Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Engineering
Department of Energy and Process Engineering

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The effect of the EU Carbon Border Adjustment Mechanism on the international trade of Slovenia

Master's thesis in Residual Resource Engineering and Industrial Ecology
Supervisor: Edgar Hertwich, Olivier Jolliet
Co-supervisor: Maximilian Koslowski
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Abstract

KEYWORDS:

Carbon border adjustment mechanism

Environmentally extended multi-regional input-output analysis

Slovenia

International trade

Consumption-based accounting

Throughflow-based accounting

In an attempt to lower global emissions, the EU introduced a Carbon border adjustment mechanism (CBAM), which puts a carbon price on specific products imported into the EU to lower carbon leakage and increase the competitiveness of domestic products. We investigated the effects of CBAM on Slovenia and how it compares to the EU, using an Environmentally extended multi-regional Input-Output (EE-MRIO) model, with EXIOBASE as the underlying dataset. For the calculation, we incorporated Production-based (PBA) and Consumption-based (CBA) as well as more novel Throughflow-based accounting (TBA) approaches. We also investigated the suitability of emissions embodied in trade (EEBT) approach for the calculation of CBAM effects. Our results show that Slovenia will not be highly affected as sectors currently under CBAM scope do not represent a large portion of imports into Slovenia (only around 0,05%). The estimated CBAM revenues generated are low in comparison to the Slovenian economy (only around 0,007%). The most affected sectors of Slovenia are Electricity by gas and coal, Aluminium and the Iron and Steel sectors. Most affected Slovenian trade partners are non-EU European countries, Russia, India, the rest of Asia and Africa. The results for the EU partially align with other studies, showing that our models seem to underestimate the effects of CBAM. We also looked at the total emissions of Slovenia and the EU, which seem to coincide with other findings and statistics. EEBT seems to be a simpler option for the investigation of CBAM, but MRIO is more accurate.

Sammendrag

STIKKORD:

Karbongrensejusteringsmekanisme

Miljøutvidet multiregionale kryssløpsanalyse

Slovenia

Internasjonal handel

Forbruksbasert regnskap

Gjennomstrømningsbasert regnskap

I et forsøk på å redusere globale utslipp, innførte EU en karbongrensejusteringsmekanisme (CBAM), som legger en karbonpris på spesifikke produkter som importeres til EU for å redusere karbonlekkasje og øke konkurransedyktigheten til innenlandske produkter. Vi undersøkte effektene av CBAM på Slovenia og hvordan det sammenligner seg med EU, ved hjelp av en Miljøutvidet multiregionale kryssløpsanalyse (EE-MRIO) modell, med EXIOBASE som underliggende datasett. For beregningen inkluderte vi produksjonsbaserte (PBA) og forbruksbaserte (CBA) samt mer nyskapende gjennomstrømningsbaserte regnskapsmetoder (TBA). Vi undersøkte også egnetheten til utslipp som er innkapslet i handel (EEBT) tilnærmingen for beregning av CBAM-effekter. Våre resultater viser at Slovenia ikke vil bli sterkt påvirket, da sektorene som for øyeblikket omfattes av CBAM-omfanget ikke utgjør en stor del av importen til Slovenia (bare rundt 0,05%). De estimerte CBAM-inntektene som genereres, er lave sammenlignet med den slovenske økonomien (bare rundt 0,007%). De mest påvirkede sektorene i Slovenia er elektrisitet fra gass og kull, aluminium og jern- og stålsektorene. De mest berørte slovenske handelspartnerne er ikke-EU-europeiske land, Russland, India, resten av Asia og Afrika. Resultatene for EU delvis samsvarer med andre studier, og viser at modellene våre synes å undervurdere effektene av CBAM. Vi så også på de totale utslippene til Slovenia og EU, som synes å samsvare med andre funn og statistikk. EEBT synes å være et enklere alternativ for undersøkelsen av CBAM, men MRIO er mer nøyaktig.

Preface

I spent the last 2 and a half years as a double degree master's student in environmental engineering and industrial ecology at both the Technical University of Denmark (DTU) and the Norwegian University of Science and Technology (NTNU). They equipped me with knowledge I believe will help me both in my career and personal life and this thesis has been written as a conclusion to this step of my education.

It explores the impact of the EU Carbon Border Adjustment Mechanism (CBAM) on Slovenia and its correlation to the EU. It was motivated by the importance of understanding how such a relevant and broad mechanism affects a small EU country. I was also very grateful I was able to work in connection to my home country.

Now, I would like to express my gratitude to both my NTNU main supervisor Professor Edgar Hertwich, and co-supervisor Maximilian Koslowski as well as my DTU supervisor Professor Olivier Jolliet for their guidance and support throughout the research process. Their expertise and insights have been invaluable in shaping this thesis.

Next, I would like to thank my friends from DTU, NTNU and Slovenia, who offered constant support that allowed me to complete my studies.

Lastly, I am immensely grateful to my parents and my sister for their amazing support and encouragement during my entire academic journey.

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List of Abbreviations

Abbreviation	Meaning
EU	European Union
CBAM	Carbon border adjustment mechanism
BTA	Border tax adjustment
BCA	Border carbon adjustment
EU ETS	EU Emission trading system
WTO	World Trade Organisation
IO	Input-Output
IOA	Input-Output analysis
MRIO	Multi-regional Input-Output
MRIOA	Multi-regional Input-Output analysis
EE-IOA	Environmentally extended Input-Output analysis
EE-MRIO	Environmentally extended Multi-regional Input-Output
EEBT	Emissions embodied in trade
BTIO	Bilateral trade Input-Output
CGE	Computable general equilibrium
EORA	EORA Multi-regional Input-Output database
WIOD	World Input-Output database
GTAP	Global Trade Analysis Project database
LDS	Least developed countries
BRICS	Brazil, India, China and South Africa
RoW	Rest of world
NEI	National emission inventory
PBA	Production-based accounting
CBA	Consumption-based accounting
TBA	Throughflow-based accounting
IPCC	Intergovernmental Panel on Climate Change
AR5	IPCC Assessment Report 5
GWP100	Global warming potential for 100 years
PYMRIO	PYMRIO documentation
GHG	Greenhouse gas
CO_2	Carbon dioxide
CH_4	Methane
N_2O	nitrous oxide

List of Symbols

Symbol	Unit	Meaning
x	€	Total output (production) vector
Y	€	Total final demand matrix
i	/	Summation vector
A	€	Technical coefficients matrix
a_{ij}	€	Coefficients of A
Z	€	intermediate demand matrix
z_{ij}	€	Coefficients of Z
I	/	Identity matrix
L	€	Leontief inverse or the total requirements matrix
d	Indicator dependent	Total impacts
S	Indicator/Stressor dependent	Characterized/Uncharacterized stressor intensity matrix
m	€	Imports
e	€	Exports
$\rho(A)$	/	Spectral radius of matrix A
R	€	Revenue
τ	€/tonne of CO_2-eq.	Price of a CBAM certificate
€	/	EURO currency

Index	Meaning
Eq.	Equivalent

1 Introduction

1.1 Background to the problem and motivation for the topic

The world is facing a global problem in form of climate change. The concerning data of the last decade (2011-2020) shows it was the warmest decade ever recorded. This has prompted international recognition that we need to keep the global temperature at least below 2°C while spending great effort to limit the rise to 1.5°C compared to the pre-industrial times. If we fail, we will face catastrophic changes in the environment and serious negative impacts on human health and well-being. The main contributor to climate change is the greenhouse effect, caused by greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. Many of them occur naturally in the environment, however, human activities caused unnatural increases in the concentration of some of them in the atmosphere (European Commission, 2023a).

To mitigate this effect the European Union (EU) has committed to reducing its net greenhouse gas (GHG) emissions by at least 55% by 2030 using the "Fit for 55" legislative package. Among other solutions an environmental policy instrument called the Carbon Border Adjustment Mechanism (CBAM) was designed to support its climate goals (European Commission, 2024a). Currently, only the EU producers face a carbon price on their products, while non-EU countries do not have such an obligation, which puts European products at risk of carbon leakage. With the introduction of this mechanism, the importers of carbon-intensive goods (cement, iron and steel, aluminium, fertilizers, hydrogen, and electricity) into the EU will bear similar carbon costs for the "embedded emissions" of the imported goods, as the EU countries do. This way the EU will try to level the playing field of EU and non-EU countries exporting to the EU and incentivise emissions reductions in non-EU countries (European Commission, 2023c, 2024b).

Generally, CBAM is considered an effective measure, to increase the competitiveness of the EU and reduce carbon leakage (Zhong & Pei, 2022), though limited coverage of CBAM might limit its efficiency (Beaufils, Ward, et al., 2023). Khan et al. (2022) also stressed that the design of CBAM will be a mix of efficiency and complexity and a trade-off between political and environmental sustainability, and requires careful attention to institutional design, especially if the goal is to strengthen global climate ambitions in line with the EU's decarbonisation strategy Magacho et al. (2023).

From the methodological perspective, computable general equilibrium models (CGE) dominate the investigation of the effects of CBAM, with Multi-regional Input-Output (MRIO) models representing a much smaller percentage (Zhong & Pei, 2022). Additionally, whenever an MRIO was used mostly EORA and WIOD databases were used while EXIOBASE-based studies were lacking. In addition to CGE and MRIO, other approaches have also been used to determine the environmental impacts of imports and analysis of border tax adjustment (BTA) (Cadarso et al., 2018). One of them is called emissions embodied in trade (EEBT) also referred to as bilateral trade Input-Output (BTIO) which considers total bilateral trade between regions.

Boundary-wise, studies usually considered only the entire EU and focused more on investigating CBAM effects on individual countries outside the EU such as China, India, the

United States, Russia, Ukraine and Turkey, which is of course of great importance since these countries will be most affected (though results vary among different sectors) (Beaufils, Ward, et al., 2023; Cadarso et al., 2018; Rocchi et al., 2018; Zhong & Pei, 2022). There are also studies focusing on individual EU countries such as the effects of CBAM on Finland using a CGE model (Kuusi et al., 2020) and a survey-based study on the acceptance of CBAM by German stakeholders (Kuehner et al., 2022). However, the pool of such studies is small, so it is important to expand the pool of studies in this area.

Despite its small estimated global contribution of carbon emissions of 0,03% (Ritchie et al., 2020). Slovenia was chosen for our investigation. Its selection is supported by the following reasons. As (Ritchie, 2023) stated, even though big countries such as China, the USA and India individually contribute a lot to global GHG emissions, it will be hard to face climate change if all of the small countries decide to do nothing because they feel like their individual contributions are negligible. Their combined emissions still represent a considerable portion of the world's emissions and need to be tackled. Additionally, according to the Climate Change Performance Index (2024), Slovenia is falling short of its commitments and was ranked with low performance in its efforts to combat climate change which provides good motivation for the investigation of the effects of CBAM on Slovenia and could provide valuable insight into which areas of the economy/sectors should Slovenia try and make improvements to lower carbon leakage and do its part in decreasing the EU and nonetheless global GHG emissions. According to the Trading Economics (2024b), around 9% of imports to Slovenia are CBAM-affected sectors. Therefore, we believe it is important to investigate Slovenia's trade relationships, how they relate to CBAM and what could be Slovenia's possible trade improvement implications in the future.

We add to the existing literature by firstly using the environmentally extended multi-regional IO model (EE-MRIO) and the inclusion of the EEBT/BTIO approach as a possible alternative for the calculation of emissions attributed to a country. Secondly, we use this model to investigate the trade implications of a small EU country (Slovenia) and its trade partners in light of CBAM and determine its share in comparison to the entire EU trade scope. Lastly, we use EXIOBASE as a database for the base of our calculations, to broaden the scope of databases used for the investigation of CBAM using MRIO models.

1.2 Goals of this thesis

This thesis aims to investigate how the EU's newly adopted Carbon border adjustment mechanism (CBAM) will affect Slovenia and its trade relationship using an environmentally extended multi-regional IOA model (EE-MRIO) and how this relates to the entire EU.

Based on the main goal the thesis is divided into multiple tasks:

1. Understand how CBAM works and what are its basic implications for international trade.
2. Research previous findings on CBAM.
3. Perform an EE-MRIO for Slovenia to:
    a. Investigate its total emissions using 3 different approaches.
    b. Investigate which Slovenian sectors and trade partners are affected by the implementation of CBAM.
    c. Calculate the CBAM revenue generated by Slovenian trade and what effects it has on the Slovenian economy and specific industry sectors.
    d. Investigate where in the supply chain are most of the Slovenian CBAM-related emissions generated using tier decomposition by the Taylor series.

4. Calculate the total emissions of Slovenia using EEBT and investigate how it compares to MRIO.
5. Use Python programming language to code the EE-MRIO and EEBT models.
6. Analyse the results.
7. Interpret/Discuss the results and assumptions/limitations.
8. Suggest options for future work.

1.3 Assumptions and limitations of this thesis

In order to carry out the thesis and its associated calculations, several assumptions had to be made that potentially impacted the results:

- Our model assumes fixed final demand.
- Use of EXIOBASE:
  - Only 20 non-EU countries/regions are available for investigation of CBAM.
  - A 2019 EXIOBASE 3 v3.8.2 dataset was used, to represent the global economy and supply chains before the COVID-19 pandemic in 2020 and the Ukraine-Russia war that started in 2021.
  - The original EXIOBASE 3 data series ended in 2011. The 2019 data is estimated on auxiliary, trade and macro-economic data.
  - We select sectors from EXIOBASE which relate to the exact sectors under CBAM scope as closely as possible.
  - Even though CBAM's scope includes Hydrogen, our study excludes it as EXIOBASE has no specific sector for Hydrogen.
  - Iceland and Lichtenstein are not included in the EXIOBASE.
- CBAM certification price of 80 €/tonne of CO_2 emitted and 150 €/tonne of CO_2 emitted were used.
- No adjustment of the EXIOBASE database with Slovenian national accounts was performed, leaving the results vulnerable to potential errors.

1.4 Thesis structure

To make the thesis clear and understandable, it is divided into 6 chapters. In the first or introductory chapter (Chapter 1), the background of the problem, the motivation for the topic, and the goals, assumptions, and limitations of the thesis are presented. The next chapter (Chapter 2) presents the theoretical background and previous research findings. Chapter 3 presents the model and its scope, the method applied, and all the indicators included in the analysis. This is followed by two more chapters, namely the presentation of the results (Chapter 4) and the discussion (Chapter 5). The last and final chapter (Chapter 6) presents the key findings of the thesis and suggestions for future work.

2 Background

2.1 What is CBAM? Why is it being implemented?

The Carbon Border Adjustment Mechanism (CBAM) is an environmental policy instrument designed by the European Union (EU) to support its climate ambitions of achieving a net reduction of greenhouse gas (GHG) emissions of at least 55% by 2030 and of reaching climate neutrality by 2050 at the latest. It complements the EU Emission Trading System (EU ETS), which was recently strengthened as part of the EU's "Fit for 55" legislative package. Under the current EU ETS, the producers of carbon-intensive goods must submit emission allowances for each tonne of CO_2-eq. emissions emitted (the relevant industry sectors have been receiving a part of their allowances free of charge) (European Commission, 2023c, 2024b).

Since many allowances are now sold on auctions or secondary markets, EU producers now face a so-called 'carbon price', while non-EU countries do not have such an obligation, which puts European products at risk of carbon leakage (a relocation of production to outside of the EU) (European Commission, 2023c).

With the introduction of CBAM, free EU ETS certificates will be gradually phased out as the CBAM is gradually phased in. Instead of alleviating the carbon costs for EU producers, the CBAM ensures that importers of goods from non-EU countries face similar carbon costs for the embedded emissions of the imported goods, which will try to level the playing field of EU and non-EU countries exporting to the EU and incentivizes those countries to increase their emissions reductions (European Commission, 2023c).

2.2 Sectors

The CBAM does not target countries but rather the embedded carbon emissions of products imported into the EU for specific sectors that pose the highest risk of carbon leakage. These are **cement, iron and steel, aluminium, fertilizers, hydrogen, and electricity**. It also includes some precursors and some downstream products of the aforementioned sectors (European Commission, 2023c).

It is also important to note that the European Parliament (2023) has in the CBAM Regulation stated that current imports of hydrogen into the Union were relatively low, while at the same time aware that the situation is expected to change significantly in the coming years as the Union's 'Fit for 55' package promotes the use of renewable hydrogen, which made the inclusion of hydrogen in the scope of the CBAM is the appropriate.

2.2.1 Price of CBAM certificates and CBAM revenue generation

The CBAM will be based on a system of certificates whose price will be based on a weekly average auction price of EU ETS allowances expressed in € per tonne of CO_2 eq. emitted. To buy CBAM certificates importers will have to register individually or through a representative (European Commission, 2024b). In the same document, the EU also wrote that if a carbon price is already paid outside the EU, it will be partially or fully deducted from the adjustment (e.g. a third country could establish an emissions trading system) and adequate regulation will be adopted by the EU Commission before the end of the transitional period.

Regarding the use of the revenue, the EU Commission proposed a mechanism where CBAM revenue is collected by the competent authority of the Member State where the declarant is located. Member States retain 25% of the CBAM revenues. The remaining 75% is allocated to the EU budget by Member States once per year (in February) following the Commission's call for funds (European Commission, 2023d).

2.2.2 Timeline

CBAM is divided into 2 phases:

1. **Transitional period** (1 October 2023 to 31 December 2025) which serves as a learning period. By the end of the transitional period, the EU Commission will review the collected data and declare whether other goods and sectors covered by the EU ETS which are at risk of carbon leakage might be included in the scope of CBAM.
2. **Definitive period** (starting on 1 January 2026) where the embedded emissions for CBAM goods will be gradually covered by the CBAM obligation. From 2034, 100% of embedded emissions of the CBAM goods will be covered by CBAM certificates and no free allocation will be given under the EU ETS for these goods (European Commission, 2023c).

2.2.3 The scope of emissions

To determine which and how the direct and indirect emissions are covered under the CBAM scope, each sector's particularities have been taken into account (European Commission, 2024b).

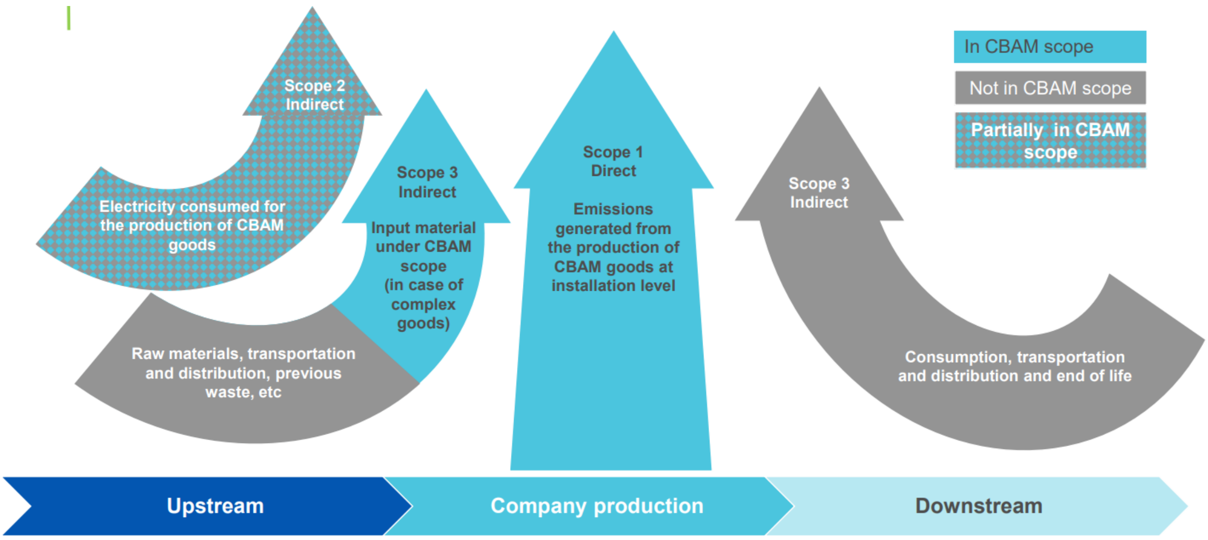

Figure 1: CBAM emissions scope coverage (European Commission, 2023e)

2.2.4 CBAM exemptions

The European Parliament (2023) states in the CBAM regulation document that certain countries/ territories and imports are exempted from CBAM if:

- A country applies the EU ETS (Norway, Iceland, Liechtenstein), or has an ETS fully linked to the EU ETS (Switzerland) as well as several small territories /exclaves such as Büsingen, Heligoland, Livigno, Ceuta, Melilla. These countries together with EU Member states form a CBAM territory,

- the price of the imported goods does not exceed 150€,
- goods are used for military purposes or,
- the non-EU country is so closely integrated with the EU internal market for electricity that a technical solution to apply the CBAM to these imports cannot be found.

2.3 Previous research on CBAM

There is an extensive pool of research that has been conducted in connection with the CBAM or general ideas of border tax mechanisms due to their effect on international trade relationships and global emissions.

Research so far mostly focused on topics such as the investigation of CBAM's effectiveness for increased competitiveness of domestic products, lower carbon leakage, effects on EU trade partners (both developed and developing), the World Trade Organisation (WTO) and other regulation compliance, initiatives/schemes for adoption of greener technologies in countries importing to EU and comparison of different CBAM scenarios (different carbon prices, enlarged scope, inclusion of export rebates, etc.).

2.3.1 CGE vs MRIO

The CBAM-related studies use various methods for their assessment, the most prevalent ones are Computable general equilibrium models (CGE), followed by the Multi-Regional Input-Output models (MRIO). CGE models are mostly used as they can account for carbon emissions as well as demand and welfare impact which are often missing in IO-based studies. Additionally, they use endogenous demand and IO uses exogenous which corresponds to a lack of dynamic adjustments (Zhong & Pei, 2022) seen in both Zhong and Pei (2022) Khan et al. (2022). CGE was also used for the original impact assessment CBAM by the European Commission (2021). However, IO analysis does have some advantages over CGE models. CGE models require many parameter estimates and assumptions (Costinot & Rodríguez-Clare, 2014), while IOA is relatively intuitive, transparent, and reproducible which is of great importance. With some extended framework, IOA can also assess the short-term impacts of a carbon tax on international trade flows (Zhong & Pei, 2022), while CGE models cannot accurately capture such effects (Fullerton & Muehlegger, 2019).

2.3.2 Databases

In this part, we only focus on IO studies. The most used databases were EORA and WIOD. With the inclusion of some other databases such as GTAP and UN COMTRADE. No IOA studies on CBAM seem to have used EXIOBASE.

A short comparison of those databases shows that EORA (Lenzen et al., 2012; Lenzen et al., 2013) has a good country coverage of 190 in comparison to WIOD (Wiod, 2021) and EXIOBASE (Stadler et al., 2021) which focus on Europe and have 43 and 49 countries/regions, respectively. EORA, however, has varying sector and product details ranging from 500 to only 25 in some cases and WIOD has an aggregated industry classification. On the other hand, EXIOBASE offers the highest level of consistent sector detail (of 163 sectors and 200 product groups for all included countries/regions), which is essential for environmental footprint analyses. A drawback of all mentioned databases is that they override country statistics since global trade is not balanced (Tukker et al., 2018). This problem is explored in Chapter 5 of this thesis.

2.3.3 Compliance of CBAM with the international obligations of the EU

Many studies have pointed out the potential noncompliance of CBAM proposals with the WTO and other international obligations and investigated the best way CBAM could be designed to comply with these obligations (Bellora & Fontagné, 2023). All concerns can generally be aggregated into two main aspects. Firstly, the treatment of imported goods in the same way as the domestic goods as WTO members should not treat imports from different trade partners differently (Khan et al., 2022). Secondly, CBAM may shift the burden of climate policy from developed regions (i.e., the EU) to trading partners, particularly developing regions. As these partners usually use carbon-intensive technologies, the mechanism could meet heavy political resistance, spark trade conflicts, and undermine global cooperation on climate action. Therefore, quantifying the competitiveness impacts of the EU CBAM under different policy designs is central to facilitating discussions among academia and policymakers (Zhong & Pei, 2022).

However, it is stated by the Guidance document for CBAM (European Commission, 2023c) that the released version of CBAM for the transitional period on 1st of October 2023 is designed in compliance with the WTO rules and other international obligations of the EU and is applied equally to imports from all countries outside the CBAM territory.

2.3.4 Effect on the main EU trade partners and developing countries

A review of existing literature on CBAM shows that from a broader perspective, CBAM can be to a certain degree considered an effective measure, to increase and maintain the competitiveness of the EU and reduce carbon leakage. The results Mörsdorf (2022) presented suggest that already a narrow version of CBAM would be on par with the current free allocation system in terms of carbon leakage prevention. On the other hand, Zhong and Pei (2023) states that regarding direct impacts there is no consensus in academia on whether CBAM policies are effective in terms of reducing carbon leakage and preserving competitiveness. Most simulations based on economic-theoretical models find CBAM to have some effect, while a few consider it to have a weak or even no effect. Their other study (Zhong & Pei, 2022) shows mixed results on CBAM, mainly that it can preserve the competitiveness of the EU and reduce the carbon leakage caused by the EU ETS, but the reduction of the impact on global carbon reduction is limited. Their literature review in the same study also found that alteration of various other CBAM parameters could make CBAM ineffective or even counterproductive. Furthermore, Khan et al. (2022) states that when implemented it will be a mix of efficiency and complexity and a trade-off between political and environmental sustainability and according to Magacho et al. (2023) requires careful attention to institutional design. It was also stressed by Beaufils, Berthet, et al. (2023) that limited coverage of CBAM might limit its efficiency and Zhang et al. (2021) that CBAM will change the carbon intensity of foreign trade.

From a more country-focused perspective, Beaufils, Ward, et al. (2023) claim that many CBAM-related studies focused mainly on the most prevalent EU trade partners or aggregated the LDS (least developed countries) countries into regions, which is true but a lot of these studies are CGE-based such as Acar et al. (2022); Chepeliev (2021); Gu et al. (2023); Mörsdorf (2022); Perdana and Vielle (2022). However, studies incorporating IOA as the main method also show research for more disaggregated LDS (Beaufils, Ward, et al., 2023; Magacho et al., 2023). Zhong and Pei (2022) find that CBAM will disproportionately affect developing countries which are often carbon-dependent (accommodate dirtier production technologies). Beaufils, Ward, et al. (2023) confirm that by finding that the wealthiest countries will be less affected than low and middle-income countries (such as North and Sub-Saharan Africa) as the latter have a high dependence on imports in the EU and are poorly diversified. They also have minor historical emission responsibilities while simultaneously being at the front line of climate impact change. Such disproportionality could cause the development of inequity (Han et al., 2018) and an increase in geopolitical risk due to unemployment or population movements, problems caused by unemployment, and increased economic burdens in places of population inflow (Bazilian et al., 2019; Wu, 2023).

A detailed look at countries shows that the introduction of the CBAM impacts countries proportionately to their exports (Magacho et al., 2023). From an absolute perspective Russia, China, India, the US and Turkey would be the most affected (Magacho et al., 2023; Rocchi et al., 2018), Zhong and Pei (2022) also adding Indonesia to this list, depending on the sector. The study on China's Belt and Road Initiative (BRI) and the effects of EU BCA (now CBAM) by Khan et al. (2022), shows that only 0.5% of emissions from LDS would be captured by a potential CBAM and around 35% of total emissions from all BRI countries would be captured by CBAM. When looking at specific sectors directly, Russia is mostly affected in connection to the Iron and Steel, Aluminium, Fertilisers, and Electricity sectors. For China, Ukraine, and Turkey most pressured are the Iron and steel and Aluminium sectors. In general, the Iron and Steel sector is the most impacted including the US, other BRICS countries (Brazil, India, and South Africa), South Korea and Ukraine. Relatively speaking (percentage of total exports from a specific country), the picture is a bit different. Again, Ukraine and Russia are highly affected, but in addition, several other countries, such as Mozambique, Serbia, Bosnia–Herzegovina, Montenegro, North Macedonia, and Bahrain will potentially be greatly impacted by CBAM as a relevant part of their emissions (direct or indirect) falls under CBAM (Magacho et al., 2023).

2.3.5 Scenarios

The majority of the studies on CBAM were conducted before the actual implementation and final version of CBAM, which prompted researchers to investigate different scenarios of CBAM and how might these scenarios affect carbon leakage and trade relationships. The various investigated scenarios included different sector coverage (Beaufils, Ward, et al., 2023; Bellora & Fontagné, 2023; Gu et al., 2023) the inclusion of export rebates on a calculation of emissions (Beaufils, Ward, et al., 2023; Bellora & Fontagné, 2023), different carbon tax prices (Khan et al., 2022; Zhong & Pei, 2022)or exemptions, price reductions and cost adjustments (Zhong & Pei, 2022). It is important to note that Hydrogen is excluded from more or less all studies and is rarely mentioned in the literature in connection with CBAM. Possibly because it was still marginal in 2016, even though it may become a larger source of emissions in the future as the trade of hydrogen is set to increase in the next decades (Beaufils, Ward, et al., 2023).

2.3.6 Revenue allocation, recycling schemes and other solutions

The distribution of CBAM revenue and the treatment of exports from developing countries are two closely related issues. After several different revenue allocation proposals it was finally accepted that CBAM would be allocated to the general EU budget (Bellora & Fontagné, 2023). Member States will retain 25% of the CBAM revenues. The remaining 75% is allocated to the EU budget by Member States once per year (in February) following the Commission's call for funds (European Commission, 2023d). Additionally, the EU has through CBAM regulation (European Parliament, 2023) committed that it will, through its budget, support climate mitigation and adaptation in low and middle-income third countries and work with them towards the decarbonisation and transformation of manufacturing industries. Such financial support (revenue recycling scheme) was also proposed by various studies (Beaufils, Ward, et al., 2023; Bellora & Fontagné, 2023; Khan et al., 2022; Zhong & Pei, 2022) to help the most vulnerable countries invest in decarbonisation and/or access low-carbon technologies to adapt to changing climate. CBAM could also create an incentive for non-EU countries to implement their carbon pricing scheme to keep the revenue otherwise captured by the EU (Beaufils, Ward, et al., 2023). (Beaufils, Ward, et al., 2023; Khan et al., 2022; Zhong & Pei, 2022) also suggests that the most vulnerable countries could be exempted from CBAM, either indirectly (limited sectors coverage) or directly (exempting the imports), though this was suggested under a comprehensive CBAM implemented which covers all imports and not only those that are currently covered by CBAM. However, this latter solution could, in specific circumstances, undermine the legitimacy of the CBAM by creating new forms of carbon havens, and must be approached with caution (Branger & Quirion, 2013).

3 Methods and Model

In this chapter we introduce the data source, the methodological approach and the model used to reach the set goals. First, we provide information about the data source and why we use it. Secondly, we provide a brief description of Input-Output basics which is followed by the more in-depth formulation of our model. Finally, we present the model that was used to assess the CBAM's effect in Slovenia and its international trade.

3.1 Database

Our analysis is based on the EXIOBASE 3 database (Stadler et al., 2021). It provides a time series of environmentally extended multi-regional Input-Output (EE-MRIO) tables for 44 countries (28 EU members plus 16 major economies) and 5 rest of the world (RoW) regions. The database offers good product coverage (homogenous coverage of 200 product classifications for all countries/regions). EXIOBASE 3 does not include Hydrogen as a product category, therefore, hydrogen was omitted from the analysis. Additionally, it offers 126 indicators for a broad environmental assessment.

For the calculation, a 2019 EXIOBASE 3 v3.8.2 dataset was used. This specific year was chosen to best represent the realistic global trade and supply chains since it was the last year before the economy was extensively affected by the COVID-19 pandemic and the Ukraine-Russia war. The original EXIOBASE 3 data series ended in 2011, however, additional data was estimated up to 2022 based on a range of auxiliary, trade and macro-economic data. Additionally, v3.8.2 was updated with some more recent endpoints: energy (2015), all GHG (2019; nonfuel, non-CO_2 are now cast from 2018), and material (2013). EXIOBASE also offers the selection of characterized or uncharacterized data for additional assessment if needed (Stadler et al., 2021).

3.2 Input-Output analysis

Input-Output analysis (IOA) is an analytical framework designed by Professor Wassily Leontief in the late 1930s. The fundamental purpose of the IO framework is to analyse the interdependence of industries in an economy. In its most basic form, an IO model consists of a system of linear equations, each one of which describes the distribution of an industry's product throughout the economy. Assume that the economy can be categorized into n sectors. If we denote by x as the total output (production) of sector i and by Y as the total final demand for the sector i's product, we may write a simple equation (3.1) accounting for how sector i distributes its product through sales to other sectors and final demand (Miller & Blair, 2021).

$$x = Zi + Y = Ax + Y \tag{3.1}$$

Other terms in the equation are as follows, A is a technical coefficients matrix (where coefficients a_{ij} represent the inputs from sector i that are required to satisfy per unit of final delivery of process j), Z is an intermediate demand matrix (where z_{ij} terms represent interindustry/intermediate sales by sector i to all sectors j, including itself, when j =i), and i is a summation vector.

The final demand in IO is often split into different N final consumers (e.g., households, governments, and capital) and must be in our case summed up to a single vector as we are not interested in separate final demand for each consumer but rather total final demand (eq. 3.2)

$$Y = \sum_{c=1}^{N} Y^c \tag{3.2}$$

If we reformulate the equation (3.1), the total output can be calculated as follows:

$$x = (I - A)^{-1}Y = L * Y \tag{3.3}$$

Where, L is the Leontief inverse or the total requirements matrix (which tells us the amount of process i that is required to deliver a unit of final demand Y) and I is an identity matrix.

$$L = (I - A)^{-1} \tag{3.4}$$

3.3 Environmentally extended Input-Output Analysis (EEIOA)

Since we are trying to investigate the environmental impacts of the products affected by CBAM imported into Slovenia an extended IO framework has to be utilised. This method accounts for environmental pollution generation and abatement associated with inter-industry activity (Miller & Blair, 2021) and is referred to as Environmentally extended Input-Output analysis (EE-IOA).

3.3.1 Accounting approaches

Since the introduction of EE-IOA, various accounting approaches have been developed to calculate the impacts associated with National emission inventories (NEI). Among those the following three are being used throughout the thesis:

- Production-based accounting (PBA)
- Consumption-based accounting (CBA)
- Throughflow-based accounting (TBA)

Production-based Accounting (PBA) evaluates impacts directly generated within a territory of an economic entity (such as a country), which is domestic production including exports, putting pressure of the environmental impacts on the producer. Conversely, **Consumption-based Accounting (CBA)** consists of domestic production including exports which shifts the responsibility for environmental impacts to the consumer. The final one called **Throughflow-based Accounting (TBA)** developed by Beaufils, Berthet, et al. (2023) capturing the volume of upstream externalities caused by all the supply chains starting from, traversing, and ending in a given country. The TBA framework further decomposes the throughflow into four meaningful elementary components: local, imported, exported, and traversing externalities, meaning that TBA is coherent with the PBA and CBA frameworks, however, it has a broader coverage than both by acknowledging simultaneously the production, consumption and intermediate contribution of a country to externalities production worldwide.

It should be noted that PBA was only used for the comparison of the total emissions of Slovenia and is excluded for sectoral/product and origin country comparison since it does not include any emissions that are affected by CBAM since Slovenia as the country under investigation is in the EU.

For the investigation of National Emission Inventories (NEI), 2 methods are widely recognized, the first being Emissions embodied in bilateral trade (EEBT), which considers total bilateral trade between regions and the other that considers trade to final consumption and endogenously determines trade to intermediate consumption called Multi regional Input-Output (MRIO) (Peters, 2008). Both are presented in more detail below, while the comparison and applicability of both methods in the investigation of CBAM are explored and discussed in Chapter 5.

3.4 Emissions embodied in bilateral trade (EEBT)

The emissions embodied in bilateral trade (EEBT) are calculated directly using monetary bilateral trade data. It determines the emissions in one region, r, to produce the bilateral trade flow e_{rs}, and these are the emissions embodied in trade from region r to region s. It is important to note that EEBT does not split the bilateral trade flow into components of intermediate and final consumption, but rather considers total consumption. Following the paper by Peters (2008), we only formulate the EEBT for CBA and PBA as TBA has only been developed for the MRIO method. When using the EEBT the emissions are separated into domestic (d_{rr}) and production/exports (d_{rs}) for PBA (eq. 3.5) and domestic (d_{rr}) and consumption/imports (d_{sr}) for CBA (eq. 3.8).

3.4.1 EEBT Consumption-based accounting (CBA)

The EEBT CBA can be formulated as follows:

$$d = d_{rr} + d_{sr} + d_Y = S_r L_{rr} Y_{rr} + S_s L_{ss} m_{sr} + d_Y \tag{3.5}$$

$$\textit{Where} \quad m_{sr} = Z_{sr} + Y_{sr} \tag{3.6}$$

$$d = S_r L_{rr} Y_{rr} + \sum_{s \neq r}^{i} S_s L_{ss} \left(\sum_{s \neq r}^{i} Z_{sr} + Y_{sr}\right) + d_Y \tag{3.7}$$

The first term of the equation is domestic emissions (d_{rr}) and the second is exported emissions (d_{rs}). The r is the country of interest, s is every country different to the country r, d is a vector of total impacts associated with the consumption of the country r, S_r is the characterized stressor intensity matrix for the country r, S_s is the characterized stressor intensity matrix for a country s, Z_{rs} is intermediate demand matrix from country s to country r, L_{rr} is the Leontief inverse of country r, L_{ss} is the Leontief inverse of the country s, Y_{rr} is the final demand of the country r to the country r, Y_{sr} is the final demand of the country s to country r, d_Y is direct emissions of final demand for the country r.

3.4.2 EEBT Production-based accounting (PBA)

The EEBT PBA can be formulated as follows:

$$d = d_{rr} + d_{rs} + d_Y = S_r L_{rr} Y_{rr} + S_r L_{rr} e_{rs} + d_Y \tag{3.8}$$

$$\textit{Where} \quad e_{rs} = Z_{rs} + Y_{rs} \tag{3.9}$$

$$d = S_r L_{rr} Y_{rr} + \sum_{s \neq r}^{i} S_r L_{rr} \left(\sum_{s \neq r}^{i} Z_{rs} + Y_{rs}\right) + d_Y \tag{3.10}$$

The first term of the equation is domestic emissions (d_{rr}) and the second is imported emissions (d_{sr}). The nomenclature: r is the country of interest, s is every country different to the country r, d is a vector of total impacts associated with the consumption of the country r, S_r is the characterized stressor intensity matrix for the country r, Z_{rs} is intermediate demand matrix from the country r to a country s, L_{rr} is the Leontief inverse of country r, Y_{rs} is the final demand of a country r to a country r, d_Y is direct emissions of final demand for the country r.

3.5 Multi-regional Input-Output Analysis (MRIOA)

Since basic IO tables are built for one region, we cannot investigate interregional interactions with them. For this purpose, we use Multi-regional IO (MRIO) tables, which show the interconnections across various industries located in different geographic regions. They record the flow of products from each industry in each region (a producer) to each of the industries in each of the regions (a consumer). MRIO tables can then be used for MRIOA which offers a variety of research options (e.g., investigation of impacts on domestic industries of a country that are induced by a change in another country and vice versa) (Murray & Wood, 2010). By contrast to EEBT, MRIO separates the total consumption into intermediate and final consumption (eq. 3.6 and 3.9) (Peters, 2008).

Since pollution generation has to be implemented into the calculation, we introduce a matrix of pollution output or direct impact coefficients matrix S. Since EXIOBASE already provides a characterized S matrix, we don't need to additionally multiply with a characterization matrix C which converts emissions of different stressors (e.g. Carbon dioxide (CO_2), methane (CH_4) …) with the same type of impacts to different impact categories/equivalents for easier interpret.

$$d = SLy = Sx \tag{3.11.}$$

The obtained d vector represents the total impacts caused by the investigated body.

For MRIO all three previously presented accounting approaches (CBA, PBA, and TBA) will be investigated and compared.

3.5.1 MRIO Consumption-based Accounting (CBA)

Since we are only interested in the satisfaction of Slovenian final consumption, we can construct the CBA framework:

$$d_r = SLY_r + d_Y \tag{3.12}$$

d_r is a vector of total impacts associated with the consumption of a country r, S is the characterized stressor intensity matrix, L is the Leontief inverse, Y_r is the final demand matrix of the country r and d_Y is direct emissions of final demand for a country r which is added since the first term only accounts for the indirect impacts of the final demand.

To obtain the total emission per sector (d_{pro}), which is needed to isolate the CBAM-related emissions the final demand vector Y_r has to be diagonalized (nominated by the hat ^):

$$d_{pro} = SL\widehat{Y_r} \tag{3.13}$$

It can also be seen that the direct emissions of the final demand d_Y are excluded here since they should not be accounted for when sectoral/product emissions are investigated.

3.5.2 MRIO Production-based Accounting (PBA)

In the PBA we are only interested in emissions occurring on the territory of Slovenia, and we can construct the PBA framework as follows:

$$d = S_r LY + d_Y \tag{3.14}$$

d_r is a vector of total impacts associated with the consumption of the country r, S_r is the characterized stressor intensity matrix, L is the Leontief inverse, Y is the final demand matrix of the country r and all other countries and d_Y is direct emissions of final demand for the country r which is added since the first term only accounts for the indirect impacts of the final demand.

3.5.3 MRIO Throughflow based accounting (TBA)

We present the structure of the TBA under the original formulation presented by Beaufils, Berthet, et al. (2023). The first three parts of the throughflow are local, imported and exported emissions. Additionally, the throughflow also includes previously mentioned traversing emissions caused by traversing supply chains which identify the emissions generated abroad for supplying the final demand abroad, but whose associated supply chain involves a country r at least once. This can be formulated in the following manner:

$$d_{tba} = d_{loc} + \sum d_{imp} + \sum d_{exp} + \sum d_{tra} + d_Y \tag{3.15}$$

where the first terms in the equation are calculated using the following formulae:

$$d_{loc} = S_r LY_r \tag{3.16}$$

$$d_{imp} = S_s LY_r \tag{3.17}$$

$$d_{exp} = S_r LY_s \tag{3.18}$$

d_{tba} is a vector of total impacts associated with the consumption of the country r, S_r is the characterized stressor intensity matrix of the country r, where all but country r's intensities are set to 0, S_s is the characterized stressor intensity matrix, where only country r's intensities are set to 0, L is the Leontief inverse, Y_r is the final demand matrix of the country r, Y_s is the final demand matrix of all countries but the country r and d_Y is direct emissions of final demand for country r which is added since the first term only accounts for the indirect impacts of the final demand.

The throughflow emissions (d_{tra}) as formulation by Beaufils, Berthet, et al. (2023) are calculated by applying the Hypothetical extraction method (HEM) which is an approach to identify how the total output changes in the absence of the extracted country in such a way that all upstream externalities generated by supply chains either starting from, passing through or ending in a given country are considered. This means that we identify the economy we want to exclude and then instead of physically deleting rows and columns of that economy we can simply replace it with zeros (Miller & Blair, 2021).

The first step is to derive the matrix of input coefficients in the absence of a given country r, called $\overline{A_r}$. The coefficients corresponding to inter-industry relations within r, imports to r and exports from r are set to 0:

$$\overline{A_r} = (\bar{a}_r^{ir\to js}) = \begin{cases} 0 & if\ s = r\ or\ c = r \\ a^{ir\to js} & otherwise \end{cases} \tag{3.19}$$

Based on the new technical coefficient matrix a HEM Leontief inverse can be defined:

$$\overline{L_r} = (I - \overline{A_r})^{-1} \tag{3.20}$$

The HEM Leontief inverse $\overline{L_r}$ describes the direct and indirect inputs needed to produce one unit of output in a hypothetical economy where a country r was removed. With the HEM Leontief, we can now define the traversing externalities:

$$d_{tra} = S_s(L - \overline{L_r})Y_c \tag{3.21}$$

Where S_s is the characterized stressor intensity matrix, where only country r's intensities are set to 0, and Y_c is a final global demand where the final demand for the country r is set to 0.

As stated before, TBA also incorporates the emissions captured by CBA and PBA approaches. Using the TBA part separation, we can formulate CBA and PBA as well (Beaufils, Berthet, et al., 2023).

$$d_{cba} = d_{loc} + \sum d_{imp} + d_Y \tag{3.22}$$

$$d_{pba} = d_{loc} + \sum d_{exp} + d_Y \tag{3.23}$$

3.5.4 CBAM emissions calculation

For the calculation of emissions directly associated with CBAM, a slight adjustment has to be made for the CBA and TBA approaches, since CBAM only covers emissions from imports. We do that by excluding domestic emissions from the CBA approach and domestic and exported emissions from the TBA approach.

Additionally, we only include emissions from countries outside the CBAM territory (described in Chapter 2).

3.6 Taylor series for tier decomposition

In the final step, we are also interested in where in the global supply chain the CBAM-related emissions related to Slovenia are generated. To achieve that we need to decompose the emissions generated in so-called tiers. Each tier represents a round of activities initiated as a result of our demand in the previous tier. This way we move further upstream.

To formulate the tiers, we have to first take a closer look at the Leontief inverse, which can be represented as a geometric series expansion. It is a sum of the matrix A^t where $i = 0\ to\ \infty$ converges and is equal to $(I - A)^{-1}$ if the spectral radius of the matrix A is smaller than 1 - $(\rho(A) < 1)$:

$$\sum_{t=0}^{\infty} A^t = I + A + A^2 + A^3 + \cdots + A^n = L = (I - A)^{-1} \quad if\ \ \rho(A) < 1 \tag{3.24}$$

Each term here is referred to as a tier (I is tier 0, A is tier 1, etc.)

In order to investigate how far the emissions from CBAM-affected sectors both CBA and TBA approaches were used, and their formulation is shown in subchapters 3.6.1 and 3.6.2.

3.6.1 Decomposed CBA

When calculating the emissions of each tier using the CBA, we have to multiply both sides of the equation with the final demand of the country r (Y_r) on the right side and characterized stressor intensity matrix (S_s) on the left side following the general formulation of CBA.

$$\sum_{i=0}^{\infty} S_s A^t Y_r = S_s I Y_r + S_s A Y_r + S_s A^2 Y_r + S_s A^3 Y_r + \cdots + S_s A^n Y_r = d_{imp} \quad (3.25)$$

$$d_{imp} = S_s L Y_r \ = S_s (I - A)^{-1} Y_r \quad (3.26)$$

$$if \ \ \rho(A) < 1$$

Each term on the right-hand side of the equation represents one tier, the first one is closest to the object we are classifying as the final emitter and the last one the furthest way.

3.6.2 Decomposed TBA

When calculating the emissions of each tier using the TBA, the calculation is more complex since the calculation also includes traversing emissions in addition to imports.

For the imported emissions we use the equation (3.25). For the traversing emissions, the equation (3.24) has to be adjusted even further if we follow the equation (3.21).

The first part is:

$$\sum_{i=0}^{\infty} S_s A Y_c = S_s I Y_c + S_s A Y_c + S_s A^2 Y_c + S_s A^3 Y_c + \cdots + S_s A^n Y_c = d_{tra_{tot}} \quad (3.27)$$

$$d_{tra_{tot}} = S_s L Y_c = S_s (I - A)^{-1} Y_c \quad (3.28)$$

$$if \ \ \rho(A) < 1$$

The second part includes the HEM (absence of country r):

$$\sum_{i=0}^{\infty} S_s \bar{A}_r^t Y_c = S_s I Y_c + S_s \bar{A}_r Y_c + S_s \bar{A}_r^2 Y_c + S_s \bar{A}_r^3 Y_c + \cdots + S_s \bar{A}_r^n Y_c = d_{tra_{HEM}} \quad (3.29)$$

$$d_{tra_{HEM}} = S_s \bar{L}_r Y_c = S_s (I - \bar{A}_r)^{-1} Y_c \quad (3.30)$$

$$if \ \ \rho(\bar{A}_r) < 1$$

Both Leontief inverses (original and HEM) were multiplied with the final demand of countries different from the country r (Y_c) on the right side and characterized stressor intensity matrix (S_s) on the left side following the general formulation of TBA.

In the next step we need to subtract the equation (3.29) from equation (3.27) to obtain the decomposed emissions equation for traversing emissions (3.31):

$$\sum_{i=0}^{\infty} S_s(A^t - \bar{A}_r^t)Y_c = S_s(A - \bar{A}_r)Y_c + S_s(A^2 - \bar{A}_r^2)Y_c + S_s(A^3 - \bar{A}_r^3)Y_c + \cdots + S_s(A^n - \bar{A}_r^n)Y_c = \quad (3.31)$$

$$= d_{tra} = S_s(L - \overline{L_r})Y_c \quad (3.32)$$

$$if \;\; \rho(\bar{A}_r) < 1 \wedge \rho(A) < 1$$

This equation identifies the tier to which emissions originate from country s, passing through country r, and ending up in country c.

To form the total CBAM-relevant TBA per tier emissions, the imports (d_{imp}) and traversing (d_{tra}) emissions have to be summed.

3.7 CBAM revenue

Estimation of the CBAM certificates and the revenue created by its implementation can also be calculated.

The price of the certificates will be calculated depending on the weekly average auction price of EU ETS allowances expressed in €/tonne of CO_2 emitted. Our model assumes 2 different prices. The 1st scenario assumes the price τ_{CBAM} of 80 €/tonne of CO_2 emitted. The value was assumed on January 8th 2024 obtained from the Trading Economics (2024a) website which tracks the EU allowances price. Since the price of the ETS allowances is expected to increase, the 2nd scenario assumes the price of 150 €/tonne of CO_2 emitted which was estimated by the Centre for Climate and Energy Analysis (CAKE) for the year 2030 (last year for which the estimation is available) presented in the paper by Pahle et al. (2022). Among the different estimations available, the price estimation by CAKE was selected as it was the only one that accounted for CBAM.

To obtain the total revenue generated by the emissions priced by CBAM, we have to multiply them by the CBAM certificate price. This way we obtain the sectoral revenue (equations 3.33 and 3.34).

$$R_{cba} = \tau_{CBAM} * d_{cba\_CBAM} \quad (3.33)$$

$$R_{tba} = \tau_{CBAM} * d_{tba\_CBAM} \quad (3.34)$$

d_{cba_CBAM} and d_{tba_CBAM} designate only the emission that falls under the CBAM scope and R_{cba} and R_{tba} designate revenue matrices.

We are also interested in the relative contribution of CBAM revenue to the increase in expenditures of sectors in Slovenia, therefore, we need to add these revenues to the appropriate coefficients in the intermediate demand matrix Z. To obtain the desired results the equation (3.35) is used.

$$\% \, increase = \left(\frac{Z_{new}}{Z_{old}} - 1\right) * 100\% \quad (3.35)$$

Additionally, the total relative increase can be calculated using the same equation (3.35) but we first need to individually sum both of the intermediate demand matrices Z_{old} and Z_{new} into single values.

3.8 Python Model

The model used was programmed in Python version 3.9.16.

3.8.1 Indicators

To obtain a broader picture regarding CBAM multiple indicators were used to assess its implications for Slovenia.

- **Global warming potential GWP100 (AR5/IPCC, 2010)** (from now on referred to as 'GWP100')
- **Employment,**
- **Value added.**

There are multiple GWP indicators available at EXIOBASE. The Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR5) GWP100 indicator from 2010, was the most recent one as was selected to provide the most up-to-date results.

Even though the focus of this thesis is to investigate the environmental aspects of CBAM and its effect on trade in Slovenia, we chose to add Employment and Value added to briefly investigate also its social-economic impacts.

3.8.2 Sector and Country Scope

3.8.2.1 Country scope

The country scope used in our model and analysis corresponds to the country coverage available at EXIOBASE - 44 countries (27 EU members and 17 major economies) and 5 rest of the world (RoW) regions. Lichtenstein and Iceland are not available for EXIOBASE and were excluded from our analysis.

Full nomenclature for the country abbreviations is available as supplementary data of the study Stadler et al. (2018).

Additionally, Norway and Switzerland belonging to the CBAM territory have been excluded as countries importing into Slovenia and the EU.

3.8.2.2 Sector scope

The exact sector scope that falls under CBAM, presented in the CBAM regulation document does not correspond directly to EXIOBASE sector availability. The CBAM sector scope included in our analysis was selected to best reflect the real sector coverage of CBAM. A full list of the selected sectors is the following:

- Cement, lime and plaster,
- Sand and clay,
- Iron ores,
- Basic iron and steel and of ferro-alloys and first products thereof,
- Aluminium and aluminium products,
- N-fertiliser,
- P- and other fertiliser,
- Electricity by coal,
- Electricity by gas,
- Electricity by nuclear,
- Electricity by hydro,
- Electricity by wind,

- Electricity by petroleum and other oil derivatives,
- Electricity by biomass and waste,
- Electricity by solar photovoltaic,
- Electricity by solar thermal,
- Electricity by tide, wave, ocean,
- Electricity by Geothermal,
- Electricity nec.

4 Results

In this section the results of our study are presented whose implications are discussed in Chapter 5: Discussion.

The main indicator for the calculation and acquisition of the results was GWP100.

The results section is divided into several subchapters, focusing on different aspects:

- Total GWP100, Total Employment and Total Value added of Slovenian trade.
- CBAM-relevant GWP100, Employment and Value added of Slovenian trade per Sector and country of origin.
- Tier decompositions of CBAM-relevant emissions.
- Comparison of Slovenia and the EU.
- CBAM revenue generation for Slovenia and the EU.

In this chapter, we also refer to some values which are presented in tables in the Appendix.

4.1 Total GWP100, Employment and Value added

The first part of the results focused on the calculation of the total GWP100 of Slovenian trade. The impacts were investigated for 3 indicators mentioned in Chapter 3 those are GWP100, Employment and Value added. For all three indicators, 5 approaches were compared.

4.1.1 Total GWP100

Table 1 and Figure 2 show an overview of the results for total emissions of Slovenia. The TBA approach captures the most emissions with a GWP100 of 35.7 Mt CO_2-eq., followed by both EEBT and MRIO CBA approaches, which in comparison to the TBA captured less emissions and sum up to 24.1 and 22.7 Mt CO_2-eq., respectively, capturing 64% and 68% of emissions in comparison to TBA. The least emissions were captured by both EEBT and MRIO PBA approaches which also yielded the same result. In comparison to TBA and CBA, they show a GWP100 of 17.1 Mt CO_2-eq., capturing less than half (48%) of total TBA emissions. Comparing PBA to CBA we can see that PBA captures around 75% of emissions that CBA does.

Table 1: Total GWP100 of Slovenia (MRIO PBA, CBA and TBA; EEBT PBA and CBA)

Emission type	TBA	CBA (MRIO)	PBA (MRIO)	CBA (EEBT)	PBA (EEBT)
Local	6.92	6.92	6.92	6.91	6.91
Imports	12.57	12.57	0	14.07	0
Exports	7.02	0	7.02	0	7.03
Traversing	9.16	0	0	0	0
Direct emissions	3.17	3.17	3.17	3.17	3.17
Total	**35.67**	**22.67**	**17.11**	**24.14**	**17.11**
Percentage of TBA	n/a	64%	48%	68%	48%

*All values are in Mt CO_2-eq.

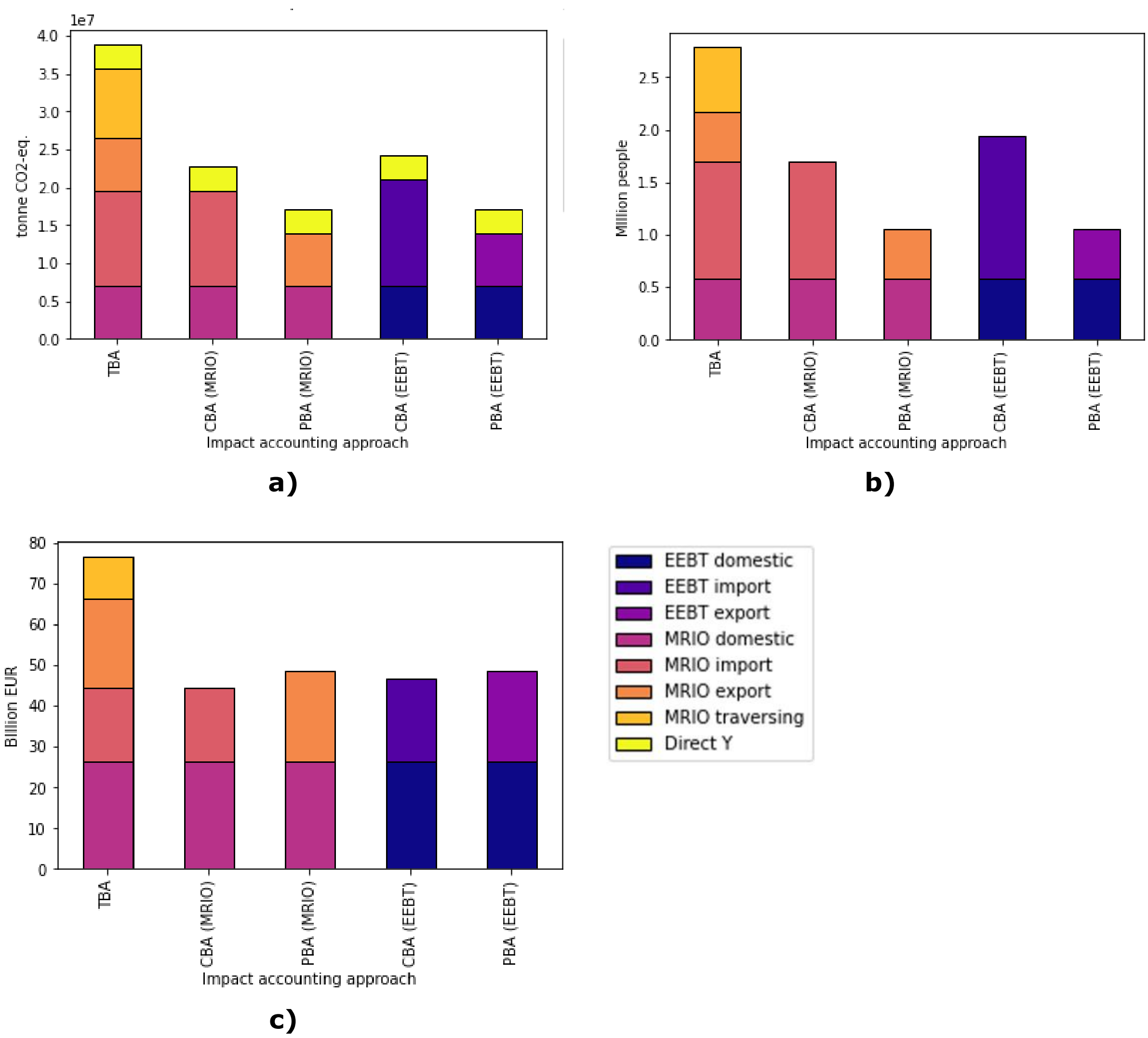

Figure 2: a) Total GWP100, b) Total Employment and c) Total Value added for Slovenia

In the flow diagram in Figure 3 (direct emissions of the final consumption are excluded), we can see the composition of TBA. Since TBA captures all the emissions of PBA and CBA as well, we can see a nice representation of emissions flows for all 3 approaches associated with Slovenia.

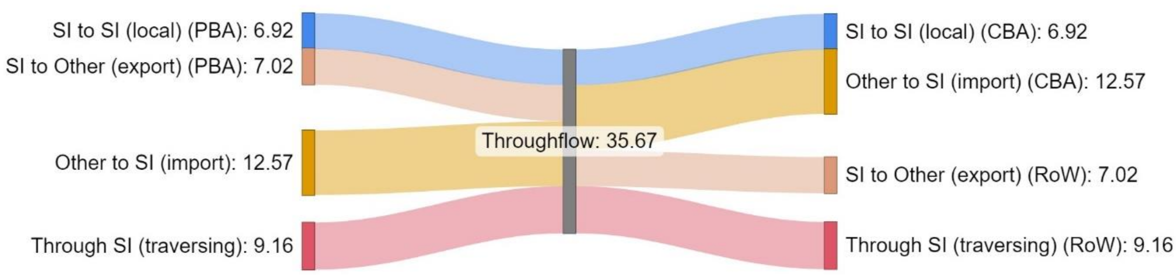

Figure 3: Flow diagram for GWP100 (Slovenia), for MRIO PBA, CBA and TBA (all values are in Mt CO_2-eq.)

4.1.2 Total Employment and Value added

Regarding the Employment indicator (Table 2) for Slovenia, we can see that TBA captures the highest amount of people employed (2.79 million people), followed by the CBA MRIO & EEBT capturing 1.70 million people (61%) and 1.94 million (70%), respectively the least is again captured by PBA and MRIO & EEBT approaches capturing 1.06 million people (38%).

Table 2: Total employment of Slovenia (MRIO PBA, CBA and TBA; EEBT PBA and CBA)

Location of employment	TBA	CBA (MRIO)	PBA (MRIO)	CBA (EEBT)	PBA (EEBT)
Local	0,59	0,59	0,59	0,58	0,58
Import	1,11	1,11	0,00	1,35	0,00
Export	0,47	0,00	0,47	0,00	0,47
Traversing	0,62	0,00	0,00	0,00	0,00
Direct	0,00	0,00	0,00	0,00	0,00
Total	**2,79**	**1,70**	**1,06**	**1,94**	**1,06**
Percentage of TBA	n/a	61%	38%	70%	38%

*All values are in Millions of people

The TBA shows the highest Value added of 76.6 billion €. The relative difference between approaches for the Value added is smaller as compared to GWP100 and Employment. PBA shows a higher amount of Value added (48.4 billion €) than both EEBT & MRIO CBAs (44.3 and 46.8 billion €). All of these approaches include around 60% of the Value added captured by the TBA approach.

Table 3: Total Value added of Slovenia (MRIO PBA, CBA and TBA; EEBT PBA and CBA)

Location of Value added	TBA	CBA (MRIO)	PBA (MRIO)	CBA (EEBT)	PBA (EEBT)
Local	26,36	26,36	26,36	26,32	26,32
Import	17,94	17,94	0,00	20,46	0,00
Export	22,04	0,00	22,04	0,00	22,07
Traversing	10,22	0,00	0,00	0,00	0,00
Direct	0,00	0,00	0,00	0,00	0,00
Total	**76,56**	**44,30**	**48,39**	**46,78**	**48,39**
% of TBA	100%	58%	63%	61%	63%

*The values are in Billion €

4.2 CBAM affected sectors

In this next batch of results, we present the results regarding the extent and effects of CBAM on the imports to Slovenia using both CBA and TBA for all indicators. The MRIO PBA, EEBT CBA and PBA were not included here for the reasons we discuss in Chapter 5.

Since CBAM only affects the imports into Slovenia, the emissions included for the analysis were adjusted accordingly:

- CBA: Only the import (d_{imp}) portion of total CBA was taken into account,
- TBA: The import (d_{imp}) and traversing (d_{tra}) portions of total TBA were taken into account.

Table 4: Separation of total GWP100 on the EU, non-EU, CBAM and non-CBAM affected sectors for CBA

CBA	All sectors	% of Total	CBAM sectors	Relative (%)**	non-CBAM sectors	Relative (%)**
EU	18.2	80.32%	/	/	/	/
non-EU	4.5	19.68%	0.009	0.21%	4.452	99.79%
Total	**22.7**			**0.04%**		**19.64%**

*All values are in Mt-CO_2-eq.
** Light grey percentages both refer to the light grey absolute value. Similarly, dark grey percentages refer to dark grey values.

Table 5: Separation of total GWP100 on the EU, non-EU, CBAM and non-CBAM affected sectors for TBA

TBA	All sectors	% of Total	CBAM sectors**	Relative (%)**	non-CBAM sectors**	Relative (%)**
EU	29.4	82.48%	/	/	/	/
non-EU	6.3	17.52%	0.019	0.30%	6.230	99.70%
Total	**35.7**			**0.05%**		**17.46%**

*All values are in Mt-CO_2-eq.
** Light grey percentages both refer to the light grey absolute value. Similarly, dark grey percentages refer to dark grey values.

CBA

From the total perspective, our results show that CBAM-relevant sectors account for 9200 tons of CO_2-eq., which is 0.04% of the total GWP100, and 0.21% of GWP100 for non-EU imports into Slovenia. In general, non-EU imported emissions account for around 20% of the total emissions of Slovenia.

Among the CBAM-relevant sectors, the most affected are Electricity by gas, Aluminium and aluminium products, followed by Basic iron & Steel, representing 33%, 32%, and 22% of the total CBAM-relevant GWP100, respectively. Several electricity sectors show no emissions at all (Figure 4).

Individual country contributions are shown in Figure 5 and Table (---) in the Appendix. The region Rest of Europe (WE) produces most of these emissions accumulating at 56%, dominating Electricity by gas sector, it is followed by the Rest of Africa region (WF) and South Korea (KR), with 13% and 9% respectively. Countries like Brazil (BR), India (IN) and China (CN) show a contribution of 4-5%, while all other countries show minimal contribution below 2%.

TBA

From the total perspective, our results show that CBAM-relevant sectors account for 18700 tons of CO_2-eq., which is 0.05% of the total CBA GWP100, and 0.30% of non-EU imports into Slovenia. In general, non-EU imported emissions as well as traversing emissions account for around 17.5 of total emissions into Slovenia.

Among the CBAM-relevant sectors, the most affected are again Electricity by gas, Aluminium and aluminium products, and Iron and steel, representing 25%, 17%, and 15% of the total CBAM-relevant GWP100, respectively. The total share of these sectors is reduced as other sectors, such as Electricity by coal, Electricity by nuclear, Iron ores and

P- and other fertilizers show non-negligible contributions to CBAM-relevant GWP100. All other sectors also show a contribution of below 3% (Figure 4; see the Appendix;). All sector's emissions are more evenly distributed among the countries in comparison to CBA.

Similar to CBA, the Rest of Europe (WE) produces the majority of CBAM-relevant GWP100 (53%). Russia (RU) (10%), the Rest of Africa region (WF) (7%) and India (IN) (6%), also have higher contributions. Generally, a much bigger portion of countries show more significant contribution.

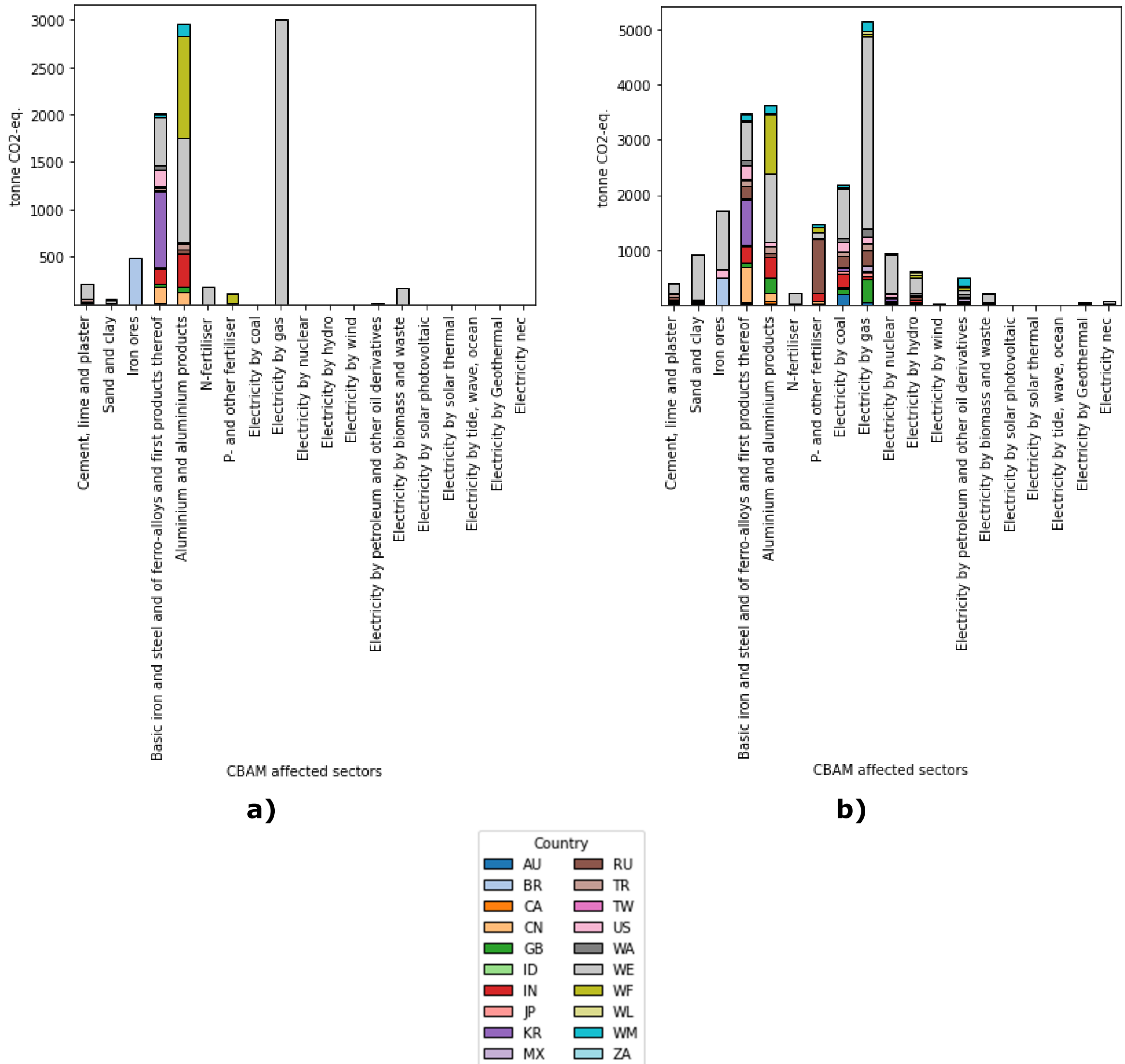

Figure 4: CBAM-relevant GWP100 of Slovenia per sector a) CBA, b) TBA

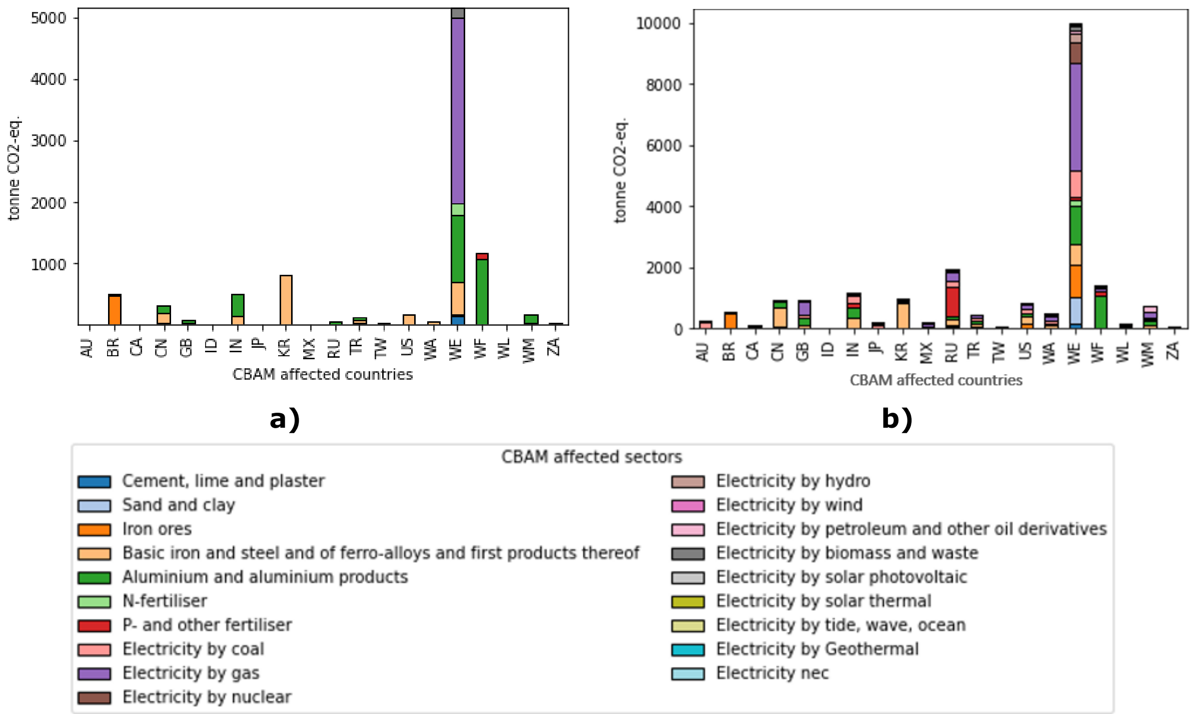

Figure 5: CBAM-relevant GWP100 of Slovenia per country a) CBA, b) TBA

Similar sectoral and country separation was performed also for both the Employment and Value added indicators. Data was due to a lower relevance to our goals put into the Appendix.

The results for the Employment indicator in terms of sector and country distribution correlate to the results for GWP100, though Value added shows quite different results. For CBA the Iron and Steel and aluminium sectors, followed by the Electricity by gas sector. Other sectors show minimal to no contribution. Country-wise, the Rest of Europe region (WE) (27%) and Brazil (BR) (24%) account for the biggest share, with South Korea (KR) (14%) and the Rest of Africa region (WF) (13%) somewhat close behind. TBA shows higher dispersion among sectors. Besides the CBA-relevant sectors, fertilizer and different electricity increase in contribution. Country-wise the rest of Europe region (WE) presents the majority with Russia following far behind with around 10% share.

4.3 Tier decomposition of emissions

In this section, we delve into the results of emissions decomposition across tiers, revealing the extent to which emissions originate in different stages of the supply chain (Figure 6; Table – see the Appendix). Tier 0 signifies the volume of emissions associated with imports directly into Slovenia's final demand. In other words, these emissions occur in countries directly exporting goods to meet Slovenia's final demand. As we trace back through the supply chain, we observe a diminishing trend in emissions attributed to imports into Slovenia. However, when analysing 'traversing emissions,' we uncover that Tier 4 holds the highest contribution to overall emissions. Notably, traversing emissions stem from Tier 2 and beyond, and are absent in Tiers 0 and 1. Moreover, imported emissions experience a significant reduction from Tier 2 onwards, indicating a notable decline as we move further upstream in the supply chain. Furthermore, traversing emissions escalate notably as we progress further upstream in the supply chain. Both imported and traversing emissions exhibit a larger proportion of traversing emissions in tiers beyond Tier 6, while imported emissions show a negligible contribution from Tier 6 and beyond.

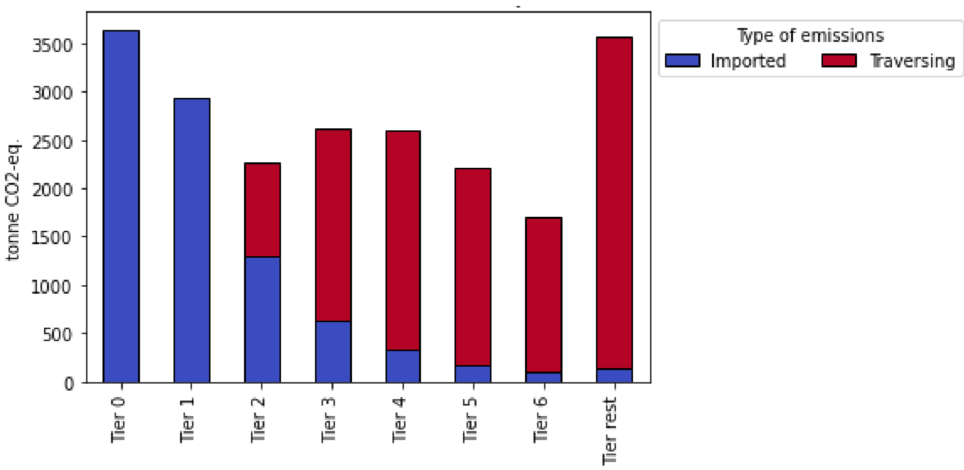

Figure 6: Tier decomposition of CBAM-relevant GWP100 for Slovenia

4.4 Comparison of Slovenia and the EU

This section provides a comprehensive overview of the EU's GWP100 (Table 6; Figure 7) and a comparative analysis of Slovenian GWP100 to those of the EU (Table 7).

4.4.1 Total GWP100

The TBA accounts for the majority of emissions linked to the EU, totalling 6258 Mt CO_2-eq. This is closely followed by the CBA and MRIO & EEBT approaches, which accumulate 5111 and 5393 Mt CO_2-eq., respectively. Conversely, the PBA approach captures the least emissions for both MRIO & EEBT, amounting to 4216 Mt CO_2-eq. In comparison to Slovenia, the EU shows a higher relative GWP100 of PBA (82%) to CBA.

Table 6: Total GWP100 of the EU (MRIO PBA, CBA and TBA; EEBT PBA and CBA)

	TBA	CBA (MRIO)	PBA (MRIO)	CBA (EEBT)	PBA (EEBT)
Local	2825	2825	2825	2791	2791
Import	1654	1654	0	1969	0
Export	758	0	758	0	792
Traversing	389	0	0	0	0
Direct emissions	633	633	633	633	633
Total	**6258**	**5111**	**4216**	**5393**	**4216**
Percentage of TBA	n/a	82%	67%	86%	67%

*All values are in Mt-CO_2-eq.

Roughly speaking Slovenia represents around 0.5% of the EU GWP100. Dividing the total GWP100 of Slovenia (Table 1) and the total GWP100 of the EU, we obtained the relative contribution of Slovenia's GWP100 to the EU. These results are represented in Table 7.

Table 7: Relative Contribution of Slovenia's GWP100 to the EU's GWP100

	TBA	*CBA (MRIO)*	PBA (MRIO)	CBA (EEBT)	PBA (EEBT)
Relative contribution	0,57%	0,44%	0,41%	0,45%	0,41%

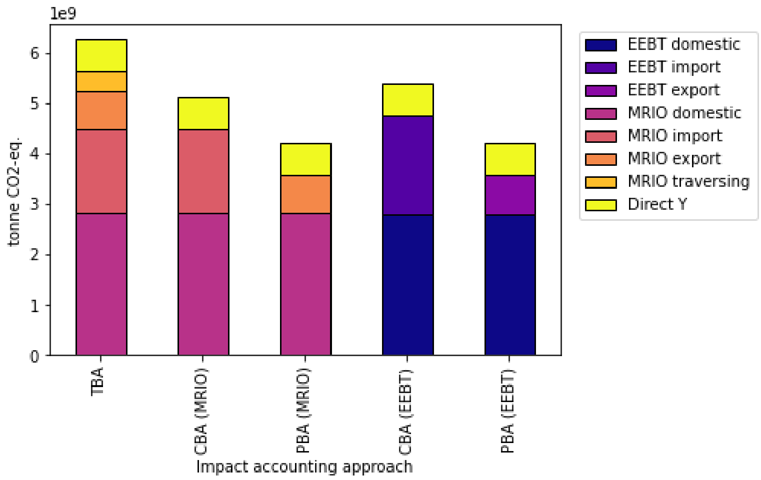

Figure 7: Total GWP100 for the EU

4.4.2 CBAM relevant sectoral emissions

Results regarding GWP100 of individual CBAM-relevant sectors of the EU and relative comparison of these sectors from Slovenia relative to the EU were also calculated (Figures 8 and 9; Table - see the Appendix). The results vary across CBA and TBA approaches.

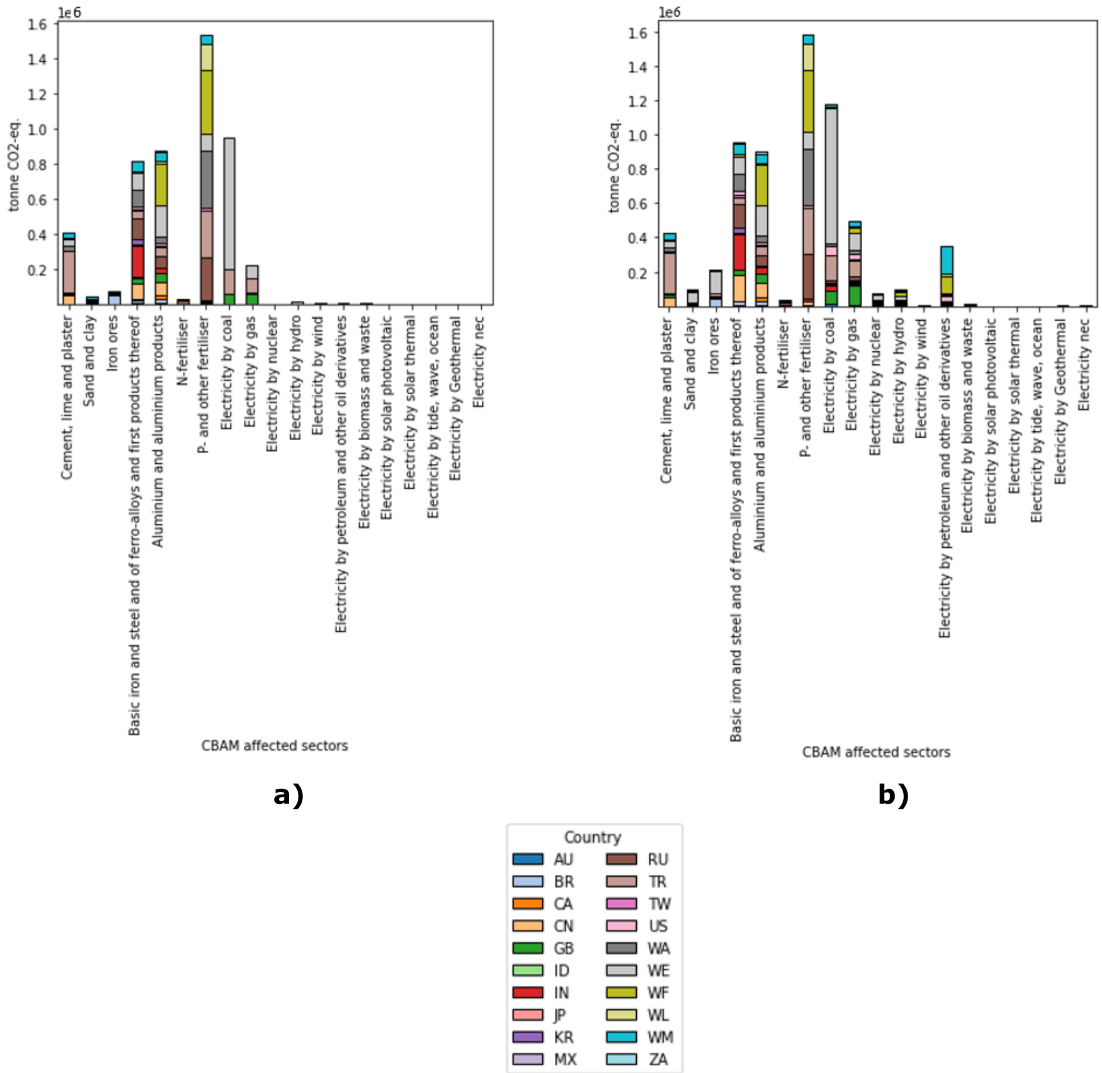

Figure 8: CBAM-relevant GWP100 of the EU per sector a) CBA, b) TBA

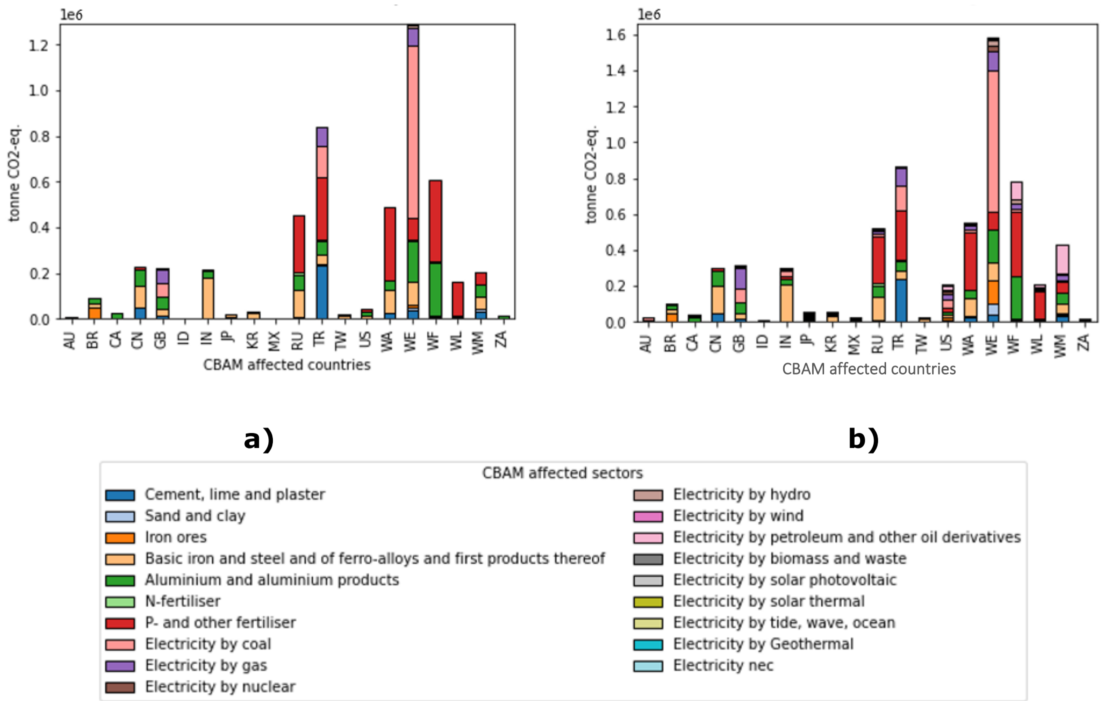

Figure 9: CBAM-relevant GWP100 of the EU per country a) CBA, b) TBA

The results for the EU regarding the CBAM-relevant sectors show that in comparison to Slovenia, the prevalent sector is P and other fertilizers. Similar to Slovenia both the Iron and Steel and Aluminium sectors still show a significant portion of total emissions in CBAM relevant sectors, however, in the EU perspective the Electricity by coal sector replaces the Electricity by gas as the main contributor of emissions in the electricity sector. More emissions are also sourced from the Cement lime and plaster sectors (CBA and TBA) and the Electricity from other derivatives sectors (only for TBA).

Generally speaking, the EU has a higher dispersity of imports from different countries than Slovenia for both CBA and TBA, which shows a much more similar country dispersion than Slovenia. Again, the Rest of Europe (WE) region has the highest import fraction of emissions (around 25% for both CBA and TBA), though Turkey (TR), Russia (RU), the Rest of Asia (WA), the Rest of Africa (WF) represent an important portion of imported emissions. TBA results also show a more relevant contribution of the Rest of the Middle East region (WM).

4.5 CBAM revenue

This last part of the results focused on the revenue generated by CBAM (Table 8; see the Appendix). 2 scenarios were investigated. 1st scenario uses 80€/tonne of CO_2-eq. emitted and the 2nd one uses 150 €/tonne of CO_2-eq. emitted. Both scenarios were applied to CBA and TBA and the revenue generated was calculated for Slovenia and the EU to compare the contribution of Slovenia to the total CBAM revenue generated by the EU.

Our results show that Slovenia generates a very minimal revenue with the introduction of CBAM. The value for both scenarios ranges from a minimum of 0.74 million EUR for CBA (80€) to a maximum of 3.23 million EUR for TBA (150€) and the relative increase of expenditures put on the total Slovenian economy due to this revenue generated is 0.0015% to 0.0067%, respectively. Additionally, the revenue generated by Slovenia represents only 0.0019% to 0.0034% of the total revenue generated by the EU.

Table 8: Potential CBAM revenues

CBAM certificate price (€/tonne)	Total revenue of the EU (million €)	Total contribution of Slovenia (million €)	Relative contribution of Slovenia to the EU (%)	The increase of expenditures of Slovenian economy due to CBAM (%)
80 (CBA)	398	0.74	0.0019	0.0015
80 (TBA)	513	1.72	0.0034	0,0036
150 (CBA)	747	1.38	0.0019	0,0029
150 (TBA)	962	3.23	0.0034	0,0067

Revenue was observed and calculated also from a sectoral perspective. The results are due to a large amount of data shown in the Appendix.

The sectors that experience the highest relative change in terms of potential change due to CBAM for CBA are Iron ores (80€: 0.67%, 150€: 1.26%) followed by the Electricity by gas and N- -fertiliser sectors as well as limited change in the Electricity by biomass and waste sector.

For TBA the results show a different outcome. The most affected sector for both prices is Electricity by Solar Thermal with a substantial increase in the sector of around 530% for 80€ and 990% for 150€. The reasons for such an increase are discussed in Chapter 5. It is followed by the same sectors that are most affected also in the CBA approach but with a higher % increase (up to 4.5% for Iron ores).

5 Discussion

To draw implications from the results and interpret different important aspects of how CBAM affects Slovenia and its international trade as best as possible, the discussion was written systematically to stress various points.

TOTAL IMPACTS OF SLOVENIA AND THE EU

The results for the total GHG emissions of Slovenia align with the general expectations. TBA captures the most emissions, while CBA and PBA both show a lower amount. A comparison of our results with the national statistics of Slovenia further confirms the results. 2019 territorial GHG emission values (PBA), amounted to 17.2 Mt CO_2-eq. (Slovenian Environment Agency & Majaron, 2023). Our World in Data website (Ritchie et al., 2020) estimates 19.7 Mt CO_2-eq. This shows that our calculation (17.1 Mt CO_2-eq. in Table 1) falls in order with the national statistics but shows a slight underestimation in comparison to data from the Our World in Data website, indicating that our model captures territorial emissions well. For CBA no data for all GHG is available, but rather only for CO_2 emissions. Those accumulated to around 20.6 CO_2-eq. (Ritchie et al., 2020). Our results show that 22.67 CO_2-eq. we generated using CBA, however, our results show all GHG emissions and not only CO_2. It is hard to say whether results from the statistics would correlate with ours if available, but if we compare the relative difference of CO_2 to all GHG from national statistics for PBA that accounts for 81%. If we use the same logic for CBA we would estimate 25.3 CO_2-eq. which would indicate that our model underestimates CBA emissions, though this estimation might not be the most accurate as other factors might affect the calculation of CBA. No data from the comparison of TBA results was available.

The comparison of Slovenia to the EU (Table 7) does match with the results from the Our World in Data website (Ritchie et al., 2020), where GWP100 of PBA relative to the EU accounts for around 0.57%. This signals that our model captures the share of Slovenian emissions in comparison to the total EU emissions well.

CBAM RELATED IMPACTS AND REVENUE

CBAM-related sectors represent a minimal amount of total Slovenian emissions (Tables 4 and 5). Two possible reasons might be that, first, Slovenia is highly dependent on trade from the EU and does not import a large portion of emissions from non-EU (only around 20% while 80% come from the EU). Additionally, CBAM does not cover sectors which represent the majority of non-EU imported/traversing emissions. The data from Tables 4 and 5 shows that an extremely small percentage of emissions (CBA: 0.21%, TBA: 0,30%) of non-EU imported emissions come from the CBAM-related sectors. The majority comes from sectors such as Natural gas and related services, Coal, Textiles, Machinery and equipment, and Wearing apparel. This means that for CBAM to capture a larger portion of GHG emissions imported into Slovenia the current CBAM scope should be expanded, to cover those sectors.

As seen in the investigation of which countries are the main importers into Slovenia in connection to CBAM-related sectors, The rest of Europe region (WE) represents the majority. According to the TBA other significant portions of emissions also originate from Russia (RU), the Rest of Africa (WF), China (CN), South Korea (KR), and India (IN), which however, only traverse through Slovenia and are not part of its final consumption. This means that Slovenia should strengthen its trade relationship and sustainability discussions with these countries to decarbonize its economy faster.

When we compare these results to the results from Magacho et al. (2023) (investigating the whole EU), we found that the most affected are the Iron and Steel and Aluminium sectors, with electricity and fertilizers falling far behind. These results do not match our results of the EU where fertilisers show the biggest contribution but do match to a certain degree with results for Slovenia where the Aluminium and the Electricity by gas sectors together with the Iron and Steel sector dominate imported emissions. With respect to countries affected by CBAM, our results seem to align quite well with findings from Magacho et al. (2023), both showing that Russia, Ukraine, India, China, South Korea and the US represent the highest imports to the EU.

From the general results of CBA and TBA, we do not know if emissions satisfying the final demand of Slovenia come directly from outside CBAM territory or first traverse through other EU countries. That was partially answered with the tier decomposition of emissions of CBAM-relevant sectors. It shows that the majority of imported emissions occur in the first two tiers (Tier 0 and Tier 1), which indicates that a large portion of emissions embedded in products from countries outside CBAM territory come directly to final or intermediate consumption 1 step before final consumption. Given that these emissions are in upstream proximity to Slovenia, Slovenia has a degree of influence over its ability to impact/reduce said emissions. On the other hand, the traversing emissions appear from Tier 3 onward, which is logical since they should not satisfy final consumption. Traversing emissions of Slovenia show us how far from the final consumption of other countries those emissions are. The majority of final consumption is present between Tiers 3-5 showing that the majority of traversing emissions through Slovenia are caused 3-5 steps before ending up in final consumption of other countries. Although these emissions are not directly part of Slovenian final consumption and could technically represent only a small portion of emissions of that other final consumption, it does not mean that they should not be tackled. The implications regarding the results for the Employment indicator align with the results for emission and are therefore not further elaborated here. On the contrary, Value added shows some differences. The iron ores sector from Brazil shows similar Value added to the Iron and Steel and Aluminium sectors despite a much lower contribution to emissions. Additionally, South Korea shows significant Value added to the Iron and Steel sector. This shows that both Brazil and South Korea highly improved the value of Iron and Steel entering Slovenia. TBA shows a much greater sector dispersion but major importance of other non-EU European countries (around 40%).

From the EU perspective, our results of total emission from CBA or TBA are 5.0 and 6.7 Mt CO_2-eq., respectively, but fall short of 83 Mt. CO_2 emissions calculated by Beaufils, Ward, et al. (2023) even for the most conservative approach. This indicates that our model shows different results due to a different database selection, sector selection and assumptions, or we have a mistake in our calculation. Concerns about the former reasons are discussed later on.

Small amounts of emissions consequently affect the amount of CBAM revenue created by Slovenia as well. The pressure put on the Slovenian economy due to CBAM revenue/tax and potential increase of prices in relevant sectors felt in the overall Slovenian economy is limited as its relative increase of expenditures of Slovenia amounts to a maximum of 0.0067% when looking at the most conservative option (TBA approach and a price of

€150/tonne of CO_2-eq.) (Table 8). The revenue generation has the highest impact on Iron ores and the Electricity by gas sectors and not Iron and steel and aluminium sectors even though these sectors have the highest number of imports. There is also a somewhat unintuitive result for the electricity by solar thermal.

HIGH IMPACT OF CBAM ON ELECTRICITY BY SOLAR THERMAL SECTOR

The electricity by solar thermal has a huge relative increase in potential expenditures for the TBA approach. We investigated the reason and found out that Slovenia produces a very small amount of electricity by solar thermal, with no import outside CBAM territory to its final consumption, consequently CBA approach shows a 0% change. But when we include the traversing emissions that amount is relatively much higher than domestically produced emissions. Therefore, when the revenue is calculated the revenue is relatively much higher than the original intermediate trade expenditures for the Electricity by solar thermal. Therefore, when we divide the new intermediate demand with added revenue with the original intermediate demand, we obtain a huge increase of around 500% for €80 and 990% for €150 prices.

From the broader EU perspective, it is important to realise that CBAM will not generate any revenue during the transitional period since it serves as the learning period for importers (European Commission, 2023c). Meaning, the first revenue generation is expected from 2026 and onward. According to Meijburg & Co (2021), it is estimated that CBAM will generate 1 billion € per year on average over 2026-2030 and the European Commission (2023b) estimated CBAM revenue generation of about €1.5 billion (2018 prices) per year as of 2028.

This would indicate that due to the expected increase in prices of EU ETS by 2030 (Pahle et al., 2022), the use of 2022 approximate price of 80€/tonne CO_2-eq. is somewhat underestimating the revenue, however, it might still offer a good overview of CBAM's effectiveness. The price of 150€/ tonne CO_2-eq. captures the real situation better as by 2026 CBAM will be already generating revenue making the comparison more feasible. However, our results still show 1,5-2x lower revenue generation than estimated values by the European Commission (2023b). This means that our calculations underestimate generated revenue, though we must be aware that it is hard to evaluate how exactly were those revenue estimations calculated.

STUDIES OF SCENARIOS

In Chapter 2 we state that numerous studies on CBAM explored various potential scenarios for CBAM implementation by the European Union. However, it's crucial to note that these discussions and suggestions occurred before the actual implementation of CBAM. Consequently, the results derived from these scenarios may not accurately reflect the current CBAM framework in place. Nevertheless, it's worth considering the possibility that certain scenarios examined in these studies could gain relevance post the transitional period of CBAM, due to the potential expansion of the current scope of CBAM sectors (Figure 1) and other regulatory aspects of CBAM align with the needs of the European Union for combating carbon leakage and global initiatives aimed at mitigating environmental pressures, promoting social sustainability in international trade.

DATABASE SUITABILITY

Data sources for the compilation of EXIOBASE have already been explained in Chapter 3. Since the original data is from 2011 with some updates from more recent years' data used in our analysis (2019), it cannot accurately represent the current Slovenian economy. More recent years are also available on the EXIOBASE website (up to 2022), however, 2019 was selected as it probably estimates the Slovenian economy the most accurately as the COVID-19 pandemic and the Russia-Ukraine war might have affected the relevancy of data post-2020. Therefore, we are aware that for more accurate analysis more recent data should be used if available in the future, while also incorporating these events in its investigation.

SECTOR COVERAGE

It's crucial to highlight that CBAM-relevant sectors of our study were selected with the intention to mirror the exact CBAM-relevant sectors as closely as possible. Due to limitations in data disaggregation within EXIOBASE, achieving pinpoint selection accuracy was not achievable and we had to make decisions about including or excluding certain sectors, potentially leading to overestimation or underestimation of their effects. For instance, while our study covered cement, lime, and plaster as a single sector, CBAM only encompasses cement, resulting in a potential overestimation of this specific sector's impact. Moreover, our inclusion of highly disaggregated electricity sectors, though not strictly necessary, provides valuable insights.

Notably, our investigation omitted hydrogen due to the absence of a specific sector for it in EXIOBASE or potential inclusion in one of the other available sectors. This exclusion might not significantly impact emissions estimations considering hydrogen's minimal global emissions share in 2016 (Beaufils, Berthet, et al., 2023), but it's crucial to recognize its potential future importance. Thus, assessing hydrogen-related emissions will be essential for accurately representing CBAM impacts for the EU or specific countries within the EU.

COUNTRY COVERAGE

While the TBA shows that some larger EU trade partners (e.g. Russia) do have relevant contributions it would be of great importance to obtain a more disaggregated view for other countries as well, especially the Rest of Europe region, which is the EXIOBASE’s biggest import region to Slovenia. Without proper disaggregation, it is difficult to assess with which countries Slovenia should prioritise sustainability talks with a view to decarbonisation. That leads to the conclusion that a database with better country resolution could provide better insights.

BALANCING AND HARMONIZATION PROBLEMS

As we know EE-MRIO analysis can be used to assess the environmental impacts of a specific region or country following an entire global supply chain. As Christis et al. (2017) explained these analyses are based on EE-MRIO tables covering the whole world, meaning that many country-specific or regional IO tables are joined together, and an estimated model is developed to represent the rest of the world economy (Dietzenbacher et al., 2013). Now, as long as it is impossible to create a complete EE-MRIO covering all regions, states, provinces, counties or neighbourhoods, detailing many hundreds of sectors and products and including all possible extensions, all based on consistent and reliable time series data, only models that try to simulate reality will be available for such investigations. Since these models are estimations they include errors, which results in variations between models. The degree of differences varies by country and depends on which models are compared (Moran & Wood, 2014). Additionally, the sensitivity of carbon footprints is especially large in some small open economies (Hoekstra et al., 2013) (e.g., Slovenia), which may lead to differing policy interpretations and different conclusions for decision-making (Christis et al., 2017). Due to differences in models of the global economy, several authors have identified issues in calculating country-specific footprints, leading to the proposal of different methods to adjust for these proxy models, such as rebalancing an entire MRIO database around national data as suggested by Edens et al. (2015) or a simplified SNAC by Tukker et al. (2018); Wood and Palm (2016).

Since our model does not incorporate any of these solutions, it is more like a broad estimation of the actual status of the Slovenian economy and the potential effects of CBAM on its economy. Therefore, to assess the Slovenian economy more accurately by using EE-MRIO, these solutions should be implemented in our model, however, that was beyond the scope of our thesis.

EEBT vs MRIO

Our thesis also tried to shed some light on the effectiveness of both MRIO and EEBT as viable options for the calculation of production-based and consumption-based NEI. Neither method is correct nor incorrect as the sum of global emissions is the same in both cases. They mostly differ in the way they treat intermediate production of imported products, due to a different method of allocation. The MRIO model uses final consumption and considers global emissions, while the EEBT model uses total consumption and considers domestic emissions only. Due to these differences, the methods can have a difference in allocation of emissions over 20% for some countries depending on their trade structure (Peters, 2007; Weber & Matthews, 2007). This can be seen in Table 1 as EEBT CBA allocates around 6.5% more emissions to Slovenia than MRIO CBA.

Each method has advantages and disadvantages and also addresses different questions, thus it is not advised to use one method over another, without previously considering what we want to find out (Peters, 2008). Both methods calculate the same value for PBA, as only domestic production and emissions are included in this measurement. In connection to CBA, EEBT will either underestimate (as seen in our case) or overestimate emissions of countries in a global value chain because the approach allocates emissions to the first importer, even if the product will pass to another country without being consumed. Some additional concerns are also presented; thus, it is not suggested to be used for such analysis (Cadarso et al., 2018). The EEBT model is more relevant for considering the environmental impacts of aggregated exports from and imports to a country. Its pros are that it is simple, transparent and more consistent with bilateral political agreements between countries. The MRIO model is more applicable to the analysis of final consumption (CBA) and considers the total emissions from raw-material extraction to final consumption, however, that does come with additional complexity (Peters, 2008). Moreover, some authors argue that neither CBA nor PBA provides a full picture of optimal mitigation policies because they do not consider all the general equilibrium implications of global production and consumption (Jakob et al., 2014), making a case for some other emissions allocation approaches such as TBA.

MRIO VS EEBT REGARDING CBAM

Both EEBT and MRIO can also be used for the estimation of the impacts of border carbon adjustments (BCA also referred to as border tax adjustment – BTA) as they both provide effective tariff rates, but each model will result in different burdens. As stated by Atkinson et al. (2011); Sakai and Barrett (2016) the use of the EEBT approach is common in estimating the impact of a BTA. As Atkinson and colleagues have additionally noted, the EEBT approach places the focus of taxation on the carbon added by the exporting country, while the MRIO approach implies that any importer would tax total carbon content; however, to prevent the problem of double taxation, the total carbon content has to be taxed only by the country where the final product is going to be consumed thus placing a higher burden on developed countries. MRIO is also the only approach, regarding the BCA schemes, that provides incentives to countries with which the importer country does not trade directly but indirectly because MRIO allows for discrimination concerning both the carbon content of the products directly and indirectly imported. This has highlighted the possible superiority of MRIO over EEBT (Tukker & Dietzenbacher, 2013).

Even though we have not selected EEBT as the main approach to calculate the potential effects of CBAM on Slovenia's international trade it remains a viable option for the future of investigations of CBAM.

DIFFERENT WAYS TO CALCULATE CBA

It is also important to stress the background between individual portions of the TBA (which also includes CBA and PBA) approach presented by Beaufils, Berthet, et al. (2023)and how those correlate to the CBA approach used in PYMRIO formulation (Stadler, 2021) which is used for calculations of CBA and PBA in EXIOBASE.

Both above-mentioned approaches yielded the same final result, but they differ in how they separate imports from the domestic/local portion of emissions as well as in notation. Beaufils, Berthet, et al. (2023) disaggregates the CBA into 2 parts: loc and imp. For both parts, they do not account for where the last point of sale is as the final demand portion is the same for both parts. Rather, they look at the origin of the emissions when tracing them to the destination. In contrast, PYMRIO (Stadler, 2021) splits the CBA into domestic and import portions. However, the import portion here is not equal to the import from Beaufils, Berthet, et al. (2023) but rather looks at the point of last sale, regardless of where the direct emissions associated with production occurred.

This is important since CBAM affects only the import portion of the emissions. For our calculation, the approach by Beaufils, Berthet, et al. (2023) was adopted as it allowed for consistency of PBA, CBA and TBA representation for easy comparability. However, if the approach used in the PYMRIO (Stadler, 2021) were adopted in our model, the results might differ. This poses the question of which approach is more accurate for the investigation of CBAM, however, this was not in the scope of this thesis.

6 Conclusions

6.1 Main takeaways

In light of the EU's recent introduction of the Carbon Border Adjustment Mechanism (CBAM) to preserve the competitiveness of the EU's domestic products and prevent carbon leakage, we decided to assess CBAM's impacts on Slovenia (a small, developed EU country) (European Commission, 2023c). The thesis aimed to explore which sectors and countries linked to Slovenia would be most affected by CBAM, how this relates to Slovenia's total emissions, and how Slovenia compares to the EU in terms of the CBAM. In addition, we calculated CBAM revenues generated by Slovenia and the EU and investigated how an alternative approach for the calculation of national emission inventories (NEI) called emissions embodied in trade (EEBT) compares to MRIO in terms of total emissions.

To perform the analysis, we constructed an environmentally extended multi-regional Input-Output (EE-MRIO) model, using a 2019 EXIOBASE dataset, since our literature review showed a rather small number of MRIO (mostly computable general equilibrium models – CGE were used) and EXIOBASE-based studies for the investigation of CBAM so far. For total emission 5 approaches were used – for MRIO production-based (PBA), consumption-based (CBA) and throughflow-based (TBA) accounting and only PBA and CBA for EEBT. For CBAM-affected emissions, only MRIO CBA and TBA were used.

The main insights from previous research, our results and discussion points can be combined into 5 main points:

1) Our model captures the total emissions of Slovenia well, while the EU emissions appear to be overestimated in comparison to national and global statistics.
2) Previous studies show mixed results on the effectiveness of CBAM, though it is generally accepted as an effective measure (Zhong & Pei, 2022). Additionally, they showed that the most affected countries are the least developed countries (LDS), big EU partners, such as Russia, China, India, the US, Ukraine and Turkey and countries which are strongly integrated into EU trade (non-EU Balkan countries, Mozambique, and Bahrain) (Acar et al., 2022; Magacho et al., 2023; Rocchi et al., 2018; Zhong & Pei, 2022). Many of these studies also suggested that some sort of recycling scheme should be incorporated to help these countries decarbonise faster (Beaufils, Ward, et al., 2023; Bellora & Fontagné, 2023; Zhong & Pei, 2022). These conclusions correlate with the results from our study, which showed that the main importers into Slovenia of CBAM-affected emissions are non-EU European countries. Russia, India, the Rest of Asia and Africa appear to have significant portions of their emissions traversing through Slovenia. Tier decomposition showed that most of the imported emissions appear close to Slovenia, meaning Slovenia could potentially reduce those emissions through policies and solution-oriented international dialogues. For the EU, in comparison to other studies, our model seems to underestimate the emissions captured. Employment-related implications fall in line with GHG emissions, while the Value added indicator shows alongside the Rest of Europe also great importance of Brazil and South Korea for the Iron and steel sector.

3) From a sector perspective, the Iron and steel as well as Aluminium sectors seem to be affected in the majority of countries (Magacho et al., 2023; Rocchi et al., 2018; Zhong & Pei, 2022). In Slovenia most affected are electricity by gas, aluminium and iron and steel sectors. With the inclusion of traversing emissions, some other sectors such as Electricity by coal and P- and other fertilisers also have a non-negligible contribution. Hydrogen was omitted from the analysis as it was not available as a separate category in EXIOBASE. In total CBAM-relevant sectors, represent minimal portions of the total emission of Slovenia around 0.05% and 0.2-0,3% of non-EU related emissions. In comparison to the EU, the results for Slovenia seem to align quite well, except for the fertiliser sector.
4) The revenue generated by Slovenia is not high. In the most comprehensive scenario using TBA and a CBAM certificate price of 150€ /tonne CO_2-eq. revenue of around 3.2 million € is generated, which represents only 0,0067% of the Slovenian economy. Individually the most affected seems to be the Iron ores sector. The revenue estimation for the EU also falls short of estimates by the EU Commission.
5) Research on EEBT uncovered that it might be a viable approach for the potential assessment of CBAM since it can be easier to implement on a practical basis as it is based on bilateral trade. MRIO, on the other hand, seems to be more accurate and can provide incentives to third-party countries to seek mitigation strategies, but comes with a higher complexity.

It can be concluded, from our study indicates that Slovenia is not highly susceptible to CBAM as most sectors importing into Slovenia from outside CBAM territory, do not fall under the CBAM sector scope. However, our results do seem to deviate from other studies which can mean that our model computes different results either due to a selection of a different database, sectors, and assumptions, or we have a mistake in our model which makes it greatly underestimate the actual emissions. Furthermore, the sector selection from EXIOBSE might not represent the sector scope from CBAM 100% accurately, as sector availability in EXIOBASE is limited. An additional concern with the results stems from the fact that when MRIO tables are constructed lots of adjustments and estimations must be made due to missing data. This deforms the real interindustry dependencies of some, especially small countries such as Slovenia, which can lead to relevant errors in data and results (Christis et al., 2017). This leads to the conclusion that our model serves more as a foundational step toward a more accurate future model.

6.2 Suggestions for future work

Drawing upon the results and insights of this thesis, suggestions for future CBAM-related research are presented:

- Using a method to rebalance the MRIO tables to match the national table of Slovenia such as SNAC (Edens et al., 2015).
- Use of a different database or a more recent year dataset to calculate the results.
- When available in MRIO databases, an inclusion of Hydrogen would be highly relevant, due to the expected rise of Hydrogen production and use.
- An investigation using broader sector coverage could be used to try as the EU Commission might expand the range of sectors covered under CBAM.
- The tier decomposition could be further expanded into a per-country/sector disaggregation or expanded to a Structural path analysis.
- We could try to incorporate demand simulation.

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Appendix

Appendix 1: Tier decomposition

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5	Tier 6	Tier rest	Total
Import	3642,94	2927,331	1291,459	629,5383	323,6607	173,2316	95,31476	126,4858	9209,961
% of total imports	40%	32%	14%	7%	4%	2%	1%	1%	
Traversing	0	0	979,3473	1989,989	2270,808	2032,361	1596,814	3446,891	12316,21
% of total traversing	0%	0%	8%	16%	18%	17%	13%	28%	

Appendix 2: GWP100 - Slovenia CBA per sector/country

sector	AU	BR	CA	CN	GB	ID	IN	JP	KR	MX	RU	TR	TW	US	WA	WE	WF	WL	WM	ZA	Total	% of total
Cement, lime and plaster	0	0	0,01595	15,2263	9,72E-01	0	0,58509	0	0,10838	0	3,16979	34,6983	0,91464	0,32126	4,08178	148,936	0,29495	0	7,75397	1,13E-01	217,1918044	2,36%
Sand and clay	0,34396	2,43287	0	7,49255	0,39559	0	0	0,20687	0	0	0	0,09915	1,91621	0,39642	1,0949	26,6825	0	1,53184	0,11275	3,62506	46,33064852	0,50%
Iron ores	0	485,677	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	485,6770341	5,27%
Basic iron and steel and of ferro-alloys and first products thereof	1,52E+00	6,18437	0,15183	182,127	18,6522	4,53741	156,335	11,3182	808,741	0,05389	12,6069	32,248	16,4762	162,056	45,6189	511,409	0,56018	0,57423	23,8975	19,8803	2014,948149	21,88%
Aluminium and aluminium products	0,2866	0,43823	1,21921	116,954	63,8923	0	349,139	0,05593	4,8048	0	33,1773	62,3849	7,97682	2,0509	12,5719	1100,78	1068,42	0,4843	133,514	0	2958,153133	32,11%
N-fertiliser	0	0	0	1,75326	0	0	0	0	0	0	0	0	0	0	0	186,449	0	0	0	0	188,2026661	2,04%
P- and other fertiliser	0	0,04369	0	0,51727	0	0	0,11375	0,02398	0	0	0,61825	0,17734	0,02347	0,00787	0	10,5555	101,869	0,63672	0,05242	0	114,6396846	1,24%
Electricity by coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,00%
Electricity by gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3009,28	0	0	0	0	3009,279304	32,67%
Electricity by nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,00033	0	0	0	0	0,00033353	0,00%
Electricity by hydro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,1E-05	0	0	0	0	6,11679E-05	0,00%
Electricity by wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,2E-05	0	0	0	0	4,16242E-05	0,00%
Electricity by petroleum and other oil derivatives	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6,9957	0	0	0	0	6,995698758	0,08%
Electricity by biomass and waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	169,715	0	0	0	0	169,7152429	1,84%
Electricity by solar photovoltaic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,00%
Electricity by solar thermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,00%
Electricity by tide, wave, ocean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,00441	0	0	0	0	0,004410325	0,00%
Electricity by Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,00045	0	0	0	0	0,000447097	0,00%
Electricity nec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,00043	0	0	0	0	0,000425634	0,00%
Total	2,15075	494,776	1,38699	324,07	83,9123	4,53741	506,173	11,6049	813,654	0,05389	49,5722	129,608	27,3073	164,832	63,3675	5170,81	1171,15	3,2271	165,33	23,6182	9211,139	
% of Total	0,0%	5,4%	0,0%	3,5%	0,9%	0,0%	5,5%	0,1%	8,8%	0,0%	0,5%	1,4%	0,3%	1,8%	0,7%	56,1%	12,7%	0,0%	1,8%	0,3%		

Appendix 3: GWP100 - Slovenia TBA per sector/country

sector	AU	BR	CA	CN	GB	ID	IN	JP	KR	MX	RU	TR	TW	US	WA	WE	WF	WL	WM	ZA	Total	% of Total
Cement, lime and plaster	3,97913	1,14671	0,33705	25,3405	25,7296	0,266	18,042	0,1157	1,04399	5,38397	67,3655	38,4029	3,72101	11,1501	5,59819	170,99	1,6953	1,54345	12,5407	4,67242	368,2607282	2%
Sand and clay	8,88762	3,40524	0,80331	17,3502	0,74022	0,01118	0,00021	0,26903	0,2645	0,1196	42,1642	1,27191	2,30224	1,45036	1,45319	838,414	0,21014	1,72506	1,09426	3,90848	894,6578671	5%
Iron ores	0,02366	489,312	0,02967	0,00147	2,8E-05	0	0,14604	7,5E-05	0,00133	0,08643	1,27361	0,0988	0,00069	149,05	6,30111	1062,7	3,11723	10,4623	0,10937	0,00341	1233,347772	7%
Basic iron and steel and of ferro-alloys and first	3,31842	19,2869	13,6672	659,159	64,0818	5,39027	312,077	21,5856	820,629	18,4431	215,355	99,3514	30,4667	260,664	103,11	691,889	14,9423	7,99879	95,9073	28,5063	2726,315739	15%
Aluminium and aluminium products	6,03494	11,0863	38,6524	169,637	271,17	0,09932	357,215	4,65288	7,83338	10,3092	64,0693	119,942	10,8253	57,6774	21,1331	1239,6	1077,36	10,7852	145,59	0,75382	3127,847674	17%
N-fertiliser	0,01811	1,29803	0,01806	1,79623	0,12617	7,3E-05	2,64023	0,25941	0,0274	0,01246	3,67253	0,08651	0,03107	0,09946	2,35271	194,938	0,32795	0,53734	8,52713	1,3219	214,8344811	1%
P- and other fertiliser	0,39364	23,5818	5,11678	36,0192	0,26036	0,09859	147,137	8,33476	2,04477	5,09147	957,317	3,9177	2,16562	9,03267	6,05862	102,331	107,394	4,32262	32,1182	4,34602	1391,709797	7%
Electricity by coal	189,812	0,0127	9,7079	0,90507	100,074	11,1389	243,307	53,9845	56,8942	13,4545	202,782	75,5076	5,64051	165,734	91,3779	885,352	20,1192	7,79458	43,3784	2,23401	1878,698867	10%
Electricity by gas	44,2616	7,48185	0,00018	4,8E-05	421,873	0	47,1479	58,1653	40,0151	100,082	279,775	116,734	4,56017	112,959	149,745	3490,59	68,1442	28,6257	195,949	0	4692,495246	25%
Electricity by nuclear	8,5E-09	0,0668	9,26261	6,6E-05	35,8284	0	7,21636	26,4143	26,6934	0	43,626	0	1,1E-05	43,962	11,5552	698,999	14,0018	15,7354	9,70901	0,00017	897,9121431	5%
Electricity by hydro	9,85509	1,70993	37,5555	4,5E-05	1,30131	0,32384	29,0598	1,93932	0,49222	5,90232	56,7622	9,92616	0,0348	18,3366	42,3121	281,247	40,9478	50,25	18,9001	3,7E-06	556,4343469	3%
Electricity by wind	0	0,00306	0	2,3E-07	1,91701	0	4,10437	0,06916	0,00108	0	0,02424	0	6,3E-06	3,57798	0,32615	3,55104	0,10442	0,11795	0,51004	1,7E-07	12,38644166	0%
Electricity by petroleum and other oil derivatives	3,34693	0,02001	9,4E-05	5,1901	4,18666	12,5246	7,94168	32,0661	11,5311	34,7347	22,4027	1,22288	1,32315	14,8182	33,5448	76,5201	42,6853	26,447	150,756	5,1E-06	468,5188458	2%
Electricity by biomass and waste	5,09556	0,07433	9E-05	2,6E-07	7,10353	0	0,0007	5,80313	0,00532	0	3,00315	0,59595	6,3E-05	6,44058	1,88024	171,016	0,45047	2,45691	0,06255	8,7E-06	191,7146474	1%
Electricity by solar photovoltaic	0	7,7E-10	0,09332	8,1E-07	0,00015	0	0,02835	0,02289	0,00074	0,00899	0	0	1E-06	0,0379	0,02618	0	0,01455	0	0,04891	9,9E-06	0,188537128	0%
Electricity by solar	0,00125	0	0	0,00017	0	0	0	0	0	0	0	0	0	0,07387	0	0	0	0	0	0	0,073872887	0%
Electricity by tide, wave, ocean	1E-08	0	0,0039	0,00184	0	0	0	0	0	0	0	0	0	0	4,5E-05	0,18701	0,06243	1,3E-05	0,03574	0	0,285239996	0%
Electricity by Geothermal	0,00096	0	0	9,3E-09	0	0	1,3E-08	0,61171	0	2,53025	0,33514	1,7E-10	0	1,11235	4,73894	19,0086	0,26343	0,7704	0,06371	0	29,43451014	0%
Electricity nec	0,34301	0,01472	0	1,5E-06	1,26439	0	0,23219	0,71809	2,4274	0	4,13605	0,90617	1,3E-05	0,47072	0,13166	57,1833	0	0,34831	0,05285	0	66,60678826	0%
Total	275,372	558,501	115,248	915,401	935,656	29,8528	1176,3	215,012	969,905	196,158	1964,06	467,965	61,0714	856,647	481,646	9984,52	1391,84	169,921	715,353	45,7466	18751,7235	
% of Total	1%	3%	1%	5%	5%	0%	6%	1%	5%	1%	10%	2%	0%	5%	3%	53%	7%	1%	4%	0%		

Appendix 4: Employment - Slovenia CBA per sector/country

sector	AU	BR	CA	CN	GB	ID	IN	JP	KR	MX	RU	TR	TW	US	WA	WE	WF	WL	WM	ZA	Total	% of Total
Cement, lime and plaster	0	0	2,5E-08	5,5E-05	1,3E-05	0	6,9E-06	0	7,8E-07	0	4E-05	3,6E-05	9,8E-06	2,2E-06	7,4E-05	0,00624	5,8E-06	0	2,5E-05	3,9E-07	0,00651	1%
Sand and clay	5,24905E-06	9,5E-05	0	0,00016	1,5E-05	0	0	5,6E-07	0	0	0	1E-06	8,5E-06	4E-06	0,00037	0,00483	0	2,5E-05	4,9E-06	5,3E-05	0,00557	1%
Iron ores	0	0,0163	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0163	2%
Basic iron and steel and of ferro-alloys and first products thereof	1,84391E-05	7,9E-05	2,2E-06	0,00369	0,00042	7,7E-05	0,00582	0,0001	0,02964	1,1E-06	0,0003	0,00151	0,00084	0,00407	0,00372	0,02788	5E-05	2E-05	0,00046	0,00049	0,07918	12%
Aluminium and aluminium products	2,65934E-06	4,3E-06	1,9E-05	0,00367	0,00272	0	0,02095	3,8E-06	0,00013	0	0,00036	0,00126	0,0003	4,8E-05	0,0011	0,08984	0,09727	1,9E-05	0,00186	0	0,21955	34%
N-fertiliser	0	0	0	9,1E-05	0	0	0	0	0	0	0	0	0	0	0	0,03705	0	0	0	0	0,03714	6%
P- and other fertiliser	0	2,8E-06	0	1,9E-05	0	0	7,5E-06	8,8E-07	0	0	1,8E-05	8,8E-07	9,5E-07	1,5E-07	0	0,00171	0,00588	1,3E-05	9E-07	0	0,00766	1%
Electricity by coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Electricity by gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,23043	0	0	0	0	0,23043	35%
Electricity by nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,7E-08	0	0	0	0	7,7E-08	0%
Electricity by hydro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,6E-09	0	0	0	0	8,6E-09	0%
Electricity by wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6E-09	0	0	0	0	6E-09	0%
Electricity by petroleum and other oil derivatives	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,00066	0	0	0	0	0,00066	0%
Electricity by biomass and waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,05137	0	0	0	0	0,05137	8%
Electricity by solar photovoltaic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Electricity by solar thermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Electricity by tide, wave, ocean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,9E-08	0	0	0	0	8,9E-08	0%
Electricity by Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,6E-08	0	0	0	0	5,6E-08	0%
Electricity nec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,9E-08	0	0	0	0	7,9E-08	0%
Total	2,63475E-05	0,01648	2,1E-05	0,00769	0,00317	7,7E-05	0,02679	0,00011	0,02977	1,1E-06	0,00071	0,00281	0,00115	0,00412	0,00525	0,45	0,10321	7,7E-05	0,00235	0,00055	0,654	
% of Total	0%	3%	0%	1%	0%	0%	4%	0%	5%	0%	0%	0%	0%	1%	1%	69%	16%	0%	0%	0%		

Appendix 5: Employment: Slovenia CBA per sector/country

sector	AU	BR	CA	CN	GB	ID	IN	JP	KR	MX	RU	TR	TW	US	WA	WE	WF	WL	WM	ZA	Total	% of Total
Cement, lime and plaster	0,00024	7,2E-05	2,1E-05	0,00072	0,00138	1,7E-05	0,00114	7E-06	5,6E-05	0,00033	0,00364	0,00027	0,00018	0,00065	0,00016	0,00772	9,7E-05	9,4E-05	0,00032	0,00029	**0,01743**	**1%**
Sand and clay	0,00053	0,00016	5,3E-05	0,0008	4E-05	7,3E-07	1,3E-08	4,5E-06	1,7E-05	8,3E-06	0,00223	7,7E-05	3,3E-05	6,9E-05	0,00039	0,06038	1,4E-05	3,8E-05	6,9E-05	7,1E-05	**0,06498**	**4%**
Iron ores	1,5E-06	0,01653	1,7E-06	9,6E-08	1,8E-09	0	8,8E-06	4,4E-09	8,7E-08	5,7E-06	8,3E-05	6,4E-06	4,4E-08	0,0091	0,00041	0,07273	0,00021	0,00072	7,1E-06	2,2E-07	**0,09983**	**7%**
Basic iron and steel and of ferro-alloys and first products thereof	0,00013	0,00089	0,0008	0,03475	0,00338	0,00013	0,0157	0,00073	0,03033	0,00126	0,01277	0,00564	0,0016	0,00978	0,00723	0,03915	0,00096	0,0005	0,00476	0,00105	**0,17155**	**12%**
Aluminium and aluminium products	0,00035	0,00064	0,00224	0,00703	0,01512	6,1E-06	0,02142	0,00028	0,00032	0,00058	0,00226	0,00433	0,00048	0,00334	0,00163	0,09859	0,09782	0,00064	0,00259	4,3E-05	**0,2597**	**18%**
N-fertiliser	1,2E-06	7,9E-05	1E-06	9,3E-05	8,2E-06	4,5E-09	0,00014	1,6E-05	1,6E-06	7,9E-07	0,00018	5,3E-06	1,8E-06	6E-06	0,00015	0,03764	2,2E-05	3,6E-05	0,00053	8,4E-05	**0,039**	**3%**
P- and other fertiliser	2,3E-05	0,00132	0,00026	0,00222	1,5E-05	6,2E-06	0,00783	0,0005	0,00012	0,00026	0,04499	0,00022	0,00012	0,00052	0,00039	0,00788	0,00625	0,00026	0,00206	0,00029	**0,07552**	**5%**
Electricity by coal	0,01236	8,3E-07	0,00067	6,4E-05	0,00703	0,00071	0,01475	0,00348	0,00372	0,00084	0,01316	0,00495	0,00037	0,01073	0,00609	0,06103	0,00133	0,00053	0,00282	0,00016	**0,14478**	**10%**
Electricity by gas	0,00286	0,00048	1,2E-08	3,4E-09	0,02965	0	0,00284	0,00377	0,00257	0,00628	0,01649	0,00805	0,00031	0,0073	0,00987	0,26434	0,00464	0,00191	0,01287	0	**0,37423**	**26%**
Electricity by nuclear	5,2E-13	4,7E-06	0,00066	4,6E-09	0,00256	0	0,00045	0,00177	0,00185	0	0,00263	0	7,5E-10	0,00287	0,00072	0,04996	0,00105	0,00106	0,00064	1,2E-08	**0,06623**	**5%**
Electricity by hydro	0,00067	0,00012	0,00265	3,2E-09	9,2E-05	2,1E-05	0,00182	0,00012	3,3E-05	0,00038	0,00336	0,00068	2,3E-06	0,00119	0,00283	0,01937	0,00287	0,0035	0,00121	2,5E-10	**0,04091**	**3%**
Electricity by wind	0	2,1E-07	0	1,6E-11	0,00014	0	0,00025	4,4E-06	7E-08	0	1,7E-06	0	4,1E-10	0,00023	2E-05	0,00025	6,7E-06	7,9E-06	3E-05	1,1E-11	**0,00095**	**0%**
Electricity by petroleum and other oil derivatives	0,00022	1,3E-06	6,2E-09	0,00035	0,00029	0,00079	0,00048	0,002	0,00069	0,00213	0,00139	7,7E-05	8,4E-05	0,00092	0,0021	0,00509	0,00278	0,00176	0,0099	3,3E-10	**0,03104**	**2%**
Electricity by biomass and waste	0,00033	5,3E-06	6,4E-09	1,8E-11	0,0005	0	4,3E-08	0,00039	3,5E-07	0	0,00019	3,8E-05	4,2E-09	0,00042	0,00011	0,05146	2,9E-05	0,00017	3,8E-06	6,5E-10	**0,05364**	**4%**
Electricity by solar photovoltaic	0	5E-14	5,7E-06	5E-11	1,1E-08	0	1,6E-06	1,4E-06	4,6E-08	5,4E-07	0	0	6,3E-11	2,5E-06	1,6E-06	0	1E-06	0	3,2E-06	6E-10	**1,8E-05**	**0%**
Electricity by solar thermal	8,2E-08	0	0	1,1E-08	0	0	0	0	0	0	0	0	0	4,7E-06	0	0	0	0	0	0	**4,8E-06**	**0%**
Electricity by tide, wave, ocean	6,2E-13	0	2,9E-07	1,2E-07	0	0	0	0	0	0	0	0	0	0	3,1E-09	1,5E-05	5,1E-06	8,5E-10	2,4E-06	0	**2,3E-05**	**0%**
Electricity by Geothermal	5,5E-08	0	0	5,7E-13	0	0	7,2E-13	3,8E-05	0	0,00013	2E-05	1,1E-14	0	7,2E-05	0,00027	0,00119	1,8E-05	5,1E-05	4,2E-06	0	**0,0018**	**0%**
Electricity nec	2,3E-05	1E-06	0	1,1E-10	8,9E-05	0	1,4E-05	4,6E-05	0,00016	0	0,00025	5,7E-05	8,6E-10	3E-05	8,3E-06	0,00356	0	2,3E-05	3,6E-06	0	**0,00427**	**0%**
Total	**0,01773**	**0,02031**	**0,00736**	**0,04603**	**0,06031**	**0,00168**	**0,06685**	**0,01316**	**0,03987**	**0,0122**	**0,10364**	**0,02439**	**0,00318**	**0,04724**	**0,03239**	**0,78036**	**0,1181**	**0,01129**	**0,03782**	**0,00198**	1,446	
% of Total	**1%**	**1%**	**1%**	**3%**	**4%**	**0%**	**5%**	**1%**	**3%**	**1%**	**7%**	**2%**	**0%**	**3%**	**2%**	**54%**	**8%**	**1%**	**3%**	**0%**		

Appendix 6: Value added - Slovenia CBA per sector/country

sector	AU	BR	CA	CN	GB	ID	IN	JP	KR	MX	RU	TR	TW	US	WA	WE	WF	WL	WM	ZA	Total	%
Cement, lime and plaster	0	0	2,5E-06	0,00106	0,00077	0	5,8E-05	0	2,6E-05	0	0,00077	0,00131	0,00015	0,00015	0,00027	0,01338	3,2E-05	0	0,0012	2E-05	0,0192	0%
Sand and clay	0,00038	0,00344	0	0,00298	0,00062	0	0	3,5E-05	0	0	0	5,9E-05	0,00052	0,00049	0,00064	0,00827	0	0,00051	9,6E-05	0,00224	0,02028	0%
Iron ores	0	1,01937	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,01937	24%
Basic iron and steel and of ferro-alloys and first products thereof	0,00132	0,00338	0,00013	0,08122	0,01707	0,00251	0,03649	0,00635	0,58102	6,9E-05	0,00956	0,04141	0,01341	0,21713	0,02781	0,10928	0,00034	0,00049	0,01982	0,0148	1,18361	28%
Aluminium and aluminium products	0,00014	0,00016	0,00118	0,06464	0,08982	0	0,15327	8,2E-05	0,00274	0	0,02691	0,02459	0,01067	0,0026	0,00718	0,31793	0,53608	0,00041	0,07101	0	1,30942	30%
N-fertiliser	0	0	0	0,00139	0	0	0	0	0	0	0	0	0	0	0	0,05219	0	0	0	0	0,05358	1%
P- and other fertiliser	0	5,7E-05	0	0,00037	0	0	6,1E-05	2,9E-05	0	0	0,0004	2,9E-05	1,3E-05	6,1E-06	0	0,00376	0,02446	0,00023	2,6E-05	0	0,02945	1%
Electricity by coal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Electricity by gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,59281	0	0	0	0	0,59281	14%
Electricity by nuclear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,7E-07	0	0	0	0	2,7E-07	0%
Electricity by hydro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,7E-08	0	0	0	0	3,7E-08	0%
Electricity by wind	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8E-09	0	0	0	0	8E-09	0%
Electricity by petroleum and other oil derivatives	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,00154	0	0	0	0	0,00154	0%
Electricity by biomass and waste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,06822	0	0	0	0	0,06822	2%
Electricity by solar photovoltaic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Electricity by solar thermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
Electricity by tide, wave, ocean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3E-07	0	0	0	0	3E-07	0%
Electricity by Geothermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,6E-07	0	0	0	0	2,6E-07	0%
Electricity nec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,7E-07	0	0	0	0	1,7E-07	0%
Total	0,00184	1,02641	0,00131	0,15166	0,10828	0,00251	0,18988	0,0065	0,58378	6,9E-05	0,03765	0,0674	0,02477	0,22037	0,0359	1,16739	0,56091	0,00165	0,09215	0,01706	4,2975	
%	0%	24%	0%	4%	3%	0%	4%	0%	14%	0%	1%	2%	1%	5%	1%	27%	13%	0%	2%	0%		

Appendix 7: Value added - Slovenia TBA per sector/country

sector	AU	BR	CA	CN	GB	ID	IN	JP	KR	MX	RU	TR	TW	US	WA	WE	WF	WL	WM	ZA	Total	%
Cement, lime and plaster	0,00408	0,0012	0,00035	0,01217	0,02461	0,00029	0,01997	0,00012	0,00099	0,00564	0,06337	0,00534	0,00299	0,01122	0,0018	0,03727	0,00154	0,00158	0,00633	0,00498	**0,20584**	**1%**
Sand and clay	0,00908	0,00446	0,00087	0,01362	0,00102	1,2E-05	2,4E-07	0,0001	0,00029	0,00013	0,04042	0,00135	0,00093	0,00158	0,00102	0,88283	0,00023	0,00073	0,00119	0,00254	**0,96242**	**6%**
Iron ores	2,5E-05	1,02313	3E-05	1,6E-06	3,1E-08	0	0,00015	7,5E-08	1,5E-06	9,3E-05	0,00139	0,00011	7,2E-07	0,15276	0,0069	1,16481	0,00344	0,01173	0,00012	3,7E-06	**2,36469**	**14%**
Basic iron and steel and of ferro-alloys and first products thereof	0,00319	0,01682	0,01335	0,58875	0,06485	0,00338	0,19219	0,01672	0,59277	0,02019	0,2096	0,10911	0,02659	0,31298	0,08581	0,28896	0,01508	0,00833	0,09162	0,02379	**2,68408**	**16%**
Aluminium and aluminium products	0,00569	0,01057	0,0366	0,12036	0,28999	0,0001	0,16119	0,00457	0,00581	0,01006	0,05956	0,07656	0,01364	0,05514	0,01575	0,45373	0,54498	0,01046	0,08303	0,00076	**1,95855**	**11%**
N-fertiliser	2E-05	0,00139	1,8E-05	0,00143	0,00014	7,7E-08	0,00254	0,00027	2,9E-05	1,3E-05	0,00339	9,2E-05	3,1E-05	0,0001	0,0025	0,06112	0,00036	0,00059	0,00903	0,0014	**0,08448**	**0%**
P- and other fertiliser	0,0004	0,02324	0,00478	0,03776	0,00027	0,0001	0,14101	0,00861	0,00212	0,00482	0,86173	0,00388	0,00212	0,00906	0,00646	0,09958	0,03041	0,00431	0,03422	0,00471	**1,27959**	**7%**
Electricity by coal	0,20113	1,4E-05	0,01017	0,00104	0,11494	0,01173	0,24821	0,05743	0,06199	0,01411	0,22344	0,08087	0,00602	0,17791	0,1002	0,9709	0,02203	0,00874	0,04795	0,0025	**2,36132**	**14%**
Electricity by gas	0,0466	0,00814	1,9E-07	5,5E-08	0,47896	0	0,0481	0,06214	0,04296	0,10608	0,28645	0,12973	0,00491	0,12112	0,16326	1,12973	0,07549	0,0314	0,21679	0	**2,95187**	**17%**
Electricity by nuclear	8,8E-12	7,2E-05	0,0097	7,6E-08	0,04126	0	0,00748	0,02882	0,03006	0	0,04488	0	1,2E-08	0,04744	0,01224	0,76456	0,01543	0,01765	0,01062	1,9E-07	**1,0302**	**6%**
Electricity by hydro	0,01076	0,00186	0,03938	5,2E-08	0,00149	0,00035	0,03047	0,00205	0,00054	0,00621	0,05801	0,01097	3,7E-05	0,01977	0,04642	0,30308	0,046	0,05661	0,02068	4,2E-09	**0,6547**	**4%**
Electricity by wind	0	3,4E-06	0	2,6E-10	0,0022	0	0,00426	7,5E-05	1,2E-06	0	2,9E-05	0	6,7E-09	0,00388	0,00034	0,00366	0,00011	0,00013	0,00052	1,9E-10	**0,01522**	**0%**
Electricity by petroleum and other oil derivatives	0,00352	2,2E-05	9,7E-08	0,00603	0,00467	0,01324	0,00819	0,03371	0,0119	0,03631	0,02373	0,00128	0,0014	0,01553	0,03561	0,073	0,04601	0,02907	0,16702	5,5E-09	**0,51025**	**3%**
Electricity by biomass and waste	0,00543	8,1E-05	9,4E-08	2,9E-10	0,00815	0	7,3E-07	0,00634	5,8E-06	0	0,00322	0,00065	6,8E-08	0,00692	0,00195	0,06944	0,00048	0,00275	6,6E-05	1E-08	**0,10549**	**1%**
Electricity by solar photovoltaic	0	8,3E-13	1E-04	8,5E-10	1,9E-07	0	2,8E-05	2,4E-05	8E-07	9,5E-06	0	0	1,1E-09	4,1E-05	2,7E-05	0	1,6E-05	0	5,4E-05	1E-08	**0,0003**	**0%**
Electricity by solar thermal	1,4E-06	0	0	1,8E-07	0	0	0	0	0	0	0	0	0	7,9E-05	0	0	0	0	0	0	**8,1E-05**	**0%**
Electricity by tide, wave, ocean	1,1E-11	0	4,1E-06	2E-06	0	0	0	0	0	0	0	0	0	0	4,8E-08	0,00017	6,9E-05	1,4E-08	3,8E-05	0	**0,00029**	**0%**
Electricity by Geothermal	9,5E-07	0	0	9,8E-12	0	0	1,3E-11	0,00064	0	0,00242	0,00035	1,8E-13	0	0,0012	0,00482	0,0194	0,00029	0,00086	6,9E-05	0	**0,03004**	**0%**
Electricity nec	0,00037	1,6E-05	0	1,8E-09	0,00144	0	0,00024	0,00077	0,00266	0	0,00431	0,00097	1,4E-08	0,0005	0,00014	0,05767	0	0,00039	5,9E-05	0	**0,06954**	**0%**
Total	**0,2903**	**1,09101**	**0,11536**	**0,78117**	**1,034**	**0,02921**	**0,86403**	**0,22239**	**0,75213**	**0,20609**	**1,88388**	**0,42092**	**0,05868**	**0,93724**	**0,48525**	**6,37991**	**0,80198**	**0,18531**	**0,6894**	**0,04069**	17,269	
%	**2%**	**6%**	**1%**	**5%**	**6%**	**0%**	**5%**	**1%**	**4%**	**1%**	**11%**	**2%**	**0%**	**5%**	**3%**	**37%**	**5%**	**1%**	**4%**	**0%**		

Appendix 8: Absolute revenue - Slovenia CBA and TBA

sector	CBA (80€)	CBA (150€)	TBA (80€)	TBA (80€)
Aluminium and aluminium products	0,24	0,44	0,29	0,54
Basic iron and steel and of ferro-alloys and first products thereof	0,16	0,30	0,28	0,52
Cement, lime and plaster	0,02	0,03	0,03	0,06
Electricity by Geothermal	0,00	0,00	0,00	0,00
Electricity by biomass and waste	0,01	0,03	0,02	0,03
Electricity by coal	0,00	0,00	0,17	0,33
Electricity by gas	0,24	0,45	0,41	0,77
Electricity by hydro	0,00	0,00	0,05	0,09
Electricity by nuclear	0,00	0,00	0,08	0,14
Electricity by petroleum and other oil derivatives	0,00	0,00	0,04	0,07
Electricity by solar photovoltaic	0,00	0,00	0,00	0,00
Electricity by solar thermal	0,00	0,00	0,00	0,00
Electricity by tide, wave, ocean	0,00	0,00	0,00	0,00
Electricity by wind	0,00	0,00	0,00	0,00
Electricity nec	0,00	0,00	0,01	0,01
Iron ores	0,04	0,07	0,14	0,26
N-fertiliser	0,02	0,03	0,02	0,03
P- and other fertiliser	0,01	0,02	0,12	0,22
Sand and clay	0,00	0,01	0,07	0,14
Total	**0,74**	**1,38**	**1,72**	**3,23**

Appendix 9: Relative revenue - Slovenia CBA and TBA

sector	CBA (80€)	CBA (150€)	TBA (80€)	TBA (80€)
Cement, lime and plaster	0,0039	0,007	0,007	0,014
Sand and clay	0,0050	0,009	0,099	0,186
Iron ores	0,6719	1,260	2,383	4,468
Basic iron and steel and of ferro-alloys and first products thereof	0,0145	0,027	0,025	0,047
Aluminium and aluminium products	0,0223	0,042	0,027	0,051
N-fertiliser	0,1632	0,306	0,189	0,355
P- and other fertiliser	0,0230	0,043	0,292	0,547
Electricity by coal	0,0000	0,000	0,052	0,098
Electricity by gas	0,4058	0,761	0,697	1,306
Electricity by nuclear	0,0000	0,000	0,022	0,042
Electricity by hydro	0,0000	0,000	0,024	0,046
Electricity by wind	0,0000	0,000	0,008	0,015
Electricity by petroleum and other oil derivatives	0,0014	0,003	0,093	0,175
Electricity by biomass and waste	0,0768	0,144	0,092	0,173
Electricity by solar photovoltaic	0,0000	0,000	0,000	0,001
Electricity by solar thermal	0,0000	0,000	527,605	989,259
Electricity by tide, wave, ocean	0,0050	0,009	0,330	0,618
Electricity by Geothermal	0,0000	0,000	0,239	0,447
Electricity nec	0,0000	0,000	0,412	0,773

Appendix 10: GWP100 – the EU CBA per sector/country

sector	AU	BR	CA	CN	GB	ID	IN	JP	KR	MX	RU	TR	TW	US	WA	WE	WF	WL	WM	ZA	Total	%
Cement, lime and plaster	107,404	17,5954	418,286	46562,6	11891,6	206,004	1116,77	1245,48	44,263	106,132	1791,9	236145	3113,49	1797,15	28149,3	38279,7	5650,58	937,236	30445,5	42,351	**408068,0909**	**8%**
Sand and clay	245,8	901,356	106,181	2362,39	1678,19	4,53076	0	4454,84	0,98251	0,927	36,1273	2885,06	567,311	2899,84	348,481	12715,5	199,018	929,17	10964,9	568,511	**41869,07844**	**1%**
Iron ores	144,585	46121,3	844,681	0,59715	0,43172	0	79,1031	3934,2	0	464,372	3383,57	452,442	0,00017	1,0406	4,78944	10496,3	2368,98	0,86601	2397,11	0	**70694,35219**	**1%**
Basic iron and steel and of ferro-alloys and first products thereof	1310,19	21915,2	1591,59	94279,1	30055,1	2227,32	178702	8856,98	27618,7	2234,22	122913	43140,8	8466,16	10580,3	98336,8	99111,9	3699,82	3443,79	53203,4	3634,03	**815319,9284**	**16%**
Aluminium and aluminium products	2884,99	24752,2	20763,2	72555,5	51909,2	58,0016	31615,5	493,468	3428,1	558,522	61568,9	55221,4	4767,69	13710,6	39014,7	182552	236250	9342,69	55644,7	9662,89	**876754,2503**	**18%**
N-fertiliser	0,03374	43,7065	8,47983	157,063	748,819	0	1,53029	263,577	0	0	16420,8	8676,3	19,0813	59,9866	1085,2	1388,66	997,067	211,073	348,768	49,0707	**30479,1996**	**1%**
P- and other fertiliser	1112,07	97,3146	456,733	10317,7	2141,93	10,7511	1631,51	59,4886	94,4493	608,996	246007	271428	690,097	16299,4	324439	98887,5	361623	148000	52320,7	2605,22	**1538830,446**	**31%**
Electricity by coal	0	0	0	0	58699,5	0	0	0	0	0	0,39933	136249	0	0	0	754091	0	0	1179,27	0	**950219,118**	**19%**
Electricity by gas	0	0	0	0	60726,8	0	0	0	0	0	145,4	85019,7	0	0	0	74552	0	0	8,0452	0	**220451,9258**	**4%**
Electricity by nuclear	0	0	0	0	298,612	0	0	0	0	0	1,4E-07	0	0	0	0	898,381	0	0	10,7077	0	**1207,699994**	**0%**
Electricity by hydro	0	0	0	0	64,9207	0	0	0	0	0	16,9075	504,022	0	0	0	14396,7	0	0	1,7E-06	0	**14982,51317**	**0%**
Electricity by wind	0	0	0	0	1462,92	0	0	0	0	0	0	0	0	0	0	469,731	0	0	1,78525	0	**1934,439647**	**0%**
Electricity by petroleum and other oil derivatives	0	0	0	0	458,2	0	0	0	0	0	0,28482	1379,48	0	0	0	2829,73	0	0	1,90358	0	**4669,598005**	**0%**
Electricity by biomass and waste	0	0	0	0	392,246	0	0	0	0	0	1,76095	252,915	0	0	0	1487,12	0	0	5,35682	0	**2139,40018**	**0%**
Electricity by solar photovoltaic	0	0	0	0	38,2985	0	0	0	0	0	0	0	0	0	0	0	0	0	0,27979	0	**38,57828272**	**0%**
Electricity by solar thermal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0%**
Electricity by tide, wave, ocean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,01764	0	0	0	0	**0,017641299**	**0%**
Electricity by Geothermal	0	0	0	0	0	0	0	0	0	0	0,00274	6,2E-05	0	0	0	0,00203	0	0	0,00034	0	**0,005164008**	**0%**
Electricity nec	0	0	0	0	54,9003	0	0	0	0	0	12,7297	4,2E-05	0	0	0	0,07798	0	0	58,2701	0	**125,9781139**	**0%**
Total	**5805,06**	**93848,7**	**24189,1**	**226235**	**220622**	**2506,61**	**213146**	**19308**	**31186,5**	**3973,17**	**452298**	**841354**	**17623,8**	**45348,3**	**491378**	**1292156**	**610789**	**162865**	**206591**	**16562,1**	**4977785**	
%	**0%**	**2%**	**0%**	**5%**	**4%**	**0%**	**4%**	**0%**	**1%**	**0%**	**9%**	**17%**	**0%**	**1%**	**10%**	**26%**	**12%**	**3%**	**4%**	**0%**		

Appendix 11: GWP100 – the EU TBA per sector/country

sector	AU	BR	CA	CN	GB	ID	IN	JP	KR	MX	RU	TR	TW	US	WA	WE	WF	WL	WM	ZA	Total	%
Cement, lime and plaster	537,70294	279,277	466,362	47800,1	14183	256,667	2885,76	1268,57	226,053	953,322	4491,13	236278	3459,52	3466,99	28348,9	39023,7	6297,15	1207,62	31148,8	771,284	**423349,6656**	**7%**
Sand and clay	868,44029	1122,26	222,85	3595,3	1568,18	5,99745	0,03972	4464,87	50,5161	15,3615	1507,55	2998,53	610,3	3037,95	415,048	64986,4	396,589	981,95	11070,1	596,206	**98514,45001**	**2%**
Iron ores	145,70237	46591	842,039	0,77457	0,38894	0	93,8388	3934,2	0,3442	472,76	3460,4	447,22	0,06712	16557,5	1199,43	127554	5189,42	2335,27	2361,65	0,4191	**211186,7534**	**3%**
Basic iron and steel and of ferro-alloys and first products thereof	1489,8973	23915,3	3200,92	150084	33443	2339,93	201923	10929,2	28822,1	4258,42	130461	45025,5	12985,2	19093,6	104796	100958	8156,37	4796,96	60357,3	5739,26	**952773,8462**	**15%**
Aluminium and aluminium products	3560,0756	25850,6	22344,4	79846,2	60877,8	74,4261	32358	1343,77	4191,77	1886,09	62898,8	54591,8	5116,47	15810,4	39770,7	179068	232572	10234,1	56672,1	9826,93	**898894,2123**	**14%**
N-fertiliser	3,1923167	376,443	11,6846	168,01	749,556	0,021	313,783	313,314	6,1105	4,72776	16402	8668,04	26,1144	85,9117	1493,62	1835,69	1126,14	377,889	1999,07	303,59	**34264,9505**	**1%**
P- and other fertiliser	1155,6709	4220,48	1083,16	18096,3	1656,98	32,8804	16416,5	1809,95	487,786	1389,3	253758	270986	1194,38	18431	324251	100062	361997	148213	56813,4	3375,49	**1585430,603**	**25%**
Electricity by coal	14619,802	11,3418	1738,05	89,2838	74575,8	1650,59	27394,1	8136,8	7118,2	2492,29	15614,4	142957	926,499	51237,3	12683,5	790024	10292,4	1943,68	9987,18	292,605	**1173784,737**	**18%**
Electricity by gas	3339,9312	1627,15	0,02817	0,0063	116508	0	7021,27	9556,49	3673,71	9472,35	20459,2	97445	705,676	30856,6	22280,1	103120	30779,4	6919,55	33478,5	0	**497243,42**	**8%**
Electricity by nuclear	1,252E-06	30,7543	1774,17	0,0076	5223,09	0	904,632	4965,69	2968,91	0	2778,51	0	0,00149	11769,1	2110,07	30647,5	5974,94	5664,67	1636,35	0,02341	**76448,40878**	**1%**
Electricity by hydro	863,20629	706,408	6897,09	0,00501	256,084	73,8976	4634,28	309,898	123,883	549,11	3780,46	1672,03	22,3106	6264,7	6635,42	27915,1	19829,9	9326,72	3646,11	0,00104	**93506,69632**	**1%**
Electricity by wind	0	1,22432	0	3,8E-05	1768,75	0	655,678	10,4484	0,22791	0	22,1575	0	0,00329	864,31	56,9777	618,648	54,0445	41,6524	94,562	8,1E-05	**4188,681515**	**0%**
Electricity by petroleum and other oil derivatives	330,55144	11,8588	0,0279	745,129	1640,17	2651,64	3074,05	7591,33	4806,47	6454,21	1700,09	1479,11	277,628	25123,1	9438,49	9555,5	96687,2	17964,3	157830	0,00161	**347360,4824**	**5%**
Electricity by biomass and waste	408,40921	31,1144	0,01839	0,00017	1512,4	0	0,12722	1057,51	2,0527	0	282,796	342,758	0,02322	2704,13	349,838	1464,54	244,005	752,717	14,4314	0,00175	**9166,870651**	**0%**
Electricity by solar photovoltaic	0	1,4E-07	18,7473	0,00023	38,297	0	3,99373	4,40831	0,14957	3,77111	0	0	0,00078	7,9015	4,50286	0	5,03801	0	7,75548	0,00312	**94,56902087**	**0%**
Electricity by solar thermal	0,1495141	0	0	0,02732	0	0	0	0	0	0	0	0	0	16,7655	0	0	0	0	0	0	**16,9423619**	**0%**
Electricity by tide, wave, ocean	1,661E-06	0	0,81942	0,30049	0	0	0	0	0	0	0	0	0	0	0,00901	5,27913	19,6123	0,00285	6,10981	0	**32,13300153**	**0%**
Electricity by Geothermal	0,2566289	0	0	2,7E-06	0	0	1,4E-06	119,304	0	312,221	25,0949	6,2E-05	0	253,145	1022,02	1348,17	104,366	308,292	10,8272	0	**3503,701108**	**0%**
Electricity nec	34,871592	4,83729	0	0,00019	324,124	0	72,3275	134,687	264,76	0	293,059	97,7596	0,00305	172,008	23,6089	3564,48	0	171,26	66,3516	0	**5224,142217**	**0%**
Total	**27357,86**	**104780**	**38600,4**	**300425**	**314326**	**7086,05**	**297751**	**55950,5**	**52743**	**28263,9**	**517935**	**862988**	**25324,2**	**205752**	**554879**	**1581751**	**779726**	**211240**	**427200**	**20905,8**	6414985,27	
%	**0%**	**2%**	**1%**	**5%**	**5%**	**0%**	**5%**	**1%**	**1%**	**0%**	**8%**	**13%**	**0%**	**3%**	**9%**	**25%**	**12%**	**3%**	**7%**	**0%**		

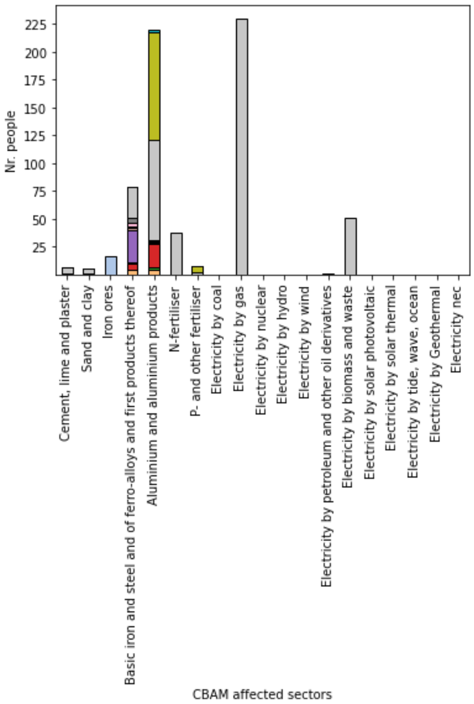
Appendix 12: Absolute and relative revenue – the EU CBA and TBA

sector	CBA (80€)	CBA (150€)	TBA (80€)	TBA (80€)
Aluminium and aluminium products	70,1	131,5	71,9	134,8
Basic iron and steel and of ferro-alloys and first products thereof	65,2	122,3	76,2	142,9
Cement, lime and plaster	32,6	61,2	33,9	63,5
Electricity by Geothermal	0,0	0,0	0,3	0,5
Electricity by biomass and waste	0,2	0,3	0,7	1,4
Electricity by coal	76,0	142,5	93,9	176,1
Electricity by gas	17,6	33,1	39,8	74,6
Electricity by hydro	1,2	2,2	7,5	14,0
Electricity by nuclear	0,1	0,2	6,1	11,5
Electricity by petroleum and other oil derivatives	0,4	0,7	27,8	52,1
Electricity by solar photovoltaic	0,0	0,0	0,0	0,0
Electricity by solar thermal	0,0	0,0	0,0	0,0
Electricity by tide, wave, ocean	0,0	0,0	0,0	0,0
Electricity by wind	0,2	0,3	0,3	0,6
Electricity nec	0,0	0,0	0,4	0,8
Iron ores	5,7	10,6	16,9	31,7
N-fertiliser	2,4	4,6	2,7	5,1
P- and other fertiliser	123,1	230,8	126,8	237,8
Sand and clay	3,3	6,3	7,9	14,8
Total	**398,2**	**746,7**	**513,2**	**962,2**

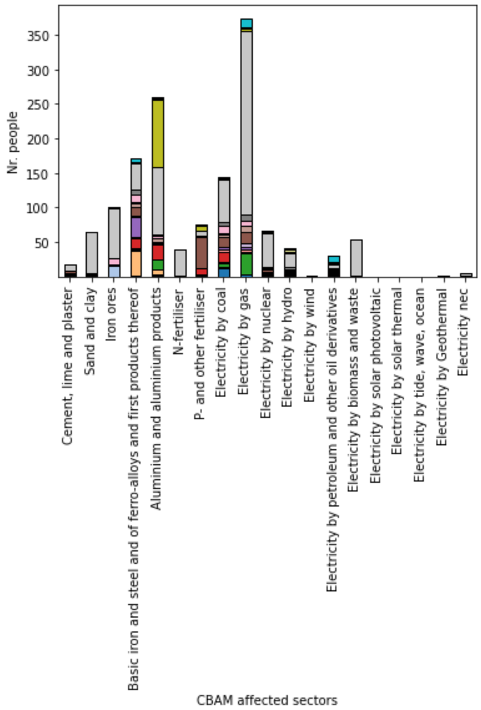
Appendix 13: Relative revenue – the EU CBA and TBA

sector	CBA (80€)	CBA (150€)	TBA (80€)	TBA (80€)
Cement, lime and plaster	0,025	0,047	0,026	0,049
Sand and clay	0,012	0,022	0,028	0,053
Iron ores	0,239	0,449	0,715	1,341
Basic iron and steel and of ferro-alloys and first products thereof	0,031	0,058	0,036	0,068
Aluminium and aluminium products	0,092	0,172	0,094	0,176
N-fertiliser	0,249	0,467	0,280	0,525
P- and other fertiliser	1,648	3,089	1,697	3,183
Electricity by coal	0,160	0,300	0,197	0,370
Electricity by gas	0,036	0,068	0,082	0,154
Electricity by nuclear	0,000	0,000	0,012	0,022
Electricity by hydro	0,004	0,008	0,025	0,047
Electricity by wind	0,002	0,003	0,004	0,007
Electricity by petroleum and other oil	0,005	0,009	0,365	0,685
Electricity by biomass and waste	0,002	0,004	0,009	0,017
Electricity by solar photovoltaic	0,000	0,001	0,001	0,001
Electricity by solar thermal	0,000	0,000	0,004	0,008
Electricity by tide, wave, ocean	0,000	0,000	0,012	0,022
Electricity by Geothermal	0,000	0,000	0,041	0,076
Electricity nec	0,000	0,001	0,017	0,033

Appendix 14: Employment - Slovenia CBA/TBA per sector

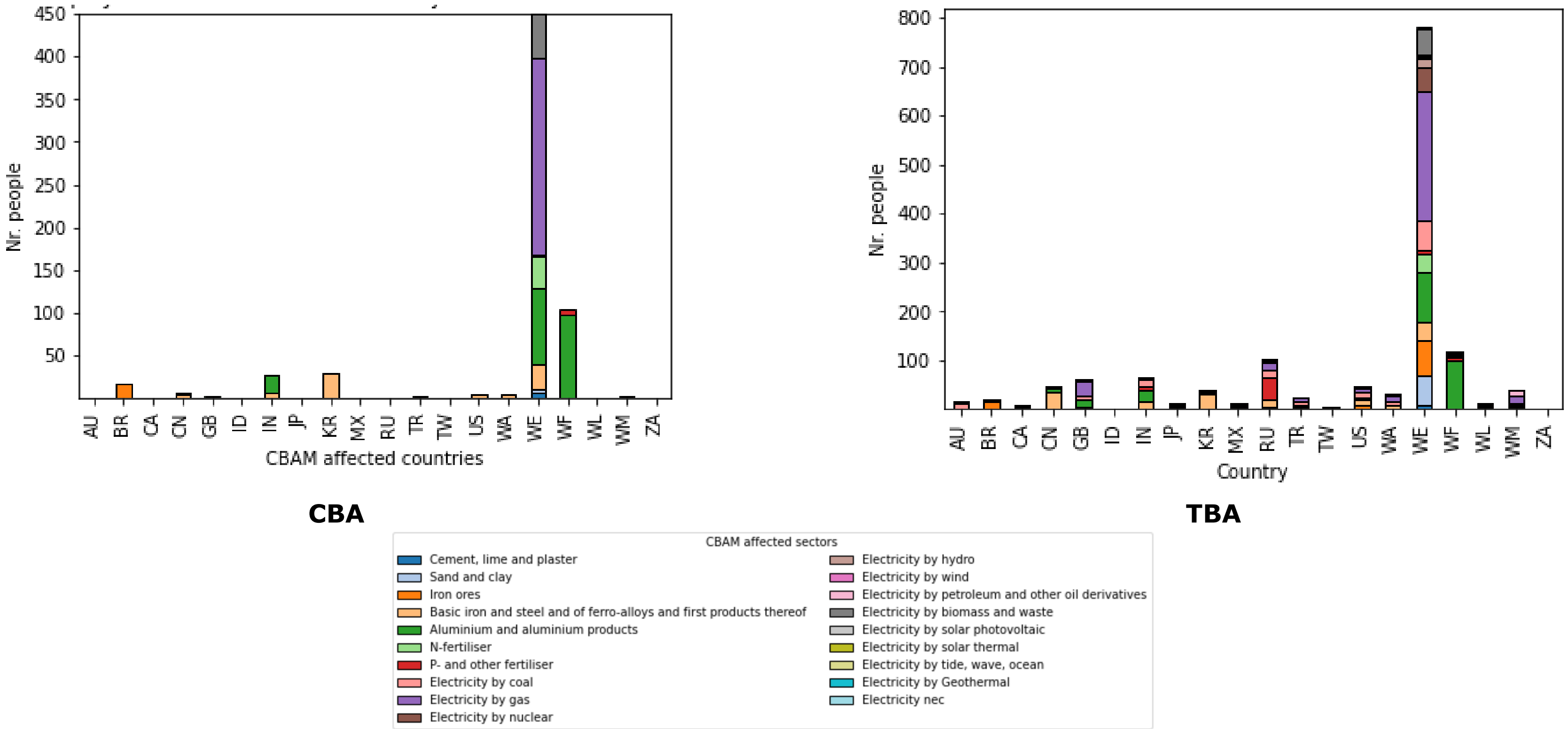


CBA

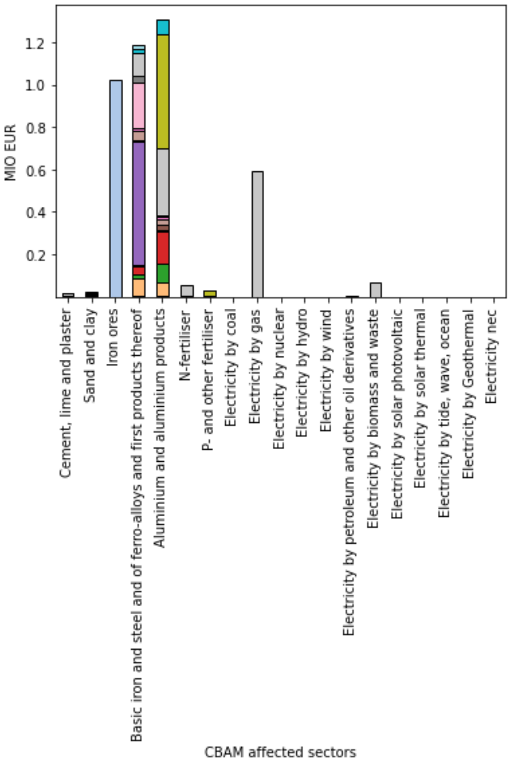


TBA

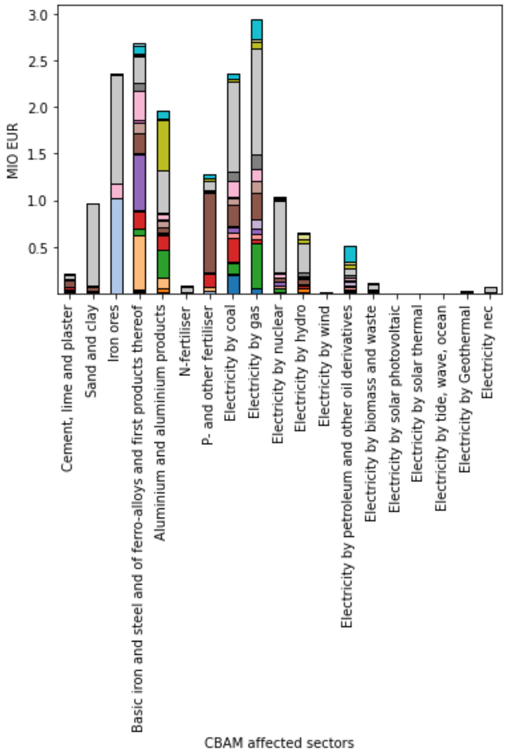
Appendix 15: Employment - Slovenia CBA/TBA per country



Appendix 16: Value Added - Slovenia CBA/TBA per sector

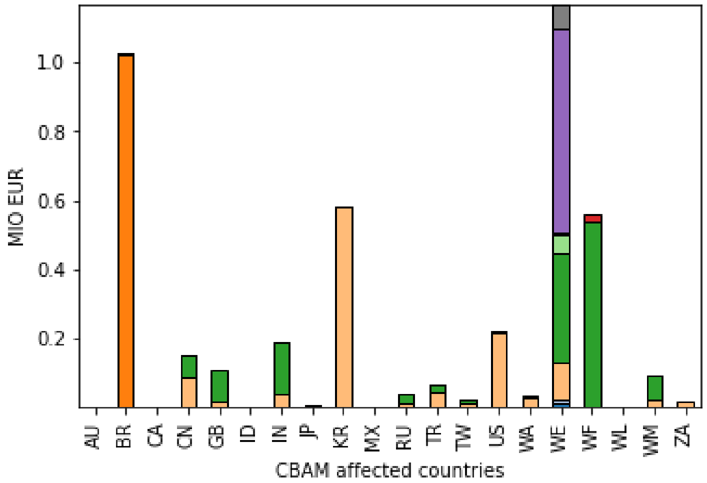


CBA

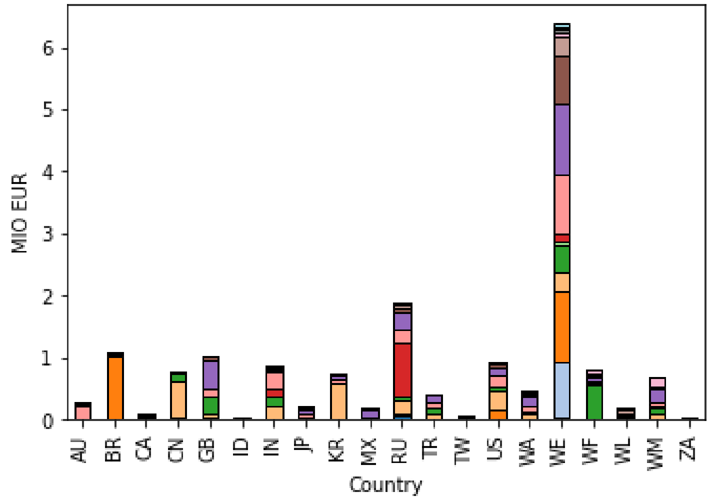


TBA

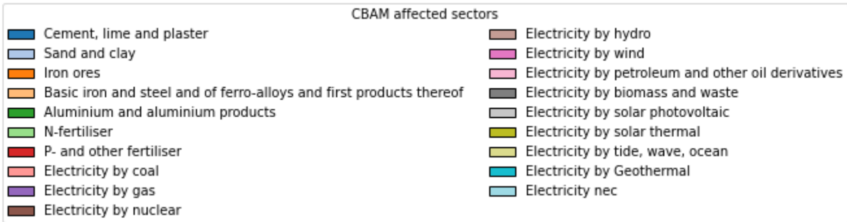
Appendix 17: Value Added - Slovenia CBA/TBA per country



CBA



TBA



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