CO2 was simulated starting in 2020. It is expected that this higher tax should reduce emissions of CO2, but GDP will be affected by this tax, as well as specific sectors.

Macroeconomic and environmental impacts

Imposing a CO2 taxes increases the price of energy, but reduces CO2 emissions. The increase in energy prices comes with a cost to GDP growth, as shown in the next table.

Table 21: Modelling results – GDP impacts of various levels of CO2 tax (%), relative to the baseline scenario.

	2020	2030	2040	2050
50 USD	-0.062%	-0.140%	-0.263%	-0.417%
30 USD	-0.030%	-0.137%	-0.259%	-0.332%
15 USD	-0.010%	-0.083%	-0.164%	-0.184%

Source: Elaboration by Prof. O'Ryan

As mentioned before, the tax forces a reduction on CO2 emissions. This impact increases with the level of the tax. The largest impacts are in 2040, where a 15 USD tax will result in a 12% reduction, whereas a 50 USD tax reaches a 31% reduction in CO2 emissions.

Table 22: Modelling results – CO2 emission impacts of various levels of CO2 tax (%), relative to the baseline scenario.

	2020	2030	2040	2050
50 USD	-11.2%	-32.3%	-30.7%	-23.3%
30 USD	-7.8%	-24.1%	-22.8%	-16.2%
15 USD	-4.0%	-12.5%	-11.6%	-8.1%

Source: Elaboration by Prof. O'Ryan

Sectoral Impacts

Increasing the current CO2 tax has different impacts on different sectors of the economy.

The sectors that are directly impacted (they emit CO2, and therefore pay the tax) include the refining of fuels sector and the supply of gas and steam sector. None of these sectors are among those considered vulnerable throughout this methodology. One section of the power generation sector (petrol-fueled generation) also sees major impacts (see Table 23).

Table 23: Modelling results – impacts on production from petrol-fueled power generation sector (% of production), relative to the baseline scenario.

	15 USD CO2 tax				30 USD CO2 tax				50 USD CO2 tax			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
Petrol-fueled power generation	-12,1	-29,3	-43,9	-62,6	-23,7	-49,0	-69,3	-86,8	-37,5	-66,9	-84,4	-94,6

Source: Elaboration by Prof. O'Ryan

There are also sectors that are impacted indirectly, most relevant are paper production and wind and solar electricity production. The former is impacted negatively, as the cost of using dirtier fuels increases, the latter two sectors see their competitiveness improve as they do not have to pay the tax – unlike their competitors.

Table 24: Modelling results – impacts on sectors impacted indirectly (% of production), relative to the baseline scenario.

	15 USD CO2 tax				30 USD CO2 tax				50 USD CO2 tax			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
Wind generation	3,1	13,3	30,5	44,5	6,3	27,8	70,5	106,5	10,1	40,8	105,4	163,3
Solar generation	2,9	19,9	29,9	23,7	5,9	41,7	64,5	57,6	9,4	59,6	92,4	98,3
Paper products	-0,5	-0,3	-0,2	-0,1	-1,3	-0,8	-0,6	-0,4	-2,3	-1,7	-1,3	-0,8

Source: Elaboration by Prof. O'Ryan

Effects on Income

The impacts of the CO2 tax on incomes is minor when compared to the impacts on some specific sectors (see previous section). Despite the decrease in GDP, incomes actually increase over all deciles compared to the baseline scenario.

One possible explanation for this is that as energy and labor are substitutes to a certain degree in the model, higher energy prices leads to energy being substituted with labour – increase employment and wages.

Table 25: Modelling results – impacts on household incomes across deciles (%), relative to the baseline scenario.

	15 USD CO2 tax				30 USD CO2 tax				50 USD CO2 tax			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
HH1	0,01	0,14	0,3	0,4	0,03	0,29	0,66	0,89	0,04	0,44	1,01	1,42
HH2	0,04	0,3	0,63	0,81	0,08	0,62	1,36	1,8	0,12	0,96	2,07	2,85
HH3	0,04	0,34	0,71	0,92	0,1	0,71	1,54	2,04	0,15	1,09	2,36	3,24
HH4	0,05	0,35	0,75	0,98	0,1	0,75	1,64	2,18	0,16	1,15	2,51	3,46
HH5	0,05	0,36	0,78	1,01	0,11	0,77	1,69	2,26	0,17	1,19	2,6	3,59
HH6	0,05	0,36	0,78	1,03	0,1	0,76	1,71	2,3	0,16	1,18	2,63	3,67
HH7	0,04	0,35	0,78	1,04	0,1	0,76	1,72	2,33	0,16	1,08	2,65	3,72
HH8	0,04	0,33	0,75	1,02	0,09	0,71	1,66	2,29	0,14	1,11	2,57	3,67
HH9	0,03	0,30	0,71	0,99	0,07	0,65	1,59	2,23	0,12	1,04	2,47	3,6
HH10	0,02	0,26	0,67	0,95	0,05	0,59	1,51	2,17	0,08	0,94	2,35	3,52

Source: Elaboration by Prof. O'Ryan

7.2.2. Qualitative assessment of domestic response measures

As noted above, qualitative assessment would follow the same steps as used in pursuing quantitative assessment, until reaching the assessment of the impacts. Qualitative assessment of the two domestic policies examined in this case study was not undertaken, as the quantitative assessment yielded satisfactory results, but were such an assessment to be undertaken it would involve analysis of the social, economic and environmental impacts of the measures in question.

For domestic coal phase out, a social lens would ask what segments of the Chilean population would be affected by direct job loss (e.g., in the coal sector), whether this would entail specific regional hardships, and would try to characterize that group's education level (potential for retraining) and demographics. It would also consider projected human health benefits – one of the major upsides to phasing out the use of coal as a generating fuel. An economic lens would consider the costs (or savings) of transition and competitiveness implications for major energy-using producers, such as the mining sector in which mines such as BHP's Escondida and Spence have already transitioned to renewably-generated electricity. An environmental lens would explore the GHG emissions avoided by the policy, relying on projections from the Government of Chile and other analysts.

A qualitative assessment of the domestic carbon tax would survey the literature on the subject, including Government of Chile projections, to explore the impacts of the current design of the tax, as well as alternatives such as the higher-tax scenarios examined in our quantitative research.

From a social perspective, it would be important to understand where jobs would be created and lost, including net impacts. From an economic perspective, it would be important to know the nature of the cost increases that such a tax implies for electricity prices, and costs for covered large industrial producers. From an environmental perspective, the assessment would explore the effectiveness of the tax in inducing fuel switching in the covered sectors, and the associated GHG emission reductions.

8. Tools to Address Impacts

The adverse and unintended impacts of climate change policies need to be identified and quantified in order to be understood. They also need to be addressed and managed to support the transition to a low-carbon society in a sustainable way.

As this case study aims to support the global transition, it seeks to also highlight whether domestic tools and international cooperative approaches to mitigate impacts are available and adequate. This section highlights any domestic tools and international cooperative approaches that are

helping or could help the country address the impacts of the implementation of response measures as much as possible.

This step is important for reporting under BURs and BTRs, as countries can highlight which support they could use with respect to addressing impacts.

Many countries have domestic tools available, even if they are not necessarily geared towards addressing the impacts of response measures. However, the discussion on international cooperative approaches is still in its early phases – even if international approaches could be particularly well suited to mitigating the impacts of international policies.

The previous sections of this report could help support a more in-depth discussion on addressing impacts, both at the national and international level, as they can help inform stakeholders about which sectors are most vulnerable, which policies have the biggest potential impacts and how those impacts could materialize across the country. This can help provide understanding on what types of tools might be necessary, which areas of the economy they should focus on and how large the impacts are that these tools might need to address.

Any unforeseen, and unintended adverse impacts of climate change mitigation policies need to be assessed earlier rather than later, in order to ensure that the tools and measures for their mitigation have been identified and prepared, ultimately enhancing efficient policymaking, decreasing the overall potential costs and ensuring buy-in for the low-carbon transition is not lost among stakeholders.

At the moment, the discussion on tools to address impacts are very much in a qualitative stage, as those climate change policies that can be considered stringent are either very young or being implemented. However, as the global transition picks up speed – as it should in the coming decade – the impacts of response measures could increase in step with the policy response to climate change. If policies are not well implemented and designed, this could bring the impacts of response measures to the top of political agendas.

It is therefore important to already assess which tools (domestic or international) countries could need and use, so that these tools can be prepared for when they will be really needed.

Impacts can be identified and quantified ex-ante and ex-post, and impacts can be addressed ex-ante and ex-post.

An ex-ante tool for addressing impacts is designing or adapting the policy to mitigate some impacts. Policy design can have a large impact on whether a response measure has unintended negative impacts, how and for whom they arise. Ex-ante tools can be considered to be a form of

risk management. They ensure that the identified adverse impacts of a policy or action are prevented. These tools are at times already a part of the response measure, built into its framework.

Both the ICAO and IMO in the development of their market-based mechanisms (MBMs) held discussions on the inclusion of measures to mitigate the impacts of these MBMs. This included *de minimis* thresholds for inclusion in CORSIA and slower compliance timetables for developing or vulnerable countries, offset mechanisms and recycling revenues.

Ex-post mitigation tools address impacts after they have materialised. This means the tools can be more precise and effective by addressing only the observed impacts. This decreases the risk of not fully addressing the impacts or overshooting the mitigation.

8.1. International Mitigation Tools

At the international level, there is the possibility of support through international cooperative approaches. These tools can assist the country when mitigating the negative impacts of their transition. They include financial aid and capacity building, both can play a large role assisting jurisdictions to tackle negative impacts from outside their own jurisdiction.

The primary international tool used to mitigate impacts, especially for developing countries, is *financial aid*. A lack of funding has been continually identified as adding to the challenge of implementing ambitious climate change policies and projects, and managing the impacts of those policies, in developing countries. A clear example of this, are the conditional-upon-funding measures Parties submit in their NDCs under the Paris Agreement, with more than half of all NDCs including these conditional components (ecbi, 2018).

These international tools and approaches may operate at a regional or global level. Examples of such tools and approaches are the Technology Mechanism, the Green Climate Fund, the Adaptation Committee, the Capacity Building Framework and the REDD+ Framework. A number of these international tools are considered to be underutilised.

As discussed above, another vital tool is the built-in measures many of the international measures have in place, such as offset mechanisms, de minimis thresholds and a slower phase-in for developing and vulnerable countries. This aids in minimising the adverse impacts of international climate change policies for those countries that are deemed to be the most vulnerable.

8.2. Domestic Mitigation Tools

Possible domestic tools to mitigate the unintended and adverse impacts of climate change policies include cost alleviation, domestic safety nets, worker training/retraining and adjustment programmes and economic diversification efforts.

An example of a cost alleviation tool are the free allocations given out under the EU ETS. Free allocations for direct emissions aim at combatting the risk of carbon leakage by providing emissions permits, free of charge, to participants covered by the carbon pricing mechanism and that are deemed eligible. The EU, California, Quebec, Korea and New Zealand currently employ varying forms of this tool.

By employing a combination of both these international and domestic tools, it can be ensured that any possible negative impacts arising from international and domestic response measures are either fully mitigated or mitigated to the furthest extent possible.

Evaluating the effectiveness and cost-efficiency of these international and domestic mitigation tools can further ensure adverse impacts are successfully mitigated. Some domestic and international mitigation tools might be better suited to addressing adverse impacts over others.

As yet, there are very few studies for determining the effectiveness of mitigation tools, compounded by the relative nascency of the field, and the fact that it is often not considered to be a high priority for countries. However, these follow-up assessments enable the establishment of feedback loops and help improve the management of identified impacts and can even aid in identifying any additional unintended impacts.

9. Conclusion

This report aimed at giving short overview of how the methodology developed by the project team could be employed for identifying and analysing the possible international, cross border and domestic impacts arising from international and domestic response measures respectively.

An in-depth description and analysis on the methodology was carried out in the "Methodology description: Chile country case study on response measures" (ERCST, 2019), which also highlights the main barriers and difficulties encountered during the implementation of the methodology. This report then moves on to present the results of the quantitative and qualitative assessment of a select number of identified response measures.

As there are a significant number of response measures that the case study identified, four response measures (two international ones and two domestic ones) were selected in order to showcase what a quantitative assessment might look like.

The overall impacts of all four policies on the GDP of Chile are expected to be limited, but the various policies could impact different sectors deemed vulnerable to a varying degree.

For example, with regards to a *potential IMO carbon tax*, even the highest modelled level of the tax (50 USD/tonne of CO2) would lead to less than -0,04% impact on Chilean GDP annually by 2050. However, the impacts on the main export product (copper) are more significant: The copper sector sees production decrease by 0,213% compared to the baseline scenario in case of a 50 USD/tonne IMO carbon tax.

Other sectors, such as the agricultural sectors and aquaculture see a limited increase in production levels (respectively +0,017% and +0,043% in 2050 compared to baseline with 50 USD/tonne IMO carbon tax) due to an expected depreciation of the Chilean peso.[9]

The research team also estimated the *implementation of CORSIA* leading to a 15 EUR or 30 EUR ticket fare increase for visitors flying to Chile. The estimations indicates that there is a potential for reduced incomes for various sectors across the Chilean economy due to less visitors coming and spending less while in Chile.

[9] Note that these results should not be taken out of context of this case study. The goal of the case study is to test the methodology and showcase a possible format for a country case study. The IMO carbon tax modelling exercise is built upon some 'back-of-the-envelope' calculations on estimating transportation cost increases through equivalent production cost increases. More details on the method and its shortcomings can be

The main direct impacts are to be found in reduced spending by travellers in the retail sector (-3,1 billion Chilean pesos for 15 EUR fare increase and -13,3 billion Chilean pesos for 30 EUR fare increase), hotels, (resp. -1,4 and -6,2 billion Chilean pesos) air transport (resp. -0,7 and -3,1 billion Chilean pesos), restaurants (resp. -0,6 and -2,7 billion Chilean pesos) and entertainment and recreational activities (resp. -0,5 and -2,4 billion Chilean pesos).

The total of the direct effects across the 60 sectors in the model is a decrease in spending of 6,81 billion Chilean pesos (EUR 15 fare increase) and 29,28 billion Chilean pesos (30 EUR fare increase).

There are minor indirect impacts on other sectors, especially due to multiplicative effects. If hotels see their turnover reduced, they might hire less staff. This would have the multiplicator effect that there is less hotel staff spending their own wages throughout the Chilean economy.

These indirect impacts are however minor in the case of a 15 EUR increase in ticket fares. This quantitative approach indicates that spending would decrease on Real estate activities (-0,56 billion Chilean pesos), Administrative and support activities (-0,37 billion Chilean pesos), and Wholesale trade (-0,37 billion Chilean pesos). The total of the indirect effects across the 60 sectors in the model is a decrease in spending of 4,58 billion Chilean pesos in the case of a 15 EUR fare increase.

In case of a 30 EUR fare increase, the indirect impacts are, however, more significant. This quantitative approach indicates that spending would decrease on Real estate activities (-2,4 billion Chilean pesos), Administrative and support activities (-1,6 billion Chilean pesos), and Wholesale trade (-1,6 billion Chilean pesos). The total of the indirect effects across the 60 sectors in the model is a decrease in spending of 19,71 billion Chilean pesos in the case of a 30 EUR fare increase

On the domestic side, two policies were also modelled: a coal-phase out announced by the Chilean government and a potential increase of the domestic CO2 tax on stationary installations (from 5 USD/tonne of CO2 to 15 USD, 30 USD and 50 USD/tonne).

The expected impacts of the *coal-phase out* are a significant decrease in Chilean GHG emissions (-7,8% annually by 2040 compared with the baseline scenario), and a small decrease in Chilean GDP due to increased prices of electricity (-0,13% in 2020 decreasing to -0,05% by 2050 compared with the baseline scenario).

In terms of sectoral impacts, there are large variations across different economic sectors. As expected, the small coal production sector (-33,5% by 2050 compared with baseline scenario) and coal generation sectors are very negatively affected. Also, sectors very dependent on electricity will see a decrease in their production, notably the copper (-0,34% by 2050 compared with baseline scenario) and mining sectors. Wind (+28,46% by 2050 compared with baseline scenario)

and solar electricity generation will be impacted (+9,24% by 2050 compared with baseline scenario) and will make up for most of the loss in coal generation.

Other non-energy economic sectors benefit because of a depreciation of the Chilean peso, for example fishing (+0,03% by 2050 compared with baseline scenario).

The sectors with the largest relative change include sectors with very low production in the baseline (minor absolute changes result in large relative changes), such as coal production, biomass generation and gas generation.

Income falls in all periods for all income deciles as a direct consequence of the fall in GDP. The impacts however are somewhat lower for the lowest decile (hh1) and the highest decile (hh10).

The potential increase of the *domestic CO2 tax* is expected to significantly decrease CO2 emissions in Chile (-23,3% by 2050 compared to the baseline scenario if the CO2 tax is set at 50 USD/tonne), and also have potential minor negative impacts on Chilean GDP (between -0,01% by 2020 if tax set at 15USD/tonne and -0,42% by 2050 if tax set at 50 USD/tonne).

The main sector deemed vulnerable that sees impacts in the modelling exercise is the generation of power using petroleum. The modelling projects a drop in production of between -62,6% (tax at 15 USD/tonne) and -94,6% by 2050 (tax set at 50 USD/tonne) compared with the baseline scenario.

There are also sectors that are impacted indirectly, most relevant are paper production and wind and solar electricity production. The former is impacted negatively (-0,8% by 2050 for tax at 50 USD/tonne), as the cost of using dirtier fuels increases. The wind (+44,5% by 2050 for tax at 50 USD/tonne) and solar (+23,7% by 2050 for tax at 50 USD/tonne) electricity production sectors see their competitiveness improve as they do not have to pay the tax – unlike their competitors.

The impacts of the CO2 tax on incomes is minor when compared to the impacts on some specific sectors (see previous section). Despite the decrease in GDP, incomes actually increase over all deciles compared to the baseline scenario.

One possible explanation for this is that as energy and labor are substitutes to a certain degree in the model, higher energy prices leads to energy being substituted with labour – increase employment and wages.

The research team also conducted a limited qualitative assessment for two international policies, illustrated a range of assessment possibilities, showing both positive and negative impacts of measures adopted at national and international levels, applied to actual and possible response measures. This overview could show a country seeking to report on response measures under

BUR/BTR what a qualitative assessment could look like. The assessment focuses on which types of economic, environmental and social impacts should be included in an in-depth qualitative assessment. For example, the impact of global measures to support sales of electric vehicles might have on the Chilean exports of copper and employment in the copper and other sectors.

Identifying impacts ex ante has the clear benefit of allowing for the management of impacts before they occur and allows for the incorporation of tools which can mitigate the identified risk at an early stage. That said, ex-post identification allows for focused and well-apportioned efforts to address the impacts that have already occurred.

Overall the case study found there to be a relatively limited number of relevant and important domestic and international response measures, with the concentration of possible impacts, both positive and negative being limited to a few sectors.

The challenges highlighted serve to further emphasise the need for the development of more comprehensive domestic and international tools, including monitoring tools and tools that countries can use to highlight specific needs in terms of tools to address impacts.

This is not however, to be interpreted or construed as encouraging a lack of mitigation action. On the contrary, it must be seen as providing a way forward that will ensure that action can be undertaken with the full support by all stakeholders, domestic and international, raising awareness on the possible impacts and allowing the chance to develop tools and measures which ensure any unintended negative impacts resulting from response measures are understood and either avoided or minimised to the best degree possible.

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12. Annex 1 – Top 100 Chilean sectors ranked by value added

Table 26: Overview table for Steps 2 and 3 Sectors Vulnerable to International Response Measures

Ranking by value added	ISIC code	Sector description	2016 Gross production value	2016 Value added	2018 Exports (in US$) millions	2016 Emissions (in kt CO2e)
1	0729	Mining of copper	21,846	12,004	18681.07	7,967
2	6810 (?)	Housing services	11,447	9,091		
3	84	Public administration and defence; compulsory social security	11,630	8,204		
4	46	Wholesale trade, except of motor vehicles and motorcycles	14,591	7,364		
5	47	Retail trade, except of motor vehicles and motorcycles	13,336	6,909		
6	64	Financial service activities, except insurance and pension funding	8,428	6,027		
7	85 (partial)	Public education	6,612	5,381		
8	82	Office administrative, office support and other business support activities	7,381	5,097		
9	WTO 1.33 & 1.36*	Tourism (travel, and expenditure by main purpose of trip)	5,055	5,055		
10	74	Other professional, scientific and technical activities	6,431	4,436		
11	71	Architectural and engineering activities; technical testing and analysis	5,989	4,041	0.60	
12	86, 87 & 88 (partial)	Private human health and social work activities	6,586	3,866		
13	43	Specialized construction activities	7,016	3,814		
14	86	Public human health activities	5,552	3,804		
15	68	Real estate activities	5,349	3,789		
16	42	Civil engineering	7,630	3,497		
17	85 (partial)	Private education	4,304	3,188		
18	5610	Restaurants and mobile food service activities	5,814	2,907		
19	3510 (partial)	Electric power generation	5,176	2,713	0.90	34,580
20	4100 (partial)	Construction of residential buildings	6,463	2,694		
21	4921 & 4922	Passenger land transport	4,768	2,505		8,290
22	69	Legal and accounting activities	2,693	2,129		
23	62 & 63	Computer and information services activities	3,382	2,122		

24	45	Wholesale and retail trade and repair of motor vehicles and motorcycles	3,659	1,917		
25	0122-0126	Cultivation of other fruit	2,835	1,911	4952.60	882
26	96	Other personal service activities	2,121	1,772		
27	4923	Freight transport by road	5,450	1,769		15,226
28	19 (?)	Manufacture of coke and refined petroleum products	4,070	1,651	25.85	1,132
29	77	Rental and leasing activities	2,678	1,605		
30	4100 (partial)	Construction of non-residential buildings	4,116	1,518		
31	522 (other than 5221)	Other support activities for transport	2,304	1,457		
32	51	Air transport	3,327	1,369		1,674
33	25	Manufacture of fabricated metal products, except machinery and equipment	2,381	1,112	429.18	
34	66	Activities auxiliary to financial service and insurance activities	2,185	1,101		
35	1200	Manufacture of tobacco products	1,170	1,023	86.20	328
36	1020	Processing and preserving of fish, crustaceans and molluscs	3,562	1,010	977.39	328
37	08, 09	Other mining, and service activities	1,413	970	206.10	
38	17 (?)	Manufacture of paper and paper products	2,794	967	4142.16	1,543
39	6120	Wireless telecommunications activities	2,653	928		
40	02	Forestry and logging	1,844	885	174.21	882
41	1071	Manufacture of bakery products	1,703	880	11.48	328
42	5221	Service activities incidental to land transportation	1,343	876		
43	94	Activities of membership organizations	1,341	824		
44	Section R	Arts, entertainment and recreation	1,439	808	1.40	
45	1104	Manufacture of soft drinks; production of mineral waters and other bottled waters	1,844	770	2.40	328
46	1050	Manufacture of dairy products	1,927	749	124.30	328
47	3600 (partial)	Water supply	1,172	738		
48	2011	Manufacture of basic chemicals	2,615	731	24.65	337
49	65	Insurance, reinsurance and pension funding, except compulsory social security	2,511	730		
50	0113	Cultivation of vegetables and nursery products	1,004	691	598.22	882

51	1080 plus others (1079)	Manufacture of other food products	1,553	675	493.08	
52	5510	Short term accommodation activities	1,264	657		
53	3510 (partial)	Electric power distribution	3,819	646	0.90	
54	6110	Wired telecommunications activities	1,346	624		
55	1010	Processing and preserving of meat	3,271	621	1043.01	328
56	0121	Cultivation of grapes	975	607	1388.58	882
57	28	Manufacture of machinery and equipment n.e.c	1,396	601	932.19	
58	33	Repair and installation of machinery and equipment	967	540	2849.59	
59	1610	Sawmilling and planing of wood	1,579	515	1652.90	
60	58, 59 & 60	Activities of publishing, producing, programming and broadcasting	1,302	506	23.68	
61	1080	Manufacture of prepared animal feeds	1,998	494	62.20	328
62	6190	Other telecommunications activities	1,846	481		
63	1102	Manufacture of wines	1,460	477	2004.00	328
64	2220	Manufacture of plastics products	1,652	471	436.37	
65	5210	Warehousing and storage	693	466		
66	011	Annual crops (cereals and others) and fodder crops	1,283	465	614.94	882
67	032	Aquaculture	2,110	447	6011.20	882
68	031	Fishing	557	437	6011.20	847
69	162	Manufacture of products of wood, cork, straw and plaiting materials	1,269	434	2622.70	
70	2100	Manufacture of pharmaceuticals, medicinal chemical and botanical products	1,198	431	192.78	
71	0141	Cattle breeding	998	424	21.41	4,022
72	38	Waste collection, treatment and disposal activities; materials recovery	715	406	824.50	
73	3510 (partial)	Electric power transmisison	452	385	0.90	
74	072 minus 0729	Mining of non-copper non-copper metal ores	743	383	973.36	
75	1030	Processing and preserving of fruit and vegetables	1,304	371	1305.90	328
76	26 & 27	Manufacture of machinery and electrical and electronic equipment	868	370	260.40	

77	016	Support activities for ag and breeding	551	347		882
78	2395	Manufacture of articles of concrete, cement and plaster	1,386	325	6.30	
79	3520 & 3530	Gas and steam supply	1,342	301	0.00	
80	0146	Poultry breeding	1,092	274	0.50	357
81	0710	Mining of iron ores	628	251	973.40	
82	29 & 30	Manufacture of transport equipment	650	232		
83	1061	Manufacture of grain mill products	798	227		328
84	1702	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard	740	226		
85	0145	Breeding of pigs	629	225		882
86	1811	Printing	693	220		
87	1020, 1040	Preparation of fishmeal and fish oil	527	211		328
88	31	Manufacture of furniture	747	211		
89	50	Water transport	631	209		745
90	2029	Manufacture of other chemical products n.e.c.	622	199		
91	14	Manufacture of wearing apparel	674	193		
92	53	Postal and courier activities	308	183		
93	1103	Manufacture of malt liquors and malt	614	175		328
94	2023 (?)	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	660	171		
95	2410	Manufacture of basic iron and steel	975	158		1,600
96	1709	Manufacture of other articles of paper and paperboard	663	149		
97	2310	Manufacture of glass and glass products	376	145		
98	221	Manufacture of rubber products	353	130		
99	13	Manufacture of textiles	419	123		
100	1040	Manufacture of vegetable and animal oils and fats	353	117		328

13. Annex 2 - Top export partners for sectors deemed vulnerable

Table 27: Top Export Partners for Each of the 10 Vulnerable Sectors

ISIC Rev 4 Code	Product Description	HS6 2007 Code	Product Description	2018 Top 5 Export Partners: Value (USD)*		Notes
				Country	Total value	
0729	Mining of copper	260300	Copper ores & concentrates	China	9,961,854,660	
				Japan	3,844,588,755	
				Rep. Of Korea	1,260,795,613	
				India	950,433,773	
				Spain	885,972,263	
0122-0126	Cultivation of other fruit	80111-91099	Fruits, nuts etc., Fresh/dried	China	1,168,531,933	Total of 69 HS Codes. We looked at the top 15 (covering just over 90% of the exports from this sector)
				USA	945,919,456	
				Netherlands	338,148,495	
				United Kingdom	117,787,507	
				Colombia	93,378,332	
19	Manufacture of coke and refined petroleum products	270400, 271311, 271312	Coke & semi-coke of coal/lignite/peat, whether/not agglomerated; retort carbon, Petroleum coke, not calcined, Petroleum coke, calcined	China	21,259,736	
				USA	1,831,003	
				India	1,611,847	
				Peru	601,729	
				Argentina	506,318	
17	Manufacture of paper and	470100-590500	Paper products	China	1,998,820,149	Over 200 HS Codes. We looked at top 10 (covering just over 98% of the exports from this sector)
				Netherlands	229,812,390	

	paper products			Rep. of Korea	216,929,369	
				Other Asia, nes	81,894,432	
				Japan	75,946,474	
2011	Manufacture of basic chemicals	260120, 270710-270820, 280110-285300, 290110-294200, 320110-320650, 350710, 350790, 380290-382370, 440210-440290, 710410-710420, 840130	Basic chemicals, except fertilizers and nitrogen compounds	Rep. of Korea	409,843,097	Over 300 HS Codes. We looked at top 10 (covering just over 90% of the exports from this sector)
				USA	276,715,240	
				Belgium	265,529,424	
				China	246,006,493	
				Brazil	220,750,671	
0121	Cultivation of grapes	80610	Grapes, fresh and dried	USA	527,478,359	
				China	203,809,055	
				Rep. of Korea	74,997,914	
				United Kingdom	63,588,129	
				Netherlands	63,232,150	
1102				China	350,217,976	

	Manufacture of wines	220410-220600	Wine and wine products	USA	220,300,100	
				United Kingdom	200,065,375	
				Japan	196,138,858	
				Brazil	145,327,256	
032	Aquaculture	30270-230120	Fish and fish products	USA	1,663,384,948	Over 200 HS products in this sector. We looked at top 10 (covering just over 90% of the exports from this sector).
				Japan	1,068,245,035	
				Brazil	519,964,705	
				Russian Federation	444,181,325	
				China	268,051,772	
031	Fishing	30270-230120	Fish and fish products	USA	1,663,384,948	Over 200 HS products in this sector. We looked at top 15 (covering just over 90% of the exports from this sector).
				Japan	1,068,245,035	
				Brazil	519,964,705	
				Russian Federation	444,181,325	
				China	268,051,772	
WTO Code	Description	HS6 2007 Code	Product Description	Arrivals by Region	Arrivals in 2017 ('000)	Notes
WTO 1.33 & 1.36*	Tourism (travel, and expenditure by main purpose of trip)	NA	NA	Americas	5,615	Covers over 90 % of arrivals, also have arrivals from Africa, East Asia and the Pacific, Middle East, South Asia although at much lower values
				Europe	497	

14. Annex 3 – International response measures

Tables 28-37: List of international response measures by list of top vulnerable sectors

Source: Authors' own elaboration on 13 databases

International sector 1: Mining of Copper (ISIC Rev 0729)				
China	Japan	Republic of Korea	India	Spain
National ETS	Grants and direct payments to renewable energy producers	Act on Encouragement of Purchase of Environment-Friendly Products.	Rajasthan - VAT exemption for generation of electricity from renewables	EU ETS
Subnational ETS pilots		Act on Encouragement of Purchase of Green Products.	Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017	Royal Decree No. 287/2015 - Regulates the direct granting of subsidies for the purchase of electric vehicles within the framework of the Comprehensive Strategy for the promotion of electric vehicles in Spain 2010-2014 (MOVELE Program 2015).
13th Five-Year comprehensive energy-saving and emission reduction work plan.		Enforcement Decree of the Framework Act on Low Carbon, Green Growth (Presidential Decree No. 22124 of 2010).	State level solar and wind power polices and strategies	Directive 2009/28/EC on the Promotion of Electricity Produced from Renewable Energy Sources
China National Plan for Tackling Climate Change (2014-2020).		Regulation on Energy Efficiency Labelling and Standards	National Action Plan on Climate Change.	Renewable Energy Road Map - Renewable energies in the 21st century: building a more sustainable future

Industrial Green Development Plan (2016-2020).		Act on the Promotion of Saving and Recycling of Resources	National wind-solar hybrid policy	Development plan of electrical energy transport network 2015-2020
Measures for the management of the energy-saving low-carbon-emission product certification.		Framework Act on Low Carbon, Green Growth.	Comprehensive Policy on Decentralized (Off-grid) Energy Generation Projects based on New and Renewable Energy (Non-Conventional) Energy Sources – 2016	Renewable Energy Plan 2011 - 2020
Renewable Electricity Quota and Assessment Method (Draft for Opinions) - Planned		Regulation on Energy Efficiency Labelling and Standards (MKE's Notification 2011-263)	India 175 GW Renewable Energy Target for 2022	National Renewable Energy Action Plan 2011-2020
Action Plan for the Development of Smart Photovoltaic Industry			National Renewable Energy Law 2015 - DRAFT	Spanish Strategy on Climate Change and Clean Energy 2007-2012-2020
Renewable Energy Green Certificate and Trading Mechanism			Pilot Emissions Trading Systems	
The Twelfth Five-Year Plan for Renewable Energy				
China 13th Solar Energy Development Five Year Plan (2016-2020)				
China's National Climate Change Programme				
Renewable Energy Law of the People's Republic of China				

Note: Sector's main products are copper ores and concentrates

International sector 2: 0122-0126 Cultivation of other fruit					
China	USA	Netherlands	United Kingdom	Columbia	International transport
Measures for the Administration of Organic Product Certification.	U.S. Fish and Wildlife Service Mitigation Policy.	Sectoral emission trading system in horticulture	Common Agricultural Policy (CAP) Greening	Resolution No. 3.002 - Provisions on the labeling of agricultural inputs.	CORSIA (for air freight)
Rules of the Environmental Protection Administration of the Executive Yuan governing the environmental protection labeling product application and review.	Federal and state level organic food labelling initiatives	Common Agricultural Policy (CAP) Greening	Food (Provisions relating to Labelling) (England, Wales, NI) Regulations 2003 (S.I. No. 2647 of 2003).		IMO climate change related measures
			The England Rural Development Programme		
			Organic Products Regulations 2001 (S.I. No. 430 of 2001).		

Note: Sector's main products are nuts and fresh fruit, including: coconuts, cherries, brazil nuts, cashew nuts, almonds, hazelnuts etc.

International sector 3: 19 Manufacture of coke and refined petroleum products				
China	USA	India	Peru	Argentina
National ETS	The President's Climate Action Plan.	National Action Plan on Climate Change.	Decree Nº 011-2015-MINAM – National Stategy on climate change (ENCC).	Renewable energy and rational use of energy law
Subnational ETS pilots	Clean air act			
13th Five-Year comprehensive energy-saving and emission reduction work plan.	United States Mid-Century Strategy for Deep Decarbonization.			
China National Plan for Tackling Climate Change (2014-2020).	Carbon pricing initiatives (RGGI, California ETS)			
Industrial Green Development Plan (2016-2020).				

Note: Sector's main product is non-calcinated petroleum coke (input for aluminium, steel and titanium smelting industry).

International sector 4: 17 Manufacture of paper and paper products				
China	Republic of Korea	Netherlands	Japan	'Other Asia'
National ETS	Act on Encouragement of Purchase of Environment-Friendly Products.	CO2 Emission Trading System (ETS)	N/A	N/A
Subnational ETS pilots	Act on Encouragement of Purchase of Green Products.	International co-operation actions in industry		
13th Five-Year comprehensive energy-saving and emission reduction work plan.	Enforcement Decree of the Framework Act on Low Carbon, Green Growth (Presidential Decree No. 22124 of 2010).	Decree No. 183 containing rules relative to packing, packing waste, paper and cardboard.		
China National Plan for Tackling Climate Change (2014-2020).	Act on the Promotion of Saving and Recycling of Resources			
Industrial Green Development Plan (2016-2020).	Framework Act on Low Carbon, Green Growth.			

Note: Sector's main products include: multi-ply paper and paperboard, unbleached sack kraft paper, newsprint, self-adhesive paper and paperboard (top 4 account for nearly 95% of exports).

International sector 5: 2011 Manufacture of basic chemicals				
China	USA	Republic of Korea	Brazil	Belgium
13th Five-Year comprehensive energy-saving and emission reduction work plan.	The President's Climate Action Plan.	Enforcement Decree of the Framework Act on Low Carbon, Green Growth (Presidential Decree No. 22124 of 2010).	National Plan on Climate Change (PNMC)	IP-A02 : Long Term Energy/CO2 efficiency Agreements in the industrial sector. Stage 2
National ETS	Clean air act	Framework Act on Low Carbon, Green Growth.	Possible Brazil ETS	EU ETS
China National Plan for Tackling Climate Change (2014-2020).	Environmental protection (ICS 13.020), Products of the chemical industry (ICS: 71.100)	Korea ETS		
Industrial Green Development Plan (2016-2020).	Carbon pricing initiatives (RGGI, California ETS)			
Subnational ETS pilots				

Note: Sector's top 10 products covering 90% of exports, include lithium carbonates, iodine, nitrate of potassium, molybdenum oxides and hydroxides, methanol, lithium oxide and hydroxide and fungicides

International sector 6: 0121 cultivation of grapes					
China	USA	Republic of Korea	Netherlands	United Kingdom	International transportation
Measures for the Administration of Organic Product Certification.	Federal and state level organic food labelling initiatives	Act on Promotion of Environment-friendly Agriculture and Fisheries, and Management and Support for Organic Foods	Common Agricultural Policy (CAP) Greening	Common Agricultural Policy (CAP) Greening	CORSIA (for air freight)
Rules of the Environmental Protection Administration of the Executive Yuan governing the environmental protection labeling product application and review.	U.S. Fish and Wildlife Service Mitigation Policy.	Support for quality certification of eco-friendly agricultural products; import and safety control of LMO; origin control; grading of livestock products; traceability system		Food (Provisions relating to Labelling) (England, Wales, NI) Regulations 2003 (S.I. No. 2647 of 2003).	IMO climate change related measures
		Improved regulations on labelling of environmentally friendly agricultural product		Organic Products Regulations 2001 (S.I. No. 430 of 2001).	
				The England Rural Development Programme	

Note: Sector's main products include fresh and dried grapes – fresh grapes accounts for nearly 90% of exports in this sector.

International sector 7: 1102 manufacture of wines				
China	Japan	USA	Brazil	United Kingdom
Announcement No. 63 of 2008 of Ministry of Environmental Protection promulgating the cleaner production standard for wine industry.	Technical criteria of Certification of Importer concerning the Organic Agricultural Products and the Organic Agricultural Processed Foods (Notification No. 821).	Federal and state level organic food labelling initiatives	Law No. 7.465 on the obligation of using biodegradable packaging.	Food (Provisions relating to Labelling) (England, Wales, NI) Regulations 2003 (S.I. No. 2647 of 2003).
China National Plan for Tackling Climate Change (2014-2020).		The President's Climate Action Plan.	National Plan on Climate Change (PNMC).	CAP - wines amendments Wales and Scotland
Measures for the Administration of Organic Product Certification.		Clean air act	Possible Brazil ETS	Organic Products Regulations 2001 (S.I. No. 430 of 2001).
Rules of the Environmental Protection Administration of the Executive Yuan governing the environmental protection labeling product application and review.		Carbon pricing initiatives (RGGI, California ETS)		

Note: Sector's main products include wine of fresh grapes, wine in various container sizes and sparkling wine.

International sector 8: 032 aquaculture				
China	Japan	USA	Russian Federation	Brazil
Directions on Issuing the Organic Labeling Approval Operations Document of Imported Aquatic Products and Aquatic Processed Products.	Technical criteria of Certification of Importer concerning the Organic Agricultural Products and the Organic Agricultural Processed Foods (Notification No. 821).	Federal and state level organic food labelling initiatives	N/A	Law No. 7.465 on the obligation of using biodegradable packaging.
China National Plan for Tackling Climate Change (2014-2020).	Aviation fuel tax			
Measures for the Administration of Organic Product Certification.				
Rules of the Environmental Protection Administration of the Executive Yuan governing the environmental protection labeling product application and review.				

Note: Sector's top 10 products cover 90% of exports, including fillets of pacific salmon, Atlantic salmon, frozen pacific salmon etc.

International sector 9: 031 fishing					
China	Japan	USA	Russian Federation	Brazil	International transportation
Directions on Issuing the Organic Labeling Approval Operations Document of Imported Aquatic Products and Aquatic Processed Products.	Aviation fuel tax	Federal and state level organic food labelling initiatives	N/A	Law No. 7.465 on the obligation of using biodegradable packaging.	CORSIA (for air freight)
Rules of the Environmental Protection Administration of the Executive Yuan governing the environmental protection labeling product application and review.	Technical criteria of Certification of Importer concerning the Organic Agricultural Products and the Organic Agricultural Processed Foods (Notification No. 821).				IMO climate change related measures
Directions on Issuing the Organic Labeling Approval Operations Document of Imported Aquatic Products and Aquatic Processed Products.					

Note: Sector's top 10 products cover 90% of exports, including pacific salmon (fresh, chilled or frozen), Atlantic salmon (fresh, chilled or frozen), fillets of trout etc.

International sector 10: WTO 1.33 and 1.36 Tourism								
USA	Spain	Peru	Russian Federation	Netherlands	United Kingdom	Belgium	Argentina	International aviation policies
Federal and state level aviation fuel taxes (at least 28 States have aviation fuel levies)	National policy on alternative energy in transport	Supreme Decree No. 013-2016-MINAM – Creates a Multisectoral Working Group in charge of proposing measures to improve air quality at the national level linked to vehicle emissions and establishes provisions on air quality.	N/A	Emission Trading System (EU ETS)	Emission Trading System (EU ETS)	Emission Trading System (EU ETS)	Taxes on petrol and gasoline	CORSIA
The President's Climate Action Plan.	Airport carbon footprinting accreditation	Resolution Nº 202/07 / CONAM - Maximum permissible emission limits for motor vehicles.			Duty on hydrocarbon fuels		Decree Nº 543/2016 – Mandated bioethanol percentage	
Clean air act	EU ETS - aviation	Supreme Decree No. 003-2017-MINAM – Approves Environmental Quality Standards (ECA) for Air.					Law Nº 26.093 and others on promotion of production and consumption of biofuels	
Carbon pricing initiatives (RGGI, California ETS)	Regional taxes on aviation	Decree Nº 011-2015-MINAM – National Stategy on climate change (ENCC).						

		Supreme Decree No. 100/11 / PCM - Modifies Supreme Decree No. 047/01 / MTC, Maximum Permissible Limits of polluting emissions for motor vehicles that circulate in the road network.						
		Supreme Decree No. 211/07 / EF - Selective Consumption Tax considering the criterion of proportionality to the degree of harmfulness of fuels.						
		Biofuel Production and Commercialisation Law with amendments						

Note: Sector's main items include travel and expenditure on various categories. Europe and the Americas account for more than 90% of arrivals.

15. Annex 4 – Domestic response measures

Table 38: List of domestic response measures by list of top vulnerable sectors

Code	Sector	Name of policy or measure
3510	Electric power generation	National climate change plan 2017-2022
		Carbon neutrality pledge
		National energy agenda (Energia 2050)
		Law 19.657
		Law 19.940
		Law 20.780
		Law 20.698
		Law 20.571
		Law 20.257 (NCRE Act)
		Law 20.365
		Solar Strategic Program
		Energy roadmap 2018-2022 (Ruta energetica 2018-2022)
		Coal phase out
		Net billing law
		Energy Efficiency Action Plan (PAE2020)
		Energy Efficiency program in public buildings (PEEP)
		Energy Strategy 2015
		Renewable energies for self-consumption
		Mitigation plan for the energy sector
4923	Freight transport by road	National climate change plan 2017-2022
		Labelling of new vehicles (2013)
		Law 20.780
		2014-2018 atmospheric decontamination strategy of the Chilean government
		Other (expansion of Santiago Subway, construction of new railway infrastructure)
		Green zone for transportation in Santiago
		E-mobility strategy (estrategia de electromovilidad)
17	Manufacture of paper and paper products	Sustainable forestry management scheme
		Carbon neutrality pledge
		National climate change plan 2017-2022

		National strategy on climate change and plant resources (Estrategia Nacional de Cambio Climatico y recursus vegetacionales (ENCCRV))
		Energy efficiency policy
		Native Forest Law
51	Air transport	National climate change plan 2017-2022
		Emission reduction plan for the aviation industry
19	Manufacture of coke and refined petroleum products	National climate change plan 2017-2022
		Carbon neutrality pledge
		Clean production agreement
2011	Manufacture of basic chemicals	National climate change plan 2017-2022
		Energy efficiency policy
		Clean production agreement
		Carbon neutrality pledge
0729	Mining of copper	National climate change plan 2017-2022
		Energy efficiency policy
		Clean production agreement
		Carbon neutrality pledge
1020	Processing and preserving of fish, crustaceans and molluscs	National climate change plan 2017-2022
		Energy efficiency policy
		Clean production agreement
		Carbon neutrality pledge
0122-0126	Cultivation of other fruit	National climate change plan 2017-2022
		National strategy on climate change and plant resources (Estrategia Nacional de Cambio Climatico y recursus vegetacionales (ENCCRV))
		Clean production agreement
		Carbon sequestration through sustainable soil management
		Carbon neutrality pledge
WTO 1.33 & 1.36*	Tourism	National climate change plan 2017-2022
		2014-2018 atmospheric decontamination strategy of the Chilean government
		Carbon neutrality pledge
		See other transport and energy policies

16. Annex 5: key assumptions for modelling exercise

Table 39: Key model Elasticities

ELASTICITIES		2013
CES KEL-ND	OLD	0.01
	NEW	0.5
CES KE-L	OLD	0.12
	NEW	1
CES K-E	OLD	0.0
	NEW	0.8
CES Tipos de Trabajo		0.4
CES Tipos de Energía	OLD	0.0
	NEW	2.0
Armington Doméstico-Importado (FIRST LEVEL)		1.5-3.0
Entre Regiones (SECOND LEVEL)		5.0
Oferta de Exportaciones (First Level CET elasticities)		5.0
Entre Regiones (Second Level CET Elasticities)		8.0
Demanda de Exportaciones		.99
Elasticidad Ingreso Quintiles		0.62-1.20
Movilidad del Capital		0.70
Elasticidad Oferta Trabajo		0.20

Source: elaboration by Prof. O'Ryan

Table 40: Exogenous GDP growth Chile 2018-2050

Year	Population*	PIB Mill US$ 2011	GDP per capita USD $ 2011	Projected growth rate	Adjusted rate (**)
2016	18.167.147	405.018	22.294	1,3%	1,3%
2017	18.419.192	411.053	22.317	1,5%	1,5%
2018	18.751.405	427.495	22.798	4,7%	4,0% +
2019	19.107.216	443.312	23.201	3,9%	3,8% +
2020	19.458.310	458.828	23.580	3,6%	3,3% +
2021	19.678.363	474.064	24.091	3,3%	3,3%
2022	19.828.563	488.964	24.660	3,1%	3,1%
2023	19.960.889	503.659	25.232	3,0%	3,0%
2024	20.086.377	518.233	25.800	2,9%	2,9%
2025	20.206.953	532.743	26.364	2,8%	2,8%
2026	20.322.807	547.234	26.927	2,7%	2,7%
2027	20.433.791	561.738	27.491	2,7%	2,7%
2028	20.539.666	576.281	28.057	2,6%	2,6%
2029	20.640.230	590.885	28.628	2,5%	2,5%
2030	20.735.289	605.568	29.205	2,5%	2,5%
2031	20.826.397	620.343	29.786	2,4%	2,4%
2032	20.912.278	635.224	30.376	2,4%	2,4%
2033	20.992.831	650.222	30.974	2,4%	2,4%
2034	21.067.996	665.346	31.581	2,3%	2,3%
2035	21.137.769	680.607	32.199	2,3%	2,3%
2036	21.202.223	696.011	32.827	2,3%	2,3%
2037	21.261.462	711.566	33.467	2,2%	2,2%
2038	21.315.630	727.280	34.120	2,2%	2,2%
2039	21.364.889	743.157	34.784	2,2%	2,2%
2040	21.409.418	759.205	35.461	2,2%	2,2%
2041	21.449.428	775.428	36.151	2,1%	2,1%
2042	21.485.105	791.833	36.855	2,1%	2,1%
2043	21.516.611	808.424	37.572	2,1%	2,1%
2044	21.544.064	825.205	38.303	2,1%	2,1%
2045	21.567.513	842.183	39.049	2,1%	2,1%
2046	21.587.015	859.361	39.809	2,0%	2,0%
2047	21.602.589	876.744	40.585	2,0%	2,0%
2048	21.614.271	894.336	41.377	2,0%	2,0%
2049	21.622.101	912.141	42.186	2,0%	2,0%
2050	21.626.079	930.164	43.011	2,0%	2,0%

Source: elaboration by Prof. O'Ryan

*Population from last census in 2017 + Idicates a projection from IPOM in December 2018
**2016 and 2017, sourced from World Bank Group. 2018-2020 follows a survey on expectations by the Chilean Central Bank. 2021 and beyond follows trend line projection

Table 41: Expected Labor Force Growth Rate. Chile 2018-2050

Year	Growth Rate	Year	Growth Rate
2018	2,2%	2035	0,5%
2019	2,1%	2036	0,5%
2020	1,4%	2037	0,5%
2021	1,0%	2038	0,4%
2022	0,9%	2039	0,4%
2023	0,9%	2040	0,4%
2024	0,9%	2041	0,3%
2025	0,9%	2042	0,3%
2026	0,8%	2043	0,3%
2027	0,8%	2044	0,2%
2028	0,8%	2045	0,2%
2029	0,8%	2046	0,2%
2030	0,7%	2047	0,1%
2031	0,6%	2048	0,1%
2032	0,6%	2049	0,1%
2033	0,5%	2050	0,1%
2034	0,5%		

Source: elaboration by Prof. O'Ryan based on data from INE.

Table 42: Yearly labor productivity growth 2018-2050 (in %)

Year	Growth Rate	Year	Growth Rate	Year	Growth Rate
2018	0,8	2029	0,7	2040	0,5
2019	0,8	2030	0,7	2041	0,5
2020	0,8	2031	0,6	2042	0,5
2021	0,8	2032	0,6	2043	0,5
2022	0,8	2033	0,6	2044	0,5
2023	0,8	2034	0,6	2045	0,5
2024	0,8	2035	0,6	2046	0,5
2025	0,8	2036	0,6	2047	0,5
2026	0,8	2037	0,6	2048	0,5
2027	0,7	2038	0,6	2049	0,5
2028	0,7	2039	0,6	2050	0,5

Source: elaboration by Prof. O'Ryan based on data from Chilean Central Bank: "Crecimiento Tendencial: Proyección De Mediano Plazo Y Análisis De Sus Determinantes" sept. 2017.

17. Annex 6: data used for assessment of impacts of CORSIA on Chile

Table 43: Reduction in plane trips to Chile. Short, medium and long trips, business and personal – for two different increases in fare prices (15 EUR and 30 EUR per ticket)

EUR 15						
	Long Trip		Medium Trip		Short Trip	
	business	personal	business	personal	business	Personal
Reduction in passengers	318	2804	455	3696	529	1978
EUR 30						
	Long Trip		Medium Trip		Short Trip	
	business	personal	business	business	personal	business
Reduction in passengers	1718	11471	2456	15120	2859	8093

Source: Authors' own elaboration

Table 44: Average stay and spending by type of trip: short trips (Argentina, Bolivia, Peru, Brazil, Colombia and Rest of South and Central America); medium trips (USA, Mexico and Canada), and long trips (Germany, Spain, France, England, Rest of Europe, Australia, China, Resto of Asia .

Short trip weighted average	Average stay (days)	Daily expenditure (USD)	Individual spending (USD)
personal	8.5	60.6	517.1
business	7.9	111.9	888.6
medium trip weighted average	**Average stay (days)**	**Daily expenditure (USD)**	**Individual spending (USD)**
personal	18.7	59.4	1113.7
business	10.4	131.9	1370.8
Long trip weighted average	**Average stay (days)**	**Daily expenditure (USD)**	**Individual spending (USD)**
personal	22.1	53.6	1182.5
business	17.9	89.7	1607.5

Source: Statistics from Ministry of Economics of Chile

Table 45: Breakdown of expenditures from international credit cards (2017)

EXPENDITURE BY FOREIGN CREDIT CARDS (% of total expenditure)	
Hotels	21.0%
Health	2.4%
Large stores	7.4%
Rent a car	7.5%
Airlines	10.5%
Gifts and home articles	5.5%
Clothing and footwear	11.3%
Buses, taxis and transport	1.4%
restaurants	9.3%
Car parts and services	1.4%
supermarkets	9.4%
casinos	0.3%
Other	7.3%
Movies and shows	0.4%
Fuels	1.8%
Quick foods	3.1%

Source: elaboration by Prof. O'Ryan

Table 46: Reclassification of numbers from Table 47 based on the Input Output Matrix for 2017:

EXPENDITURE BY FOREIGN CREDIT CARDS (% of total expenditure)	
Hotels	21.0%
Private health and social assistance	2.4%
Retail sector	45.6%
Air transport	10.5%
Other passenger road transports	1.4%
Restaurants	9.3%
Entertainment and recreational activities	8.0%
Fuel production	1.8%

Source: elaboration by Prof. O'Ryan

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