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CBAM – Steering the World Trade to Fit the Future

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We hope our thesis can help the world a small step towards the green transition, or at least put the spotlight on a new potential policy measure to mitigate climate change. Enjoy!

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Executive Summary

A Carbon Border Adjustment Mechanism, also known as CBAM, is a policy proposed by the European Commission as a part of “Fit for 55” - an intermediate goal along the way to achieve the final goal of the European Green Deal: climate neutrality within 2050. The increased ambition level of the EU consists, among others, of phasing out free allowances and decreasing the overall cap of quotas in the EU ETS. Additionally, the Commission has proposed to introduce a CBAM. The CBAM will strive to prevent carbon leakage, protect the decarbonization initiatives in the EU/EFTA, incentivize third country producers to reduce emissions, and ensure that the price of imports to the EU/EFTA reflects their carbon content.

In this thesis, we focus on Norway and analyze the effects, on both imports and production, when implementing the CBAM at the EU/EFTA border. First, we analyze the effects in the EU/EFTA aluminum market when both phasing out the free allowances and phasing in the CBAM. Second, we analyze the direct impacts of the CBAM on the imports of cement, fertilizer, iron & steel, and aluminum to Norway.

We find that EU/EFTA producers and third country producers with low carbon intensities will be able to capture additional market shares as a consequence of the CBAM. This will cause a reduction in consumption-related emissions in the EU/EFTA. Whether total greenhouse gas emissions are reduced globally depends on whether foreign producers increase their ambition levels in line with the EU/EFTA. Furthermore, we calculate the direct impacts of the CBAM on Norwegian imports, comparing the effects of including scope 1 emissions versus scope 1+2 emissions in the policy. For both alternatives, the CBAM tariff will eliminate the most carbon-intensive goods from the Norwegian imports. The cement sector is hit the hardest in relative terms, while the carbon content of imports is reduced the most in absolute terms in the aluminum sector. However, we find that the inclusion of scope 2 in the CBAM imposed on imports at the Norwegian border will not increase the efficiency of the policy.

Glossary

Term or acronym	Meaning or definition
BCA	Border Carbon Adjustment
CBAM	Carbon Border Adjustment Mechanism
EE MRIO	Environmentally Extended Multi Regional Input Output
ETS	Emission Trading System
Extra-EU/EFTA	Transactions with country/region outside of the EU/EFTA
GDP	Gross Domestic Product
GHG	Greenhouse Gas
ixi	Industry by industry
MAC	Marginal Abatement Costs
MEUR	Million Euros
MT	Million Tons
PMC	Private Marginal Cost
pxp	Product by product
RoW	Rest of World
Scope 1	Direct emissions
Scope 2	Indirect emissions caused by purchased energy
Scope 3	Indirect emissions caused by all other sources than energy
Third country	Country outside of the EU/EFTA
UN	United Nations
WTO	World Trade Organization

Contents

List of Figures

List of Tables

1 Introduction

The globe is getting warmer, and scientists are now witnessing rapid and severe climate changes all over the world (IPCC, 2021). July 2021 was even the warmest month ever recorded (Masters, 2021). This emphasizes the necessity and cruciality of taking real climate action during the next decade, not leaving future generations with an uninhabitable globe.

«Carbon must have its price – because nature cannot pay the price anymore». Such were the words of the President of the European Commission, Ursula von der Leyen, when she first announced the Carbon Border Adjustment Mechanism as a key initiative for 2021 (Leyen, 2020). This mechanism, also known as the CBAM, is one of many initiatives along the way of reaching the EU's increased level of climate ambition. Two milestones are set for the next decades: reducing greenhouse gas (GHG) emissions by at least 55% within 2030 compared to 1990 levels and becoming climate neutral by 2050 (European Commission, n.d.b). These pillars are respectively known as "Fit for 55" and the European Green Deal.

On the 14th of July 2021, the European Commission (EC) presented its "Fit for 55" package, including the CBAM, alongside 12 other legislative proposals. The CBAM proposal bears the mark of still being under development, yet the essence of the border mechanism is clearly presented; prevent carbon leakage, protect the decarbonization initiatives in the EU/EFTA, incentivize producers from third countries to reduce emissions, and ensure the price of imports to the EU/EFTA reflects their carbon content (European Commission, 2021).

Carbon leakage occurs if domestic production is transferred to third countries or if carbon-intensive imports replace less carbon-intensive products domestically due to differences in climate policies (European Commission, 2021). Currently, the risk of carbon leakage in the EU's Emission Trading System (EU ETS) is managed by granting free allowances and compensating for increased electricity costs under state aid rules (European Commission, 2021). However, free allowances weaken the price signal of the EU ETS compared to full auctioning. The EC thus claims the free allowances reduce incentives among domestic producers for investing in further abatement of GHG emissions (European Commission, 2021). In order to reach its ambitious goals, the EC will therefore phase out free allowances within 2035. As this takes place, the CBAM will be an important but not least a necessary policy tool in order to create a level playing field in the EU/EFTA market.

1.1 Research Questions

This thesis provides an overview of the EC's policy proposal on implementing the CBAM in the EU/EFTA region, and focuses on how it will affect Norway and the Norwegian industry. The CBAM seeks to prevent carbon leakage, protect the decarbonization initiatives in the EU, incentivize producers from third countries to reduce emissions, and ensure the price of imports to the EU/EFTA reflects their carbon content. We will bear these four motivations in mind when answering the following research questions:

Question 1: *How will the EU/EFTA aluminum market adapt when the CBAM is implemented?*

Question 2: *What are the direct impacts of the CBAM on imports to Norway?*

In the current proposal from the EC, the EFTA countries Iceland, Lichtenstein, Norway, and Switzerland are excepted from the CBAM (European Commission, 2021). This means goods imported to the EU from these countries will not be subject to the CBAM. At this point in time, it is not yet decided whether the EC will impose the CBAM on the border of the EFTA countries or if they are given the authority to implement it themselves. Nevertheless, throughout our analysis, we consider the CBAM to be implemented at the border of all EU/EFTA countries.

1.2 Outline

Our thesis is structured in the following way. First, in chapter 2, we present the EC's proposal of the CBAM and the response from the Norwegian industry. In chapter 3, we present theories and studies meant to improve knowledge of the concepts used throughout our analysis. In chapter 4, we present our data retrieved on imports, carbon intensities, and transactions. The chapter provides an overview of our process of delimitating and merging the data sets into our final data used for calculations. Last, we present the descriptive statistics of the data. In chapter 5, we present our methodology. This includes the approach of the CBAM calculation and the approach of calculating the carbon intensities of scope 2 emissions. In chapters 6 and 7, we analyze the effects of implementing the CBAM. In chapter 6, we analyze how the phase-in of the CBAM and the simultaneous phase-out of free allowances may affect the EU/EFTA aluminum market. In chapter 7, we analyze the direct impacts of imposing the CBAM on imports of cement, fertilizer, iron & steel, and aluminum to Norway and compare the two alternatives of including scope 1 or scope 1+2 emissions in the policy. Chapter 8 shed light on possible weaknesses of our analysis, while chapter 9 concludes and suggests potential focuses for further research.

2 Background on the CBAM

The aim of introducing the CBAM is to support emissions reduction in the EU/EFTA while preventing this effort from leading to increased emissions in other regions (European Commission, 2021). This part aims to give a brief overview of the policy proposal on the CBAM presented by the EC on the 14th of July 2021 and shed light on the response from the Norwegian industry.

2.1 The EC's Proposal

By setting the ambitious goals of reducing GHG emissions in the EU by at least 55% within 2030 compared to 1990 levels and becoming climate neutral by 2050, the EU has to decarbonize at a pace never seen before. Thus, as a part of the "Fit for 55" package, the EU ETS is proposed for revision (European Commission, 2021). Most noteworthy, this means phasing out free allowances and reducing the overall cap of quotas.

Up until this very point in time, free allowances have effectively prevented carbon leakage (European Commission, 2021). The free allowances are assigned to industries in the EU ETS exposed to the risk of carbon leakage and give industries permission to emit without paying for quotas. Thus, the free allowances have prevented production in the EU/EFTA from being transferred to countries with less stringent climate policies. However, free allowances have also weakened the price signal on carbon in the EU ETS compared to full auctioning (European Commission, 2021). Thus, the EC has expressed its concern that the mechanism does not give domestic producers a strong enough incentive to reduce emissions and has also claimed that it is a costly measure (European Commission, 2021). The revision of the EU ETS will, therefore, reinforce the emission trading system. Howbeit, in order to prevent carbon leakage from occurring, the EC has proposed to introduce the CBAM, a policy measure meant of replacing the current granting of free allowances.

The CBAM will function as a carbon tariff on imports, based on units of emissions, which has the purpose of reflecting the price of carbon at any given point of time in the EU/EFTA. The CBAM tariff will be paid by the importer of the goods and collected at the border to the EU/EFTA. Thus, in addition, to prevent carbon leakage, the CBAM will also give revenues to the EU budget.

Like the system of allowances in the EU ETS, the distribution of CBAM certificates will be based on the carbon intensity of the imported goods[1]. The price of the certificates will correspond to the price in the EU ETS, expressed in EUR per ton of CO_2 equivalents emitted. Thus, the price of the certificate will mirror the price of the EU ETS allowances. Albeit, in contrast to the EU ETS price, which is set on a daily basis, the CBAM certificate price will be calculated on the average weekly auction price of the EU ETS (European Commission, 2021). The reason for this is to reduce needless uncertainty for the importer. The tariff on imports will be based on actual emissions from third country producers or be set by default values. Finally, the certificates will not be directly linked to the EU ETS system, as there should be no cap of imports (European Commission, 2021). The rationale of this is that a cap of imports could create unacceptable restrictions to global trade, which is not the aim of the CBAM. In fact, the CBAM will be in line with World Trade Organization (WTO) rules and other international obligations of the EU (European Commission, 2021).

Even though the emissions monitoring of imports is outside the EU, the responsibility of conveying this information lies with the importer (European Commission, 2021). Therefore, it will be the importer's role to report the actual emissions stemming from the production and surrender the corresponding number of CBAM certificates. Where sufficient emission data is not available, default values will apply. The importer is, however, allowed to prove that the actual emissions are lower than the default value or prove that a carbon price has been paid in the country of origin. This assumes there is no other rebate or compensation upon export of the good. Proving the goods have a lower carbon content than the default values would reduce the CBAM tariff.

As mentioned, the CBAM will replace the free allowances in the EU ETS. However, in order to protect the domestic industry from unnecessary harm, the free allowances will not be gone overnight but phased out over a ten-year period (European Commission, 2021). As this happens, the CBAM will be phased in proportionally. It all begins with a transitional period, from 2023 to 2025, where importers must report the direct and indirect emissions of imports. There will be no financial transactions involved during these years. From 2026, however, the plan is to phase out the free allowances and, at the same time, phase in the CBAM by ten percentage points each year (European Commission, 2021). In 2035, the free allowances will

[1] The emissions accounted for in the CBAM calculation will be based on the same GHG emissions as those covered in the EU ETS.

be fully phased out, while the CBAM will be fully phased in. First at this point in time, the full price signal of the CBAM will be present. During this period, the overall cap of quotas within the EU ETS will also decline in addition to the phase-out of free allowances (European Commission, 2021). Together these effects will increase the price signal on carbon for EU/EFTA producers.

Even though the final objective of the CBAM is to cover a broad range of products, both basic products, semi-finished and finished goods, the EC has found it prudent to start implementing the CBAM with only a few sectors with relatively homogeneous products (European Commission, 2021). The sectors covered in the current proposal are cement, fertilizers, iron & steel, aluminum, and electricity. These sectors are at high risk of carbon leakage and have high GHG emissions (European Commission, 2021). At the same time, the EC finds it desirable to reduce complexity and administrative effort. However, the EC has a list of 63 other sectors and sub-sectors which are exposed to carbon leakage[2] (European Commission, 2021). The EC will evaluate whether the CBAM also will cover more of these sectors at a later point in time.

As of now, the CBAM will only cover direct emissions caused by production. Nevertheless, the EC leaves the door open for reevaluating whether the CBAM also should cover indirect emissions by the end of the transition period (European Commission, 2021). If this happens, the system of financial compensation for indirect emissions will be phased out. This compensation scheme exists because electro-intensive sectors are affected indirectly through increased electricity prices. This is due to power producers in the EU ETS do not receive free allowances and thus have to cover their emissions with buying quotas (European Commission, 2020b). Therefore, EU ETS Member States are allowed to compensate the most electro-intensive sectors through financial compensation for indirect emissions (European Commission, n.d.a).

2.2 Norwegian Response to the Proposal

Although the Norwegian industry supports the EU's increased ambition level, it has not surprisingly expressed its concern regarding the new policy proposals. The industry is particularly concerned regarding the CBAM replacing the scheme of free allowances and potentially the financial compensation for indirect emissions for sectors exposed to carbon

[2] The list can be found in the Official Journal of the European Union L 120, Volume 62, 8th of May 2019

leakage. In 2020, the Norwegian industry received free allowances corresponding to 15 557 448 tons CO_2 equivalents (Norwegian Environment Agency, n.d.). Additionally, approximately 2 526 $million\ NOK$ was given to the industry in compensation for indirect emissions (Norwegian Environment Agency, 2021).

The industry, including businesses, industry- and labor associations, agrees that the policy must be designed not to hinder EU/EFTA employment, industrial activity, and value creation (Alfheim, Almlid, Eggum, Følsvik, & Lier-Hansen, 2021; Confederation of Norwegian Enterprise, 2021; Fog, 2021). They claim free allowances and the financial compensation for indirect emissions are vital for the Norwegian industry and argue that competitiveness for the industry likely will decrease if these measures are replaced by the CBAM.

The Confederation of Norwegian Enterprise (NHO) argues that production costs for EU/EFTA producers will increase by removing free allowances (Confederation of Norwegian Enterprise, 2021). Outside the EU/EFTA, competitors will not be charged the same carbon price. This means European producers exporting to third countries lose competitiveness due to higher production costs, even if EU/EFTA products have a lower carbon content. Therefore, the business community has called for a refund of the carbon cost for exports to be included in the policy (Confederation of Norwegian Enterprise, 2021). Such a refund would entail equal treatment of EU/EFTA and third country producers also in the world market. However, such an export rebate is not included in the current CBAM proposal.

The industry argues that phasing out free allowances and phasing in the CBAM will increase costs for EU/EFTA manufacturers further down the value chain who use the CBAM products as input material in their production (Confederation of Norwegian Enterprise, 2021; Fog, 2021). As the proposal only covers products of 100% raw materials, it will be possible to import finished products from third countries without being affected by the CBAM. This means EU/EFTA producers using CBAM products as input factors will get increased costs without being able to increase prices. Loss of competitiveness for these producers may result in both reduced production in the EU/EFTA and cause a negative demand effect for EU/EFTA producers of primary materials (Confederation of Norwegian Enterprise, 2021). Besides, Hydro claims that this will lead to loss of jobs in the EU/EFTA and increased global emissions (Fog, 2021). Hydro, therefore, argues that the CBAM must cover more products further down the value chain, including products that consist of less than 100% raw materials (Fog, 2021).

Hydro further claims that the CBAM only optimally will prevent carbon leakage and provide real incentives for emissions reduction if the EU/EFTA industry is financially equipped for the green transition (Fog, 2021). The company argues that the industry's financial sustainability will deteriorate if free allowances and financial compensation for indirect emissions are removed. Norwegian trade unions and business associations desire that the income from the CBAM should be returned to businesses and be inspired by the EU Innovation fund (Alfheim, Almlid, Eggum, Følsvik, & Lier-Hansen, 2021).

3 Literature Review

In this chapter, we will present literature on different aspects one should bear in mind when discussing the CBAM. This includes both theory and studies within the field of externalities, carbon leakage, and the implementation of tariffs on imports.

3.1 Internalizing Negative Externalities

The EC (2021) has announced that they want to promote relevant instruments and incentives to better implement the 'polluter pays principle.' Meaning the polluter has to bear the cost of preventing and controlling any pollutant source he owns (OECD, 1992). In this case, that is to reduce pollutant GHG emissions.

When free markets fail to maximize social welfare, by creating externalities, they are referred to as market failures (Bowen, Dietz, & Hicks, 2014). GHG emissions are negative externalities. Externalities because the emitter is not bearing the costs associated with their emissions and negative because the emissions reduce social welfare. Economic agents usually do not take the negative externalities into account when making decisions. Consequently, GHGs are being over-emitted. However, when a price is set on emissions, the negative externality will become internalized, hence correcting the market failure (Goolsbee, Levitt, & Syverson, 2013). The internalization makes it more costly to emit. In this way, the producers get incentivized to both reduce emissions and invest in clean technology.

In current international climate agreements, there are strong incentives for free riding (Nordhaus, 2015). Free riding occurs when someone gains benefits from a public good without contributing to the costs. In the case of the international climate-change policy, countries have an incentive to rely on the emissions reduction of others without doing equivalent abating themselves. Even though free riding is widespread, it is especially tough to evade for global public goods. Global market failures differ from national market failures as no market nor governmental mechanisms effectively can handle them (Nordhaus, 2015). Therefore, it has proven challenging to persuade countries to join international agreements with emissions reduction of significance. Even though global climate agreements have been signed, such as the Kyoto Protocol and the Paris Agreement, there are still strong incentives to rely on other countries' emissions reduction (Nordhaus, 2015). Nordhaus (2015) claims the global problem of free riding exists because there are no penalties if countries choose not to follow today's agreements.

3.2 Carbon Leakage

The EC (2021) emphasizes that there is a risk of carbon leakage when there exist different levels of climate ambitions. This can lead to domestic production being transferred to third countries or imports from third countries replacing less carbon-intensive, but equivalent products, at home. The literature often defines the phenomenon as production, investments, or consumption of fossil fuels moving from an area where climate policy is stringent to other areas where restrictions are less stringent (Assous et al., 2021; Bye & Rosendahl, 2012; Felder & Rutherford 1993). Sectors which are exposed to trade, and are energy-intensive, such as cement, steel, and aluminum, are shown to have considerably higher leakage rates compared to other sectors (Demailly & Quirion, 2008, as referred in Mehling, Asselt, Das, Droege, & Verkuijl, 2019).

Kuusi et al. (2020) find empirical evidence for an increase in carbon leakage as the EU ETS over the past years has become stricter. Their evidence builds on both increased CO_2 intensity and CO_2 content of imports. Peters (2010), on the other hand, puts forth that an increase in emissions in countries outside of areas with a carbon price rather occurs in order to meet consumption in the countries with carbon pricing. He refers to this kind of leakage as a demand-driven carbon leakage and the one caused by climate policy as policy-induced carbon leakage.

When it comes to carbon leakage caused by climate policy, two sources of leakage are addressed more in the literature; the competitive effect and the energy market effect (see e.g., Böhringer et al., 2012b; Felder & Rutherford, 1993; Winchester, 2012). The competitive effect occurs as competitive, and energy-intensive industries lose competitiveness abroad and at home due to stricter climate policies in the domestic market. Hence, industrial production becomes at risk of being moved to regions where constraints are lower in order to increase competitiveness (Bye & Rosendahl, 2012). The energy market effect occurs when countries introduce climate policies that reduce the demand for fossil fuels (Böhringer, Bye, Fæhn, & Rosendahl, 2012b). As a consequence, international prices for fossil fuels will decrease. The risk of carbon leakage will then arise because demand in areas with less stringent regulations could increase due to the reduced prices. According to Böhringer et al. (2012b), most studies indicate that the energy market effect accounts for a larger share of the total carbon leakage than the competitive effect.

Sinn (2012) refers to the increased demand abroad as a result of stricter domestic policies as the Green Paradox. He discusses how regions implementing "green" policies rather have accelerated global warming. He points out that while the stricter policies succeed in reducing the domestic emissions, consumers in third countries may likely increase consumption due to falling resource prices and hence offset the domestic emissions reduction.

3.3 Tariffs Imposed on Imports

Tariffs on imports are often used to restrict trade (Norman & Orvedal, 2010). If a foreign producer sells its goods in a country where a tariff is imposed on the imports, the tariff will act as a price surcharge on the world market price, which must be paid at the border (Norman & Orvedal, 2010). Hence, tariffs act as trade barriers and will reduce international trade while protecting producers in the import-competing sector in the domestic market.

Tariff on imports will cause a gap between the domestic market price and the world market price. If the good still is imported after the tariff has been introduced, the gap will be identical to the tariff (Norman & Orvedal, 2010). In order to look at how imports will be affected by a tariff, several researchers have attempted to estimate the belonging trade elasticities. These analyzes isolate the historical trade effect of tariffs. Albeit, there is great disagreement about whether these elasticities are best estimated at the product or sector level and whether heterogeneity of goods should be accounted for (Fontagné, Guimbard, & Orefice, 2019; Giri, Yi, & Yilmazkuday, 2021; Imbs & Mejean, 2017; Kuusi et al. (2020)).

Estimates of trade elasticities, found at the sectoral level, are found to be negative. This shows imports are reduced with higher tariffs, assuming all other economic factors are held constant. Giri, Yi, & Yilmazkuday (2021) and Imbs & Mejean (2017) find trade elasticities ranging in an interval of respectively -3.0 to -8.9 and -2.8 to -10.9. These estimates are somewhat higher than Kuusi, et al. (2020), which find trade elasticities to range from -0.7 to -6.5. These differences are believed to be due to a greater amount of countries included in the latter analysis (Kuusi, et al., 2020). In comparison, Fontagné, Guimbard, & Orefice (2019) find different estimates at the product level. They even find positive elasticities for some products, which are assumed to keep the imports constant at today's level. This adds to the discussion of trade elasticities that heterogeneity of products is of greater importance than some assume (Fontagné, Guimbard, & Orefice, 2019).

3.4 Border Carbon Adjustment

Even though the empirical evidence on the effect of Border Carbon Adjustments (BCAs) on carbon leakage and competitiveness is limited, the mechanism has been evaluated in literature even prior to the proposal of the CBAM. Cosbey et al. (2012) argue that there are at least three possible motivations for introducing a BCA. These are to reduce the risk of carbon leakage, maintain industry competitiveness, and create leverage. However, only the first motivation should be a reason to introduce a BCA, as preventing carbon leakage is the only motivation that is ultimate for environmental reasons (Cosbey, et al., 2012). Conserving scarce natural resources and protecting plant, animal, and human life and health are legitimate objectives for violating international trade law obligations (Fischer & Fox, 2009).

The second motivation, preventing loss of industry competitiveness, is in contrast purely an economic motivation (Cosbey, et al., 2012). This motivation is based on concerns related to losing profits, market shares, production, investments, and jobs as carbon regulations are introduced. Those losses can occur as production is moved to an area with less stringent climate policies (Condon & Ignaciuk, 2013). Since the motivation is purely economic, it disputes with the WTO rules (Cosbey, et al., 2012). It is, however, essential to note that the first motivation also may have implications for competitiveness, but the underlying drivers differ from the second motivation.

The third motivation, leverage, means a BCA could put pressure on other countries to increase their level of ambition in order to reduce emissions of significance. According to Cosbey et al. (2012), the leverage motivation is inappropriate as it may be ineffective. It may as well backfire by weakening the efforts of other countries to achieve a multilateral climate agreement. Winchester (2012) also argues that foreign producers can view the tariff as a tariff on export rather than a tariff on emissions if emissions calculations are not updated frequently enough. This third motivation may also come in conflict with the UNFCCC principle of common but differentiated responsibility and respective capabilities (CBDR), which underlines that developing countries are not expected to implement the same policies as developed countries (Cosbey, et al., 2012).

To date, the problem of carbon leakage has been prevented with the granting of free allowances and financial compensation for indirect emissions (European Commission, 2021). The literature discusses whether the free allowances or a BCA is more efficient in preventing carbon leakage. As a part of the discussion, it is pointed out that the minimal amount of carbon leakage observed with free allowances could be due to the mechanism being effective (Assous, Burns, Tsang, Vangenechten, & Schäpe, 2021). Howbeit, it is argued that observed effects may have been mixed with the low carbon prices that have existed in the EU ETS. Although, implementing a BCA appears to be a more comprehensive mechanism compared to the free allowances, which means free allowances could be advantageous to keep, as it is easier to administrate (Marcu, Mehling, & Cosbey, 2021).

According to Assous et al. (2021), a huge drawback of the free allowances is that the mechanism support carbon-intensive rather than less carbon-intensive production and are, after all, not giving high incentives for industries to use more carbon-efficient technology. Hence, today's mechanism is defeating one of the main pillars of the EU ETS, which is the reason why it has received much criticism. As found in the research of Harstad & Eskeland (2010) the allocation of permits creates distortions in the market. With periodic allocation, firms adopt strategic behavior in order to signal their future needs for permits as the governments have imperfect information. Only firms with high marginal abatement costs (MAC) will signal successfully in the equilibrium and pollute too much, while firms with low MAC will pollute too little.

3.5 The Range of the CBAM

In the pilot phase of the proposed CBAM, only imports of basic materials and basic material products will be subject to the tariff. Additionally, only direct GHG emissions from production of the goods will be included in the calculations of the tariff (European Commission, 2021).

Direct GHG emissions, also referred to as scope 1 emissions, are defined as emissions originating from sources owned or controlled by a company (Ranganathan, et al., 2004). Indirect GHG emissions, on the other hand, consist of both scope 2 and scope 3 emissions, which occur at sources owned or controlled by other companies (Ranganathan, et al., 2004). Scope 2 includes all emissions stemming from purchased energy consumed by a company, which are present in the upstream value chain (Sotos, 2015). In scope 2, emissions from at least four energy forms are included. These are electricity, steam, heat, and cooling (Sotos, 2015). Scope 3 includes all other indirect emissions, which do not stem from an energy source, occurring in a company's value chain (Barrow, et al., 2013). This scope is present both in the upstream and downstream value chain and includes emissions from purchased goods and services, waste, transportation, and employee commuting, among others.

The literature is somewhat divided regarding which emission scopes should be included when introducing a BCA. Böhringer et al. (2012a) argue carbon leakage will decrease when more scopes are included in an import tariff on embodied carbon. However, their results show that it is of great importance whether the tariffs are based on emission factors of European or non-European countries, as non-European production is more emission-intensive than European production. Assous et al. (2021) find that adding indirect emissions from electricity consumption in the CBAM would have a relatively low impact on most sectors except from aluminum. This is due to the aluminum production process consuming considerably more electricity. Cosbey et al. (2020) recommend including both scope 1 and 2, but advise against including scope 3, as this would require complex calculations. Besides, they claim that there would be major challenges finding data or benchmarks for scope 3 emissions. In contrast, Böhringer et al. (2012a) argue that this information often is available in national accounts and other public sources. In their study on how a CBAM will affect the EU, Kuusi et al. (2020) find that including scope 3 emissions will more than double the CO_2 reduction compared to only including direct emissions and indirect electricity emissions. However, Böhringer et al. (2012a) argue that the higher the CBAM gets, the greater is the risk of political conflicts and trade wars.

The introduction of the CBAM may cause a risk of carbon leakage downstream the value chain where imported goods affected by the tariff are used as input factors (Marcu, Mehling, & Cosbey, 2021). Industries dependent on buying the basic materials as input factors will face higher prices than their competitors in third countries, which increases total costs. Assous et al. (2021), however, argue that the increased cost from basic materials will be insignificant. Whether the increased costs are notable or not depends on the share of the basic materials affected by the CBAM in the final good. Howbeit, they further argue that unless equivalent compensation is set up for exporters, the CBAM will reduce profit margins for EU/EFTA manufacturers exporting their products globally due to increased costs. Without such compensation, goods produced outside the EU/EFTA could potentially become financially more attractive compared to goods produced in the EU/EFTA.

3.6 Global Response to the CBAM

With the proposed CBAM it is, among others, desirable to motivate third countries to follow the EU/EFTA's ambition level of climate policies (European Commission, 2021). However, several publications are stressing a border mechanism could give other effects than desired, and hence not encourage for emissions reduction.

First of all, if the EU gives the EFTA countries the authority to decide themselves whether they want to introduce a CBAM, they are very dependent on the EFTA countries to follow the regime (Holzer, 2021). If these countries do not implement a mechanism at the border, they will most probably be used for transshipment by importers when importing goods into the EU. Thus, the CBAM will be added to carbon-intensive products in the most lenient way.

The CBAM could otherwise encourage third countries to implement what is referred to as resource shuffling (Assous, Burns, Tsang, Vangenechten, & Schäpe, 2021). Thus, products that are more carbon-intensive could be exported to regions where the climate policy is less stringent, while the least carbon-intensive products are exported to regions that have implemented the CBAM. Nonetheless, resource shuffling will only be an opportunity if there exists an option to use cleaner energy in production (Stede, Pauliuk, Hardadi, & Neuhoff, 2021).

The usage of certified verified measures in the CBAM calculation, to register carbon intensities of goods, may also lead to manipulation of emissions. That is, default values create incentives to only provide verified data where emissions, in reality, are lower than the default values (Assous, Burns, Tsang, Vangenechten, & Schäpe, 2021). In the opposite case, it will be more beneficial to make use of the default values.

Last, retaliation from major extra-EU/EFTA trading partners can be a response to a border mechanism (Böhringer, Bye, Fæhn, & Rosendahl, 2012b). If these partners are not willing to subjugate the same system as the EU/EFTA, they may, for example, introduce a counter-tariff. Such a mechanism can be based on other policy principles, such as emissions per capita, which most probably will trigger trade disputes.

If third countries do not take any immediate action of reducing emissions, as discussed above, there is, however, an opportunity for the EU/EFTA to acquire a first-mover advantage. Karkatsoulis et al. (2016) examine the possible first-mover advantage of the EU from taking action for climate change now, rather than delaying the action until the rest of the world also take climate mitigation actions of significance. To postpone the climate action will, according to their research, cause higher gross domestic product (GDP) losses for the EU.

4 Data and Descriptive Statistics

In order to calculate the direct impacts of the CBAM on imports, we have retrieved data from two main sources: Exiobase for emissions data and UN Comtrade for data on imports. We have chosen to extract data from years prior to the COVID-19 pandemic; Exiobase data in 2018 values and UN Comtrade data in 2019 values. This chapter focuses on the cleansing and delimitation of all data to create our final data set used for calculations.

4.1 UN Comtrade

Data on imports, both to Norway and EU/EFTA countries, are retrieved from the United Nation's (UNs) Comtrade Database (United Nations, 2021). The classification of goods in this database belongs to the 2017 revision of the UNs Harmonized System (HS). This corresponds to the classification used in the EC's proposal of the CBAM. Thus, commodity codes included in the data retrieved reflect the commodities that are to be affected by the policy[3]. In the case of imports to EU/EFTA, we find data on imports of aluminum. The aluminum industry is chosen for illustration as it is particularly interesting to see how a large Norwegian industry may be affected. In the case of Norwegian imports we include both cement, fertilizer, iron & steel, and aluminum. We have chosen to keep electricity out of our analysis, even though this sector also will be affected by the CBAM. This is because most of the electricity consumed in Norway is generated domestically. Besides, in addition to the EU/EFTA countries, Russia is the only country Norway imports electricity from, which only accounts for 0.8% of total electricity imports (United Nations, 2021). As the electricity imports from third countries are minor, we find it to be irrelevant for our analysis.

Since there is some lack of data on the weight of imported goods, we use monetary values of imports throughout the analysis of this thesis. The monetary values are originally given in US Dollars (USD) but are converted into Euros (EUR) with the exchange spot of 1.1234, which was applicable on the 31st of December 2019 (European Central Bank, 2019). Flows of imports are monitored with an annual frequency, whereof we have chosen to retrieve the data from 2019. This is because it is desirable to be as close to the present time as possible, and due to COVID-19, we have chosen not to use data from 2020.

[3] Commodity codes included from UN Comtrade are listed in appendix A1, within the column of HS classifications.

It is worth mentioning that data on imports, both to Norway and the EU/EFTA, could also have been retrieved from Eurostat. The classification of activities in this data is based on the Statistical classification of economic activities in the European Community (NACE) (European Commission, n.d.d). As will be seen later, this corresponds to the classification of economic activities in Exiobase. However, as NACE differs from HS, used in the EC's proposal, it is desirable to use data from UN Comtrade. Data on the Norwegian imports could as well have been retrieved from Statistics Norway. However, since we want to use the same database for both parts of the analysis, we only use data from UN Comtrade.

In the first part of our analysis, we analyze the direct impacts of the CBAM on imports of aluminum to the EU/EFTA. The data of imports are retrieved for all EU countries in total, and the EFTA countries are added manually. At first, the imports to the EU from the EFTA countries are eliminated from the retrieved data set. Second, the imports to the EFTA countries from all third countries are added to the data set of imports. When cleansing the UN Comtrade data for the first part of the analysis, we are also especially aware of the inclusion of the United Kingdom (UK). In 2019, which is the year of our retrieved data, the UK was still a part of the EU. Because of Brexit in 2020, the import data will not represent a realistic picture of the trade flows into the EU/EFTA when the CBAM enters into force at a future point in time. The imports to the UK from third countries are therefore removed from the data. Additionally, exports from the UK to EU/EFTA countries are manually included in the form of 2020 UN Comtrade values, as a best possible approach to solve this challenge.

According to the EC's proposal (2021), Lichtenstein, together with the other EFTA countries, will not be hit by the CBAM. Nevertheless, as there exist no individual data for Lichtenstein, neither as an importing reporter nor as an exporting partner in UN Comtrade, this data has not been corrected for in the data of imports to the EU/EFTA.

In the second part of the analysis, we look at the direct impacts of the CBAM on imports of cement, fertilizer, iron & steel, and aluminum to Norway. Due to a ban on nitrate fertilizer production in Turkey, China, Afghanistan, Colombia, and the Philippines (Ring & deGuzman, 2019), we have chosen to remove the observations on imports of fertilizer from China and Turkey. There exist no imports of fertilizer from the remaining countries affected by the ban in our data.

4.2 Exiobase

In order to access data of global value chains and emissions, we use Exiobase 3, Monetary version 3.8.2, released September 2021 (Stadler, et al., 2021a). Exiobase is an environmentally extended multiregional input-output (EE MRIO) database (Stadler, et al., 2018). The database consists of EE MRIO tables which show global economic relationships and their environmental consequences and aims to support analysis in relation to EU sustainability policies.

Bilateral trade flows of 44 countries are covered in the database, among them EU countries[4] and 16 major economies, in addition to five aggregated rest of the world (RoW) regions. The country coverage accounts for about 90% of global GDP (Stadler, Steen-Olsen, & Wood, 2014). The classification codes of economic activities are in line with those of NACE Revision 1 (Stadler, et al., 2018). The EE MRIO tables are based on official supply-use tables and input-output tables from 1995 up until 2011. However, estimates of tables for more recent years are published based on additional auxiliary data (Stadler, et al., 2021b). In 2020, trade data from UN Comtrade was updated to 2018 data, while in 2021 macroeconomic data from the UN and Taiwan was updated to 2019 data. In addition, all CO_2 fossil emissions are updated to 2019 based on Edgar Database, while all other GHG emissions, based on PRIMAST database, are updated to 2017.

There exists a trade-off between EE MRIO databases with high country detail versus high sector detail. Exiobase belongs to the rather low country detail databases compared to, for instance, the GTAP database, which includes 140 countries and regions (Aguiar, Chepeliev, Corong, McDougall, & Mensbrugghe, 2019). Howbeit, Exiobase is highly detailed on a sector level, covering 200 products over 163 different industries for all countries and regions included, compared to only 57 sectors in GTAP (Stadler, et al., 2018). Since we are more interested in detailed data on a sectoral level, Exiobase data best meets the requirements of our analysis.

As previously mentioned, it is desirable to be as close to the present time as possible. However, in tables from 2019, we find what we consider to be unlikely estimates for input-output relations, especially in Chinese aluminum production. Since the UN Comtrade data for trading in Exiobase has been updated to 2018 data, we assume that the transaction coefficients for 2018 are more accurate compared to years closer to the present. Therefore, we have chosen to extract the Exiobase estimates of 2018.

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[4] Including EU28, meaning the United Kingdom is referred to as an EU country.

Input-Output tables are often based on either an industry by industry (ixi) approach or a product by product (pxp) approach (Nathani & Hellmüller, 2019). The disadvantage of using ixi-tables is that firms in a specific industry also may produce goods that, in terms of product classification, should be attributed to other industries. Consequently, the input structure of an industry in the ixi-table may reflect a mix of input structures of different goods and hence not give a very precise picture of input to the commodities we are particularly interested in. However, this problem can be solved using pxp-tables, where specific products, rather than the industries, define the production categorization. The disadvantage of this approach is the assumption that products classified the same way have the same input structure, no matter where it is produced. There is not necessarily a difference between the ixi- and pxp-estimates. However, we assume the skewness in the estimates potentially could be greater if the production of goods has mixed input structures rather than if the products in reality are not homogeneous within an industry. Thus, the pxp-tables are chosen as our best alternative for usage.

The direct impact coefficients from the EE MRIO tables are used to find carbon intensities of scope 1 emissions from production. The coefficients are measured as GHG emissions (in kg) per $MEUR$ produced of the relevant good (Stadler, et al., 2021b). We convert all coefficients into tons of emissions per $MEUR$. The emissions included in the CBAM are the same as those covered by the current EU ETS. Therefore, the emissions of interest selected from Exiobase are "CO_2 – combustion- air", "CO_2 – non combustion – Cement production – air", "CO_2 – non combustion – Lime production – air", "N_2O – combustion – air", and "PFC – air". CO_2 from combustion is included for all commodities, while CO_2 from non-combustion is only included for cement production[5]. Additionally, PFC emissions are included for aluminum production, and N_2O emissions for fertilizer production. According to the EC's proposal, N_2O emissions should not be included in ammonia production. As ammonia nevertheless is a part of the "N-fertilizer" classification in Exiobase, these emissions will be included in our analysis.

All emissions but the ones for N_2O are given as CO_2 equivalents. In order to convert N_2O emissions into CO_2 equivalents, we use the global warming potential in a 100-year perspective (GWP_{100}). The GWP_{100} converts different GHG emissions' potential effect on global warming, over a 100-year time period, into the equivalent of a ton CO_2. The GWP_{100} value on N_2O varies somewhat between different sources and assessments. According to the Norwegian

[5] Non-combustion in cement production accounts for approximately 60% of scope 1 emissions (Norcem, n.d.).

Environment Agency (2019) the value is 298, which is used in our analysis to convert N_2O emissions into CO_2 equivalents.

For the calculations of scope 2 emissions in production, the transaction matrix from the EE MRIO tables is included to find purchased energy for the production of goods. The direct impact coefficients are used to find emissions related to the production of purchased energy. The only emissions included for scope 2 is "CO_2 – combustion – air", which is in line with the EU ETS coverage of electricity and heat generation. Energy production included from Exiobase are various forms of electricity generation in addition to steam and hot water supply[6]. Last, the total output table from Exiobase is included in order to find the carbon intensity of the purchased energy.

4.3 Merging of UN Comtrade and Exiobase

4.3.1 Sector Classifications

As earlier mentioned, commodity codes of the UN Comtrade data are consistent with the HS classification and fully reflect the commodities included in the EC's proposal of the CBAM. The Exiobase sectors are, on the other hand, classified in accordance with NACE. The following delimitation gives the concordance between Exiobase and UN Comtrade sector and commodity classifications used for our analysis[7]. As the purpose of this thesis is not to find carbon intensities for product categories at a more detailed level than Exiobase, we will ignore that the classifications are not fully compliant. Nevertheless, we assume that the emissions data are applicable for the commodities included in our analysis.

First of all, the classification "Cement, lime and plaster" in Exiobase is included to match all commodities of cement included from UN Comtrade, which includes the HS classifications of clinker and portland cement. According to Eckel (2015) both lime and plaster are respectively used in the manufacturing of cement clinker and the grinding of the clinkers.

Second, "N-fertilizers" in Exiobase is included to match the commodities of fertilizer from UN Comtrade. This includes ammonia, urea, nitric acid, and ammonium nitrate. The N-fertilizer

[6] Energy production included from the transaction matrix in Exiobase are listed appendix A3.
[7] A final overview of how the sectors of Exiobase and commodities of UN Comtrade are matched can be found in appendix A2. This table also includes the sector classification used throughout the analysis as well as the initial shortlist of goods covered by the goods, presented by the EC.

industry includes the production of all the fertilizers and associated nitrogen products mentioned, in addition to a few more nitrogen compounds (Cheremisinoff, 2010). It is worth pointing out that the N-fertilizer industry includes more primary products than those we are particularly interested in.

Third, "Basic iron and steel and of ferro-alloys, and first products thereof" is included from Exiobase to match with all products of iron and steel included from UN Comtrade. Ores and concentrates, as well as secondary steel treatment, are excluded from the EC's proposal and are therefore held out of our analysis. Ferro-alloys are also noted by the EC to be excluded from the CBAM. However, this commodity is included in our Exiobase classification. As earlier mentioned, it is, however, viewed as inexpedient to part this out from the NACE category.

Last, "Aluminium and aluminium products" is included from Exiobase to match with all commodities of aluminum included from UN Comtrade. Ores and concentrates, in addition to waste and scrap, are left out of the EC's proposal of the CBAM and are therefore left out from our analysis.

4.3.2 Region Classifications

In order to merge the Exiobase data with the data of imports from UN Comtrade, we also match the production regions of the two different databases. The categorization of the regions is first and foremost coordinated by linking the residual countries from UN Comtrade, which do not have corresponding observations in Exiobase, to RoW categories in Exiobase[8].

In the UN Comtrade database, there also exists a residual category of regions, "Not elsewhere specified" (nes). Under the nes category, there are seven groupings, whereof six are continents[9] (Nyirongo, 2021). For this analysis, the nes continent groupings are merged with their respective RoW categories in Exiobase. North and Central America, and South America are merged into one common category "RoW America". The seventh nes grouping is "Areas, nes", where imports are assigned in the case of low trade values, unknown trade partner, or error in data. Another residual category of the UN Comtrade database is "Special Categories", where

[8] The final categorization of UN Comtrade regions into RoW categories of Exiobase can be found in appendix A2.
[9] Groupings of the "Not elsewhere specified" (nes) category in UN Comtrade are "Areas, nes", "South America, nes", "North and Central America, nes", "Oceania, nes", "Africa, nes", "Asia nes and Europe, nes".

imports are assigned if the reporting country does not want the trade relationship to be revealed. We merge “Special Categories” and “Areas, nes” into a shared group of residual imports, called “Other” in our final data set. This shared group will only be used when looking at imports to the EU/EFTA as there exist no imports from “Special Categories” or “Areas, nes” in the data of Norwegian imports.

It is worth to note that the regions Büsingen, Heligoland, Livigno, Ceuta, and Melilla are noted out by the EC to be excluded from the CBAM policy (European Commission, 2021). However, we have not taken any special account for goods originating from these regions in our data and analysis.

4.4 Descriptive Statistics

This section gives an overview of the data our calculations are based on. First, we present data of imports from UN Comtrade, both for the imports of aluminum to the EU/EFTA and imports of cement, fertilizer, iron & steel, and aluminum to Norway. Second, we show the carbon intensities of scope 1 emissions in production, retrieved from Exiobase. Last, the inputs of purchased energy in production of commodities imported to Norway are presented.

Table 1 shows the imports of aluminum to the EU/EFTA from third countries. The categorization of the regions is in line with the delimitation in section 4.3.2. The data is retrieved from UN Comtrade and reflects the post-Brexit situation.

Table 1: Imports of aluminum to the EU/EFTA, measured in MEUR. Data source: UN Comtrade

	Aluminum
Australia	4,07
Brazil	9,61
Canada	203,07
China	1 609,01
India	348,44
Indonesia	9,84
Japan	53,84
Mexico	4,93
South Korea	198,60
Russia	2 776,92
South Africa	330,42
Turkey	1 117,93
United States	368,68
United Kingdom	923,79
RoW Africa	1 166,81
RoW America	36,81
RoW Asia and Pacific	550,35
RoW Europe	436,63
RoW Middle East	2 344,66
Other	125,20
Total	**12 619,60**

The largest exporters of aluminum to the EU/EFTA are Russia, RoW Middle East, China, Row Africa, Turkey, the United Kingdom. Australia and Mexico are, on the other hand, the least important exporters of aluminum to the EU/EFTA. In total, the imports of aluminum to the EU/EFTA are approximately $12\ 620\ MEUR$.

Table 2 shows the imports of cement, fertilizer, iron & steel, and aluminum to Norway. The second last row shows the total imports from the EU/EFTA countries, while the remaining rows show extra-EU/EFTA imports.

Table 2: Imports of commodities in the CBAM sectors to Norway, measured in MEUR. Note: Cells with values of zero represent minor imports. Data source: UN Comtrade.

	Cement	Fertilizer	Iron & Steel	Aluminum
Australia			0,96	0,13
Brazil		0,00	4,58	0,12
Canada	0,00	0,02	0,83	0,14
China			72,58	27,76
India		0,00	16,11	0,91
Indonesia			4,71	0,07
Japan	0,02	0,00	289,69	0,11
Mexico			7,37	0,00
South Korea			544,77	0,14
Russia		79,70	18,40	316,66
South Africa	0,00		0,57	11,42
Turkey			16,23	1,59
United States	0,00	0,43	57,36	1,68
United Kingdom	0,02	2,39	183,43	4,62
RoW Africa			2,81	0,46
RoW America		8,60	27,90	0,01
RoW Asia and Pacific	0,01		35,89	11,78
RoW Europe			10,58	0,38
RoW Middle East	0,00	0,13	7,65	5,95
EU + EFTA	44,80	105,15	2 154,72	188,31
Total	**44,86**	**196,42**	**3 457,13**	**572,23**

Iron & steel is the sector Norway imports the superior most from, followed by aluminum, fertilizer, and cement. One may notice that only a small fraction of the imports in the cement sector comes from extra-EU/EFTA imports. In the case of fertilizer and iron & steel, extra-EU/EFTA imports account for just under half of the total imports. In the aluminum sector, on the other hand, as much as 70% of the imports come from extra-EU/EFTA partner countries.

Depending on the sector, some specific countries stand out as more important trading partners than others. Even though extra-EU/EFTA imports of cement are generally low, the imports from Japan and the United Kingdom are of higher values than imports from others. In the case of fertilizer, Russian imports are the absolute highest compared to other extra-EU/EFTA partner countries. For iron & steel, especially large values are imported from South Korea, Japan, and the United Kingdom, while the greatest imports come from Russia also in the aluminum sector.

Table 3 shows carbon intensities given as CO_2 equivalents emitted per $MEUR$ of production, stemming from scope 1 emissions[10]. The carbon intensities are presented both for all countries exporting aluminum to the EU/EFTA and countries exporting cement, fertilizer, iron & steel, or aluminum to Norway. The cells remain empty in all cases where no imports are found in our data of imports. At the very bottom, the carbon intensity of Norwegian production and the average of the EU/EFTA producers weighted on the share of total EU/EFTA production are added for comparison.

Table 3: Carbon intensities of scope 1 emissions, measured in tons of CO_2 equivalents emitted per MEUR produced. Data source: Exiobase.

	Cement	Fertilizer	Iron & Steel	Aluminum
Australia			128	453
Brazil		374	1 024	1 845
Canada	5 473	567	545	257
China			958	154
India		398	2 089	395
Indonesia			250	122
Japan	8 905	945	266	9
Mexico			298	2 441
South Korea			186	36
Russia		2 080	676	1 007
South Africa	3 524		507	4 675
Turkey			344	357
United States	1 414	1 123	134	78
United Kingdom	767	1 053	270	57
RoW Africa			69	267
RoW America		2 897	240	100
RoW Asia and Pacific	12 921		355	391
RoW Europe			2 892	614
RoW Middle East	5 481	620	274	507
Weighted average EU/EFTA	958	783	299	233
Norway	1 852	607	499	233

As can be seen in the table, carbon intensities vary greatly both between and within sectors. First and foremost, the variations within sectors can be due to the commodities included in each sector being heterogeneous. However, it can also be due to differences in development and technology between regions. The variations could also partly be explained by differences in energy sources used in production if they are owned or controlled by a company itself.

[10] The region "Other" has been assigned a carbon intensity equal to the average of carbon intensities of the RoW regions.

When it comes to the differences between the sectors, it is clear that the cement sector is the overall most carbon-intensive, with higher carbon intensities than the other sectors in almost all cases. RoW Asia and Pacific stands particularly out with a carbon intensity of 12 921 tons of CO_2 equivalents emitted per $MEUR$ produced. On the other edge of scale is the United Kingdom, with a value of only 767. Howbeit, compared to the other sectors, this value is relatively high.

Within the remaining three sectors, there are more variations. However, the carbon intensity of the fertilizer sector seems to have overall higher values than iron & steel, and aluminum, based on the countries present in our data. In the fertilizer sector, the intensities range from 2897 in RoW America down to 374 in Brazil. The country Norway imports the most from among third countries, Russia, has a carbon intensity of 2080. This is the second largest value of the fertilizer sector.

In the sector of iron & steel, the most carbon-intensive products come from RoW Europe, where 2892 tons of CO_2 equivalents are emitted per $MEUR$ produced. RoW Africa located at the other edge of the scale has a carbon intensity of 69. In the aluminum sector, the outer edges also vary greatly. South Africa has the highest carbon intensity with 4675 tons of CO_2 equivalents emitted per $MEUR$ produced, while Japan only has a carbon intensity of 9. Russia, which Norway imports the most from, has a relatively high carbon intensity of 1007.

The diagrams in figure 1 show the energy mix from purchased energy into the production of cement, fertilizer, iron & steel, and aluminum. The input mix is caught up in the transaction matrix of Exiobase. Thus, if a company owns or controls the energy source itself, the input is not monitored in this figure. The diagrams, in other words, reflect all transactions that will be input to production causing scope 2 emissions. The energy sources are classified into four categories: renewable electricity, non-renewable electricity, other electricity, and other energy[11].

[11] The classifications of energy sources can be found in appendix A3. The distinction between renewable and non-renewable electricity is in line with the classification in Eurostat (European Commission, 2020a).

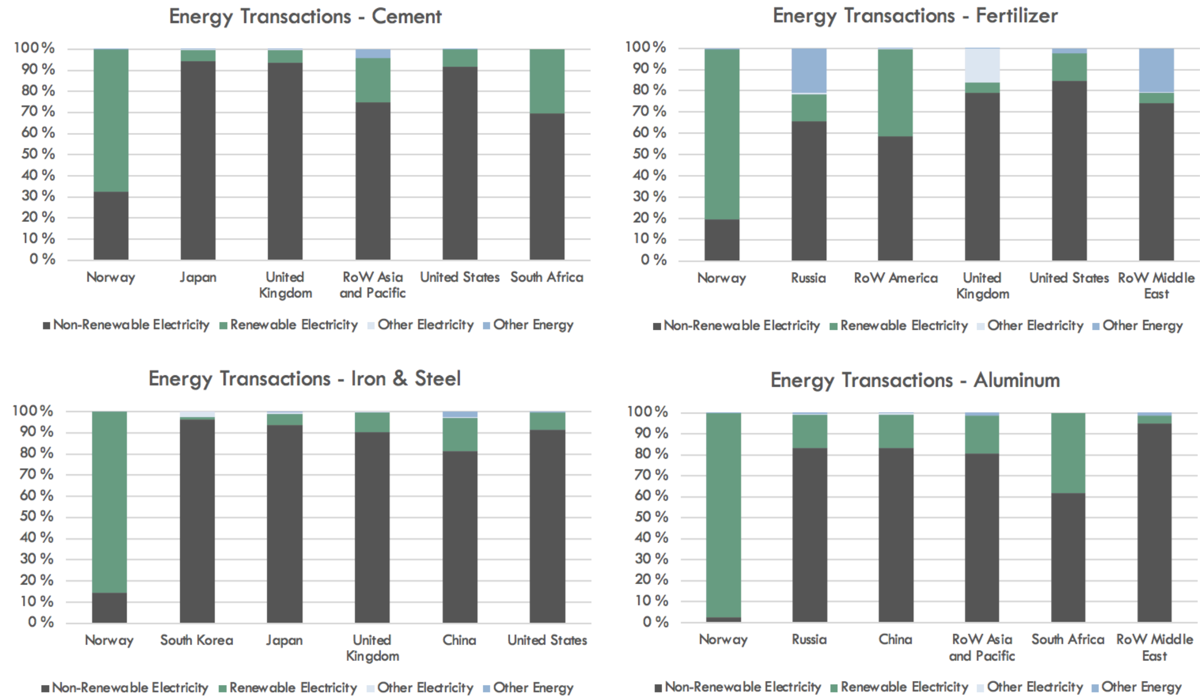

Figure 1: Mix of purchased energy as input in production of commodities in the CBAM sectors. Data source: Exiobase.

For each of the sectors, the five regions Norway imports the most from among third countries, are presented. For comparison, the energy mix in production in Norway is also included for each of the sectors. As observed in the figure, Norway has the highest share of electricity from renewable sources purchased for input in all sectors. Even though the share of non-renewable electricity is major in the third countries presented, this does not necessarily reflect the amount of carbon emissions. This is both because electricity from nuclear is included in the non-renewable category and electricity from biomass and waste is included in the renewable category. Nevertheless, the differences in the energy mix between the regions still give a good indicator for believing the scope 2 emissions in third countries are higher than in Norway.

5 Methodology

In this chapter, we will present the methodology used for our analysis. First, we will present the approach used to find the CBAM tariff and its direct impacts on imports. Second, we present the approach used to calculate the scope 2 emissions of production and carbon intensities related to these emissions.

5.1 Calculation of the CBAM

5.1.1 Carbon Prices

The domestic carbon price used in our calculation of the CBAM is based on the average EU ETS price during the fall of 2021, which has been approximately $60\,EUR$ per ton $\mathrm{CO_2}$ equivalents emitted (Ember, 2021). This is a simplification, as the price of the CBAM certificates, in reality, will be based on the average weekly auction price of the EU ETS, which varies greatly.

We set the default value of the carbon price for all third countries to be zero. The World Bank has logged all carbon pricing in the world, both carbon taxes and ETS (The World Bank, 2021). However, most of these price mechanisms are used to regulate electricity generation from fossil fuels. Besides, fairly often, only some of the sectors covered by the CBAM are covered by the existing carbon price mechanism. Thus, these price instruments either do not affect the CBAM sectors directly or only affect some of them. Additionally, many of the carbon pricing initiatives only cover specific provinces or states, and some are even still in the pilot phase. To avoid needless complexity in our estimates, we thus have chosen to leave foreign carbon initiatives out of our analysis.

5.1.2 Trade Elasticities

To make projections of the direct impacts of the proposed CBAM, all other economic factors held constant, we make use of the trade elasticities estimated by Kuusi et al. (2020). These can be seen in table 4. The trade elasticities are in their study referred to as global import tariff elasticities and are found as the response in imports due to tariffs imposed at the border during the period 2000 to 2018 for 132 reporting countries. Their estimates are found while controlling for substitution and income effects on demand and preferences globally. There are mainly two reasons why these estimates are viewed as suitable for our analysis. First, the gravity model used to estimate these trade elasticities is often referred to as the main tool for evaluation of the effect of various determinants on international trade (Yotov, Piermartini, Monteiro, & Larch, 2016). Second, the trade elasticities estimated by Kuusi et al. (2020) are in their origin used to analyze the direct impacts of the CBAM on imports and are viewed to represent good estimates for our purpose, as this also is to find the direct impacts of the CBAM.

Table 4: Trade elasticities of the CBAM sectors. Source: Kuusi et al. (2020).

Sector	Trade Elasticity
Cement	-5,29
Iron & steel	-2,89
Aluminum	-6,47
Fertilizer	-3,86

In the study by Kuusi et al. (2020), there is no individual trade elasticity found of fertilizer. Nevertheless, they estimate a trade elasticity of "Manufacture of chemicals and chemical products". In the NACE Rev. 1 classification, "Manufacture of fertilizers and nitrogen compounds" is a subcategory of "Manufacture of chemicals and chemical products" (European Commission, 2002). We assume the trade elasticity of the subcategory alone is approximately equal to the trade elasticity of the overall category and thus use -3.86 as our trade elasticity of fertilizer for calculations.

As the elasticities are negative, higher tariffs will reduce imports, all other economic factors held constant. For instance, the imports of cement have an elasticity of -5.29. Consequently, imports of cement will decline by 5.29% if tariffs are raised by one percentage point. Larger elasticities imply that an increase in tariffs will have a large negative impact on imports. This testifies that products with high trade elasticities more easily can be substituted with other products of the same characteristics, either from the domestic or foreign supply. According to the elasticities in table 4, the imports of cement and aluminum will be more negatively affected by an increased tariff than the imports of iron & steel and fertilizer.

5.1.3 Formulas

Our calculations of the CBAM are based on the approach of Kuusi et al. (2020) and Assous et al. (2021), who analyze the direct impacts of the CBAM. In contrast to their analyzes, both import values and the economic core of carbon intensities are measured in monetary values instead of weight in our analysis. This is due to the lack of data on the weight of imports, as pointed out in section 4.1.

In order to calculate the CBAM and its impacts, the following sets[12] and parameters are defined.

$\boldsymbol{L}$**:** Set of sectors producing commodities covered by the CBAM

$\boldsymbol{J}$: Set of regions where commodities are imported from

$\boldsymbol{M}$: Set of regions where commodities are imported to

$\boldsymbol{y_{ljm}}$**:** Value of commodities within sector l imported from region j to region m (in $MEUR$)

$\boldsymbol{s_{lj}}$**:** Carbon intensity of scope 1 emissions from the production of commodities of sector l in region j (in tons of CO_2 equivalents emitted per $MEUR$ produced)

$\boldsymbol{p_j}$**:** Carbon price in region j (in $MEUR$ per ton of CO_2 equivalents emitted)

$\boldsymbol{p_m}$**:** Carbon price in region m (in $MEUR$ per ton of CO_2 equivalents emitted)

$\boldsymbol{e_l}$: Trade elasticity of sector l (as a percentage change of imports when import tariffs increase by 1%)

First, we calculate the CBAM in monetary values ($MEUR$). Since the CBAM is a tariff based on units of emissions (in tons), the value of the tariff imposed on imports will vary among all sectors l and regions of production j. The CBAM is calculated with use of the value of imports (y_{ljm}), the carbon intensity of the imports (s_{lj}), and the difference in carbon prices between the region of imports (p_m) and the region of exports (p_j).

[12] $\boldsymbol{L}$ contains cement, fertilizer, iron & steel and aluminum. $\boldsymbol{J}$ contains all regions where commodities of the sectors in L are imported from. $\boldsymbol{M}$ contains all regions imposing a CBAM tariff on imports. In our analysis this set will only contain one region at a time, EU/EFTA in chapter 6 and Norway in chapter 7.

(1)

$$CBAM_{ljm}\,(MEUR) = y_{ljm} \cdot s_{lj} \cdot (p_m - p_j), \qquad \forall l \in L, j \in J, m \in M$$

In order to calculate the CBAM tariff as a percentage, we find the relative relationship between the monetary value of the CBAM and the initial value of imports. This percentage will be added on top of the original monetary value of imports once the CBAM is imposed at the border. This means, in other words, that the CBAM tariff as a percentage will differ among all sectors l and regions j, rather than being a unison percentage imposed on all imports. This reflects the fact that the CBAM is based on units of emissions in the production of the commodities, which will vary over all sectors l and regions j.

(2)

$$CBAM_{ljm}(\%) = \frac{CBAM_{ljm}\,(MEUR)}{y_{ljm}} \cdot 100\%, \qquad \forall l \in L, j \in J, m \in M$$

The direct impacts of the CBAM on the volume of imports, all other economic factors held constant, are calculated with the use of the trade elasticities presented in table 4. The estimated percentage change of imports of commodities from a specific sector l and a specific region of origin j to a specific region m is calculated in accordance wto the formula presented below. The change in imports is presented as a percentage relative to the original imports.

(3)

$$Reduction\ of\ imports_{ljm}(\%) = CBAM_{ljm}(\%) \cdot e_l, \qquad \forall\, l \in L, j \in J, m \in M$$

For each sector l where commodities are imported from j to m, the monetary value of the reduction in imports is calculated as follows.

(4)

$$Reduction\ of\ imports_{ljm}(MEUR) = \frac{Reduction\ of\ imports_{ljm}(\%) \cdot y_{ljm}}{100\%}, \qquad \forall\, l \in L, j \in J, m \in M$$

The total reduction in imports of commodities from a specific sector l imported to a specific region m is found as the sum over all imports of such commodities from all regions j.

(5)

$$Total\ reduction\ of\ imports_{lm}(MEUR) = \sum_{j \in J} Reduction\ of\ imports_{ljm}(MEUR), \qquad \forall l \in L, m \in M$$

As it also is desirable to find the percentage change of imports per sector l, the total reduction of imports of l to m found in (5) is divided by total initial imports of l to m.

(6)

$$Total\ reduction\ of\ imports_{lm}(\%) = \frac{Total\ reduction\ of\ imports_{lm}(MEUR)}{\sum_{j \in J} y_{ljm}} \cdot 100\%, \qquad \forall l \in L, m \in M$$

The CBAM tariff on imported goods will gain an income at the border. As the CBAM can lead to some imports being totally eliminated, the calculation of this income is based on the imports that will be maintained. In cases where the reduction of imports exceeds 100% in our calculations, we restrict the reduction to be maximum 100%. The formula below presents the income of the CBAM for each sector l where commodities are imported from j to m.

(7)

$$Income_{ljm}(MEUR) = \frac{\left(y_{ljm} - Reduction\ of\ imports_{ljm}(MEUR)\right) \cdot CBAM_{ljm}(\%)}{100\%}, \qquad \forall l \in L, j \in J, m \in M$$

Total income at the border of region m as a result of the CBAM imposed on imports will equal the sum of all income from the CBAM imposed on all imports to this region.

(8)

$$Total\ income_{m}(MEUR) = \sum_{l \in L} \sum_{j \in J} Income_{ljm}(MEUR), \qquad \forall m \in M$$

5.2 Calculation of Carbon Intensities of Scope 2 Emissions

To include carbon intensities of scope 2 emissions in our analysis of the CBAM, we first need to calculate these carbon intensities based on the data retrieved from Exiobase. As earlier defined, scope 2 includes all emissions stemming from purchased energy consumed by a company in its production. Our approach to derive the scope 2 emissions of different sectors in various regions are structured as described in this section.

In order to calculate carbon intensities of scope 2 emissions, the following sets[13] and parameters are defined.

$\boldsymbol{K}$: Set containing all forms of energy that can be produced and transferred

$\boldsymbol{L}$: Set of sectors producing commodities covered by the CBAM

$\boldsymbol{I}$: Set of regions where energy is produced and transferred from

$\boldsymbol{J}$: Set of regions where energy is purchased and used as input in production

$\boldsymbol{z_{kilj}}$: Value of energy form k produced in region i, used as input of production in sector l in region j (in $MEUR$).

$\boldsymbol{s_{ki}}$: Carbon intensity of scope 1 emissions from the production of energy form k in region i (in tons of CO_2 equivalents emitted per $MEUR$ produced)

$\boldsymbol{x_{lj}}$: Total output of production in sector l in region j (in $MEUR$)

For each form of energy k produced, the carbon intensity (s_{ki}) depends on the localization i of production. This carbon intensity is multiplied by the value of energy transferred to its destination (z_{kilj}). The destination is a specific region j, where the energy is used as input in the production in a specific sector l. To find the total CO_2 content of each such transaction (in tons), we use the following formula.

[13] $\boldsymbol{K}$ contains all forms of energy transferred which are accounted for in Exiobase, listed in appendix A3. $\boldsymbol{L}$ contains cement, fertilizer, iron & steel, and aluminum. $\boldsymbol{I}$ contains all regions included in the transaction matrix from the Exiobase database, where energy is produced and transferred from. $\boldsymbol{J}$ contains all regions where energy is purchased and used as input in production. In our analysis in chapter 7 we restrict this set to only contain regions where Norway imports commodities belonging to sectors in L from.

(9)

$$CO_2content_{kilj} = s_{ki} \cdot z_{kilj}\,, \qquad \forall k \in K, i \in I, l \in L, j \in J$$

Next, we calculate the total CO_2 content of energy purchased and used in the production in sector l in region j. This leaves us with the total scope 2 emissions (in tons) associated with the production of commodities belonging to sector l in region j.

(10)

$$Scope\ 2\ emissions_{lj} = \sum_{k \in K} \sum_{i \in I} CO_2content_{kilj}\,, \qquad \forall l \in L, j \in J$$

To find the carbon intensity of scope 2 emissions in the production of commodities belonging to sector l produced in region j, we need to calculate the relative relation of the total scope 2 emissions from the production of l in j to the economic core of production (x_{lj}). That is, we need to divide the scope 2 emissions by the total output of production. While the total scope 2 emissions are given in tons, the total output is given in $MEUR$. Thus, the carbon intensity is given in tons of CO_2 equivalents emitted per $MEUR$ produced, as follows:

(11)

$$Carbon\ intensity_{lj} = \frac{Scope\ 2\ emissions_{lj}}{x_{lj}}, \quad \forall l \in L, j \in J$$

6 Analysis of the EU/EFTA Aluminum Market

In this chapter, we will analyze how the EU/EFTA aluminum market will adapt when the CBAM is implemented. We will calculate the direct impacts of the CBAM on imports of aluminum from the rest of the world (RoW) to the EU/EFTA and discuss how this may affect domestic producers. For simplicity, we assume the CBAM enters 100% into force once implemented. In our calculations, all other factors are held constant. This also means no changes are observed in carbon intensities. However, the impact of the CBAM must be considered alongside other measures, such as the phase-out of free allowances and the overall reduction of quotas in the EU ETS. We also assume all of the free allowances will be removed at once. Furthermore, in our analysis, the EU/EFTA is presumed to represent a large country able to affect the world market price.

All numeric calculations are based on the approach presented in section 5.1. We assume our import values represent the import data after the phase-out of the free allowances. That is, our calculations will only show the isolated direct impacts of the CBAM. Throughout this chapter, we will stick to the EC's proposal on emissions covered. Thus the calculated CBAM will only cover scope 1 emissions.

6.1 A Simplified Market Model

The first part of this analysis aims to illustrate how supply in the EU/EFTA market may shift between different producers as free allowances are phased out, and the CBAM is phased in. We assume total EU/EFTA consumption is maintained after the policy measures are implemented. Hence demand is 100% inelastic. For this analysis, it is desirable to also measure aluminum in tons. Since all our values of imports are given in monetary values, we divide them by the world market price of aluminum in 2019, $1596\ EUR$ per ton (The World Bank, 2020). By this, we assume the aluminum price is unison for all commodities in the sector.

According to the European Aluminium's Digital Activity Report (2021), the EU's consumption of aluminum ingot requirements consists of approximately 50% domestic production and 50% imports. We assume this to be transferrable to consumption of all aluminum products included in the CBAM proposal. Additionally, EU and EFTA each account for 50% of European production of primary aluminum (European Aluminium, 2021). Norway takes approximately 68% of the share of EFTA (U.S. Geological Survey, 2020), giving Norwegian producers a 34%

share of the EU/EFTA production. For simplicity, we assume these shares of production to be identical to the EU/EFTA consumption.

6.1.1 Current Supply

Figure 2 shows the equilibrium of total aluminum supply in the EU/EFTA market with free allowances and without a CBAM. The horizontal axis shows the total supply of aluminum in tons which are divided into EU/EFTA- and foreign export supply ($x^D, im^D = ex^{RoW}$). The vertical axes show the price with currency in EUR. As we assume demand to be 100% inelastic, only supply is shown in this model. However, two aggregated supply curves, based on private marginal costs (PMC), are presented. The first is for EU/EFTA producers ($PMC^D + Free\ quotas$), while the second is for foreign producers exporting to the EU/EFTA region (PMC^{RoW}). Each of the aggregated supply curves is the horizontal summation of all individual supply curves in the respective regions. Hence, as there are more suppliers in the RoW region compared to the EU/EFTA region, the PMC^{RoW} curve is flatter than the $PMC^D + Free\ quotas$ curve.

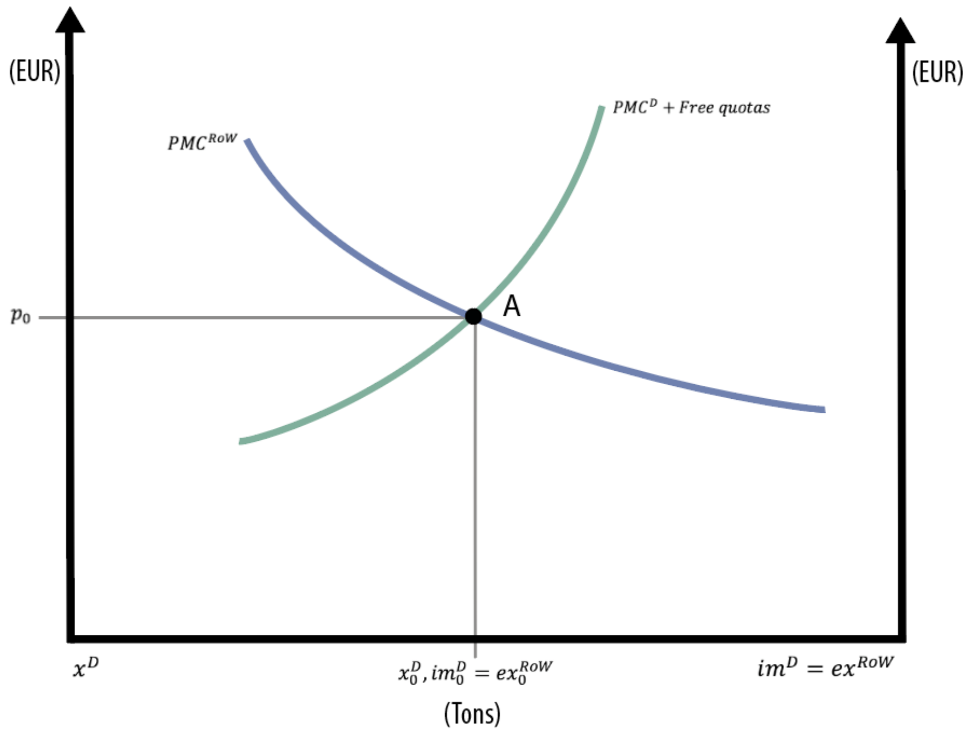

Figure 2: Current supply of aluminum.

The equilibrium can be found in A, at price p_0. In A EU/EFTA producers are faced with free allowances, while foreign producers are not faced with any policy measures.

6.1.2 Phasing Out the Free Allowances

In order to reach the EU's increased level of ambition, the EC (2021) plans to phase out all free allowances within 2035. This is done with anticipation of increasing domestic producers' incentive to reduce emissions and invest in low-carbon technology.

Until now, the vast majority of the quotas in the aluminum sector of EU/EFTA have been distributed for free to avoid carbon leakage and retain the competitiveness of domestic producers. As quotas are distributed for free, the industry has not been forced to pay for the emissions caused by their production. To put this in perspective, we have calculated that the Norwegian industry of primary aluminum had 2 333 073 tons of emissions subject to quotas in the EU ETS in 2019 (Norwegian Environment Agency, n.d.). Out of these, approximately 82% were given to the industry for free, which means the industry did not pay a carbon price for the majority of its emissions.

Figure 3 shows how the phase-out of free allowances will affect the market. When the phase-out occurs, EU/EFTA producers will be forced to pay for all units of CO_2 equivalents emitted. This will create a shift in the domestic supply curve, from $PMC^D + Free\ quotas$ to $PMC^D + Quotas\ with\ price$.

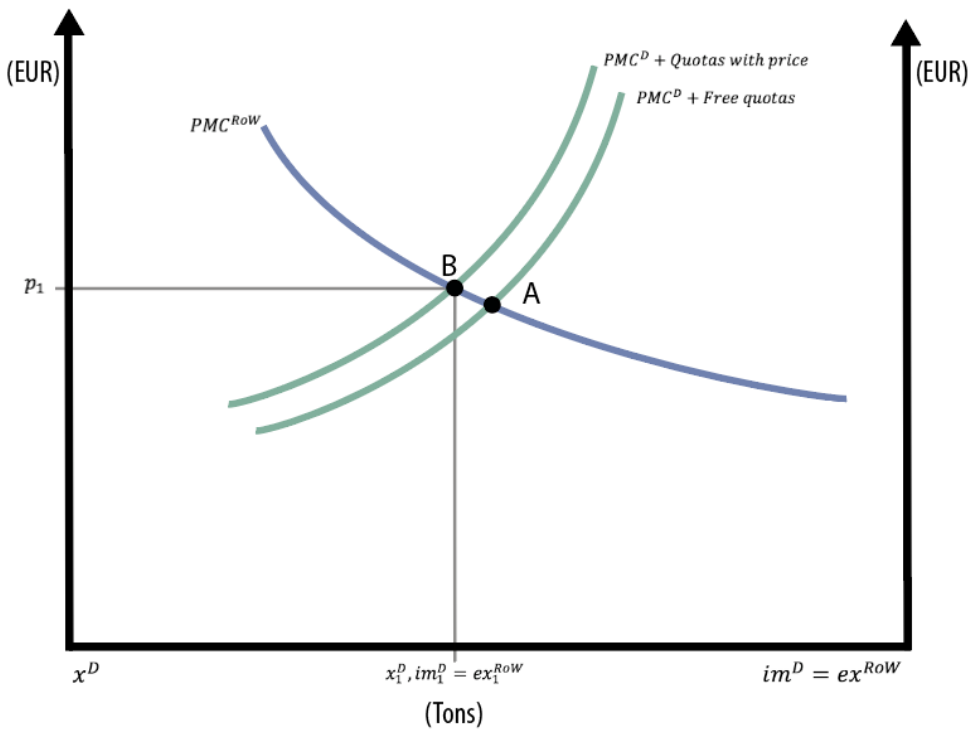

Figure 3: Supply of aluminum when removing free allowances from the EU ETS.

A new market equilibrium will occur, where $PMC^{D} + Quotas\,with\,price$ intersects PMC^{RoW} in B, with a somewhat increased price, p_1. The phase-out will cause a significant cost increase for EU/EFTA producers. In the case of the Norwegian aluminum industry, the increased cost will be approximately $115\ MEUR$[14], if the quota price remains at the level of $60\ EUR$ per ton of CO_2 equivalents emitted. The market price will, however, not increase in parallel with the cost increase, as only domestic producers must take their negative externalities into account. If EU/EFTA producers, regardless, raise the market price in parallel with their increased costs, domestic consumers will rather buy aluminum from third country producers, which do not face the same costs. Therefore, EU/EFTA producers are forced to bear most of the costs themselves. This may be intolerable for some EU/EFTA producers, which potentially will have to shut down their operations or move to an area with less stringent policies. The phase-out of the free allowances in the EU/EFTA could, in other words, increase the risk of carbon leakage either if domestic production moves out or consumers prefer foreign goods.

As the free allowances are phased out, domestic producers will get an increased incentive to reduce emissions. Nevertheless, as different producers have different carbon intensities, producers would likely deal with the increased carbon costs in different ways. Producers with marginal abatement costs (MAC) higher than the quota price will rather pay for permits than reduce their emissions, as it will be more profitable for them to pay for permits than to invest in cleaning. On the other hand, producers with MAC lower than the quota price will rather clean than pay for permits.

6.1.3 Phasing In the CBAM

In order to prevent carbon leakage and protect the decarbonization initiatives in the EU/EFTA, the EC will create a level playing field in the EU/EFTA market. Therefore, the CBAM will be introduced, which will ensure the price of imports reflects their carbon content.

Figure 4 shows how the CBAM will affect the EU/EFTA market. When the CBAM is imposed on imports at the border, the supply curve of the rest of the world will shift from PMC^{RoW} to $PMC^{RoW} + CBAM$ as foreign producers are faced with the CBAM tariff[15]. Hence, the new

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[14] The calculation is based on an amount of free allowances equal to $82\% \cdot 2\ 333\ 073$

[15] In reality, it is the importers, rather than the exporters, who will be met by the CBAM tariff at the border of EU/EFTA countries (European Commission, 2021). Our illustration shows a shift in the foreign supply curve as a direct increase in costs rather than an indirect increase in costs.

foreign supply curve, $PMC^{RoW} + CBAM$, will intersect domestic supply, $PMC^{D} + Quotas\ with\ price$, in a new equilibrium C, at an increased price p_2.

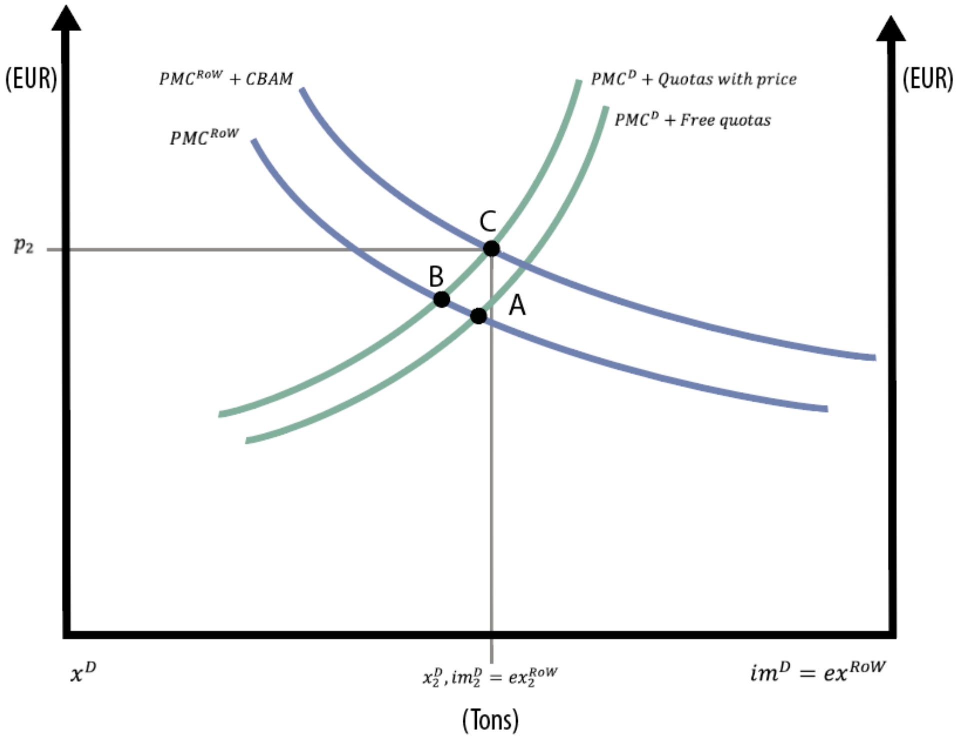

Figure 4: Supply of aluminum when imposing the CBAM on imports at the EU/EFTA border.

As shown in table 3 in section 4.4, both the carbon intensity of Norwegian producers and the weighted average of carbon intensity among EU/EFTA producers is 233 tons of CO_2 equivalents emitted per $MEUR$ produced. The weighted average of carbon intensity in foreign production is, on the other hand, 581 tons of CO_2 equivalents per $MEUR$. While the intensities among EU/EFTA producers are weighted on gross output, the intensities of the exporting regions are weighted on the share of imports from the relevant countries to the EU/EFTA. As the carbon intensity in the imports is higher than the intensity of EU/EFTA production, we presume the shift from PMC^{RoW} to $PMC^{RoW} + CBAM$ to be larger than the shift from $PMC^{D} + Free\ quotas$ to $PMC^{D} + Quotas\ with\ price$. The rationale of this is that the costs from the quotas and the CBAM will increase in line with the producers' level of carbon intensity. By this, we presume EU/EFTA producers, on average, are less negatively affected by the policy measures compared to foreign producers exporting to the EU/EFTA. It should be mentioned that the figure is only illustrative, which means the consumption of foreign versus domestic aluminum may be distributed differently in reality when the CBAM is implemented.

According to our calculations, the reduced imports from third countries to the EU/EFTA will be approximately 2578 $MEUR$ which is equal to 1.6 $MTons$ of aluminum, when moving from B to C. As the most carbon-intensive imports are faced with the highest CBAM tariff, this is the export that will be reduced the most. In fact, the weighted average carbon intensity of the imports that are eliminated is 1214 tons of CO_2 equivalents emitted per $MEUR$ produced, while the weighted average carbon intensity of the maintained imports is reduced to 418. This will lead to a reduction in carbon emissions of imports equal to 3.1 $MTons$. By this, the carbon content of imports is reduced by more than two fifths of its original value, while the value of the imports itself is only reduced by one fifth of its original value. This means the CBAM will not exclude foreign goods in EU/EFTA consumption but will rather eliminate the most carbon-intensive imports. An overview of the effects caused by the CBAM can be seen in table X. Income from the CBAM will only come from imports that still remain after the CBAM is implemented. By our calculations, this income will be approximately 252 $MEUR$ in our simplified model.

Table 5: Change in imports, the carbon content of imports, and the income from the CBAM when the policy measure is imposed on imports at the EU/EFTA border. Data source: UN Comtrade and Exiobase. Our calculations.

		Before the CBAM	After the CBAM	Difference
Imports	$(MEUR)$	12 620	10 042	-2 578
Imports	(MT)	7,9	6,3	-1,6
Carbon content of imports	(MT)	7,3	4,20	-3,1
Income at the border	$(MEUR)$	-	252	252

As previously mentioned, consumption is held constant regardless of shocks in the market in our simplified model. Thus, we assume that EU/EFTA producers will acquire additional market shares equal to the reduced imports. As the weighted average carbon intensity of EU/EFTA producers is 233 tons of CO_2 equivalents emitted per $MEUR$ produced, the total carbon content of this increased production will be 0.6 MT. This will cause a reduction in the overall carbon content of 2.5 MT. To put this in perspective, this is equivalent to eliminating emissions from approximately 390 thousand EU citizens. The calculation is based on carbon emissions per capita of 6.4 tons (The World Bank, 2018).

The new acquired market share will create an increased income of $2\ 578$ $MEUR$ for EU/EFTA producers if the aluminum price in the market is held constant. Since we assume Norwegian producers have a market share of 34%, this will create an additional income of 877 $MEUR$. Increased production will cause increased emissions, which must be paid for. If we assume the carbon intensity of Norwegian producers remains unchanged at the level of 233 tons of CO_2 equivalents emitted per $MEUR$ produced, the total cost of quotas will be approximately 12 $MEUR$. This will lead to an increased net income of 865 $MEUR$, as shown in table 6. These calculations are made without taking into account costs of operation, other than from the purchase of quotas. However, as shown in figure 6 the market price of aluminum will increase when the CBAM is imposed. As the price increases, the income for EU/EFTA producers will be even higher than shown by our calculations.

Table 6: Increased net income for Norwegian producers in the EU/EFTA market when imposing the CBAM on imports at the EU/EFTA border. Data source: UN Comtrade and Exiobase. Our calculations.

New Market Share for Norwegian Producers		
Increased income	$(MEUR)$	877
Costs from quotas	$(MEUR)$	12
Net Income	$(MEUR)$	865

As the free allowances are going to be phased out in parallel with the CBAM being phased in, the market will never occur in B in figure 4. It will, however, gradually shift from A to C. When the two policy measures are phased in and -out simultaneously, it will create a level playing field, as foreign producers are faced with the same external costs as EU/EFTA producers. When this happens, domestic consumers will have no other option than to buy aluminum where all external costs are taken into account by producers.

6.1.4 Reducing the Overall Cap of Quotas in the EU ETS

When the EC tightens its climate policies, they desire to reduce emissions even more than what is done through todays' cap in the EU ETS. In addition to phasing out free allowances from the EU ETS, the total cap of quotas will also be reduced. This will cause a new negative shift in the domestic supply curve from $PMC^D + Quota\ with\ price$ to $PMC^D + Quota\ with\ price'$. As the cap of permits decreases, the quota price will likely increase. Hence, as the CBAM is determined by the quota price in the EU ETS, a negative shift in the foreign supply curve will also occur, from $PMC^{RoW} + CBAM$ to $PMC^{RoW} + CBAM'$. In the new equilibrium D, with the price p_3, total consumption will remain; however, emissions will be reduced in the EU/EFTA. When the total cap in the EU ETS decreases, and hence the quota price increase, producers will get even stronger incentives to rather invest in abatement measures than to pay for permits to emit.

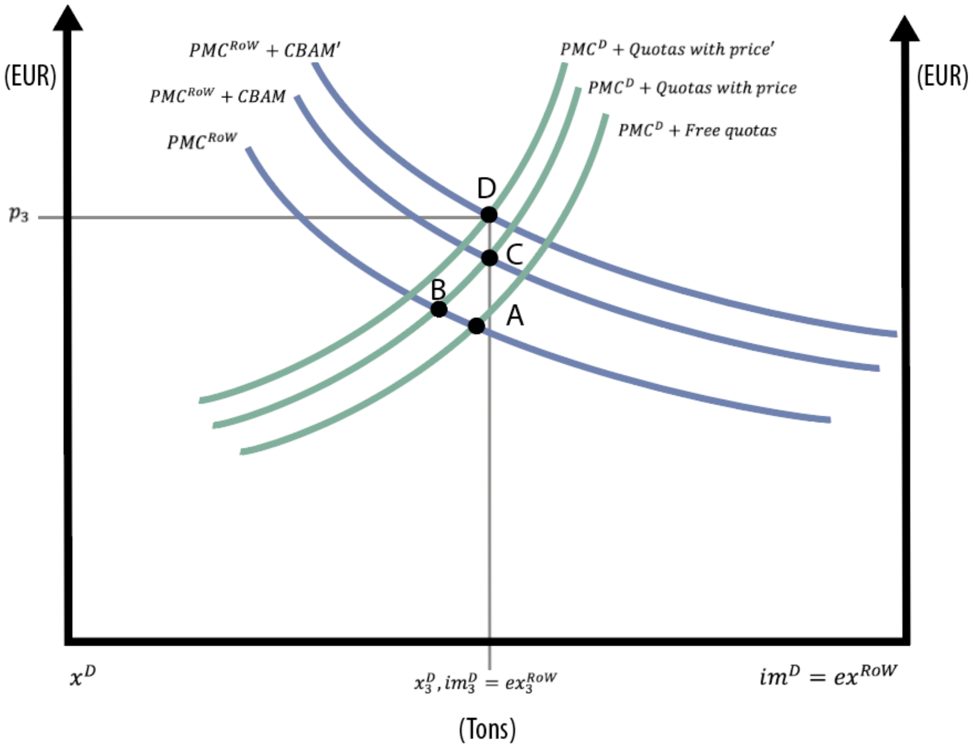

Figure 5: Supply of aluminum when reducing the overall cap of quotas in the EU ETS.

6.2 An Extended Market Model

In the previous section, demand was assumed to be 100% inelastic, and total supply was held constant. This is, however, rarely the case for any commodity. In the following section, we will therefore introduce a demand curve. Hence, the consumption of aluminum is assumed to change due to shocks in the market. Additionally, the free allowances are assumed to be phased out already. This framework will thus make us able to analyze how both the domestic EU/EFTA market and the world market may respond to the CBAM.

6.2.1 Demand Elasticity of Aluminum

Understanding how demand changes due to shocks in the market is vital when forecasting how future consumption may alter. Particularly price- and income elasticities determine the demand for a good. Fernandez (2018), Evans & Lewis (2005), and Stuermer (2017) all find a negative long-run price elasticity of aluminum, ranging from -0.5 to -0.08. Even though their results differ, they all conclude that the long-run price elasticity for aluminum demand is relatively inelastic. This means the quantity demanded does not change much when the price changes. Furthermore, Fernandez (2018) and Evans & Lewis (2005) find a positive long-term income elasticity of aluminum marginally above 1, while Stuermer (2017) finds it to be 1.5. As aluminum is mainly a derived good used as an input into the production of other goods, this means an increase in manufacturing output leads to a relative increased demand for aluminum as an input factor. For the sake of our analysis, we will predominantly focus on how demand changes due to changes in the price of aluminum.

6.2.2 Changes in the Market Equilibrium

Two diagrams are shown in both of the following figures: the EU/EFTA market to the left and the world market to the right. In both diagrams, the vertical axes show the price in EUR. The two horizontal axes show the output of aluminum in tons and the CO_2 equivalents from production and consumption. In the diagram of the EU/EFTA market, the horizontal axis of output shows domestic production (x^D) and consumption (c^D), while in the world market this axis shows domestic imports which equals foreign exports ($im^D = ex^{RoW}$). The emissions from imports ($E^{im} = E^{ex}$), caused by foreign production, and the emissions from consumption of domestic goods (E^x), caused by domestic production, together make up the total emissions of CO_2 equivalents related to total domestic consumption (E^c). Any change in production and consumption will lead to a change in emissions. We assume that the carbon intensity is equal among all domestic EU/EFTA producers, and equal among all RoW producers, but differs between those two. Also, we assume that, in a ceteris paribus scenario of imposing the CBAM, domestic consumers always prefer domestic production to foreign imports if the price is identical. Given these assumptions, we derive the demand curve for foreign imports.

Figure 6 shows an illustration of how domestic consumers in the EU/EFTA market will consume aluminum if free allowances are phased out for EU/EFTA producers, while foreign producers are not faced with similar climate policies. Hence, domestic producers will face their external costs from production, through the quota price. Thus, $PMC^D + Quota\ with\ price$ is the domestic supply curve. While foreign export supply is equal to foreign producers' private marginal costs, hence their supply curve is PMC^{RoW}.

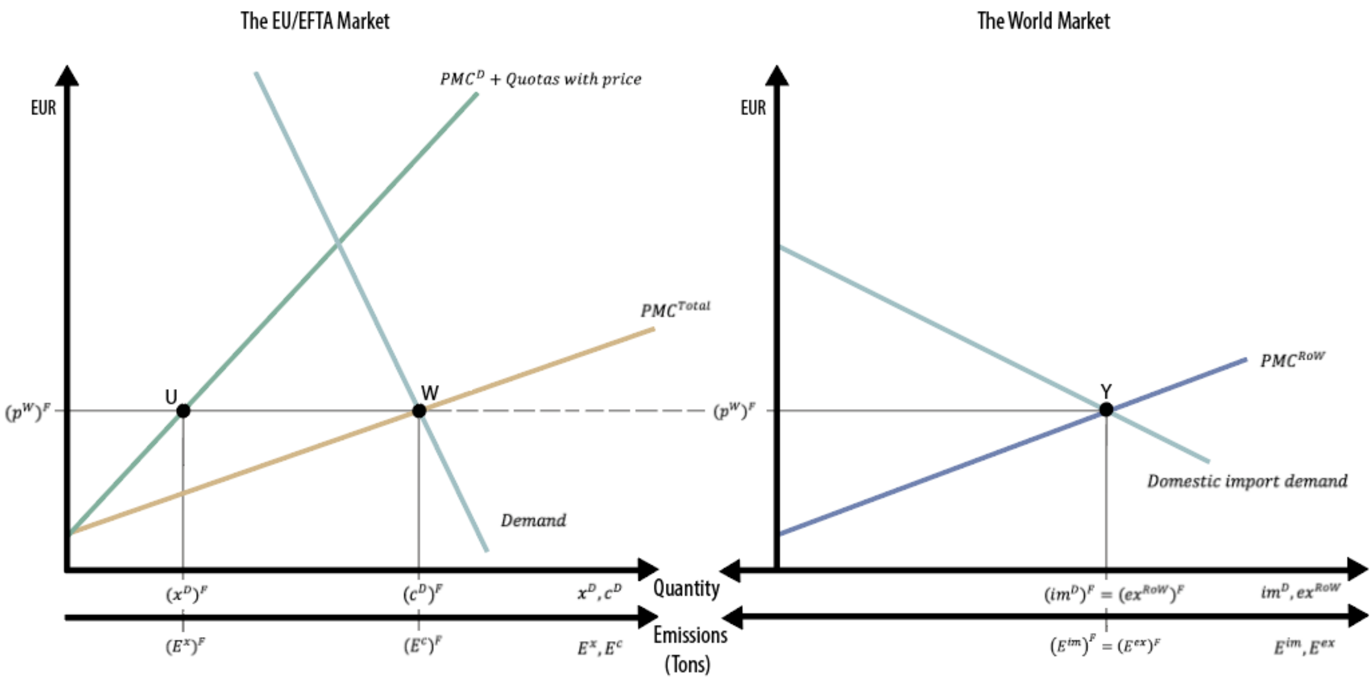

Figure 6: The EU/EFTA market and the world market when free allowances are phased out for the EU/EFTA producers, while the RoW producers are not faced with any policy measures.

In this market, the EU/EFTA is operating with free trade. Because of this, domestic consumption is where domestic demand intersects total supply, consisting of both domestic and foreign supply ($(PMC^D + Quota\ with\ price) + PMC^{RoW} = PMC^{Total}$) in W. Of this, domestic aluminum producers supply the market with $(x^D)^F$ at the world market price $(p^w)^F$. The market equilibrium of domestic production and consumption is found in U. The rest of domestic consumption is coming from imports. This equilibrium is found in Y at the price $(p^w)^F$, where domestic import demand intersects foreign export supply $(im^D)^F = (ex^{RoW})^F$.

Figure 7 shows how the domestic EU/EFTA market and the world market will respond if the CBAM tariff is implemented, all other economic factors held constant. The foreign supply curve will shift from PMC^{RoW} to $PMC^{RoW} + CBAM$. The shift will be equivalent to the CBAM tariff per unit of emission, which will be equal for all producers as we have assumed the carbon intensity is unison for all producers in the world market.

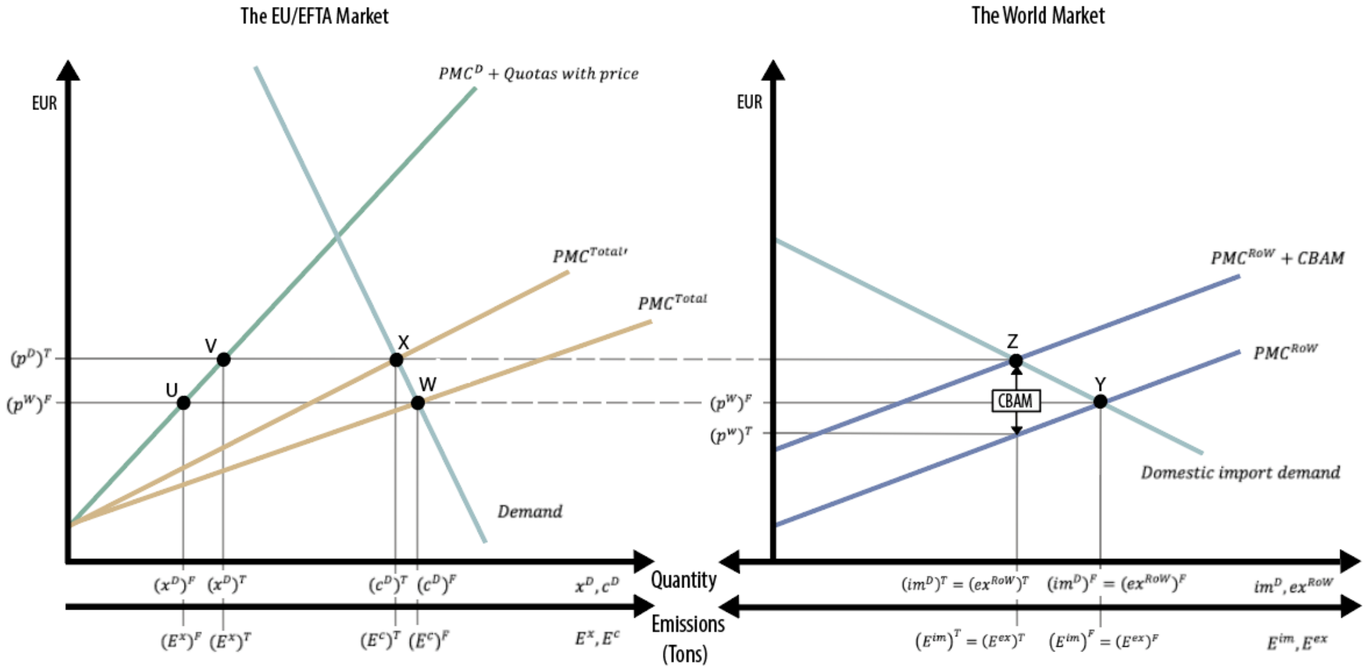

Figure 7: The EU/EFTA market and the world market when the CBAM is imposed on imports at the EU/EFTA border.

The new market equilibrium of foreign export supply and domestic import demand $(im^D)^T = (ex^{RoW})^T$ will be in Z. As can be seen in figure 7, the total supply curve in the domestic market will also shift as the CBAM is imposed on imports at the border. As a consequence of the CBAM, the price in the domestic EU/EFTA market will increase from $(p^W)^F$ to $(p^D)^T$. However, an increased price will likely reduce demand. Therefore, domestic consumption is expected to decrease from $(c^D)^F$ in W to $(c^D)^T$ in X, where overall emissions are reduced. Domestic production will likely increase from $(x^D)^F$ in U to $(x^D)^T$ in V, which will increase domestic emissions. At the same time, imports will decrease from $(im^D = ex^{RoW})^F$ in Y to $(im^D = ex^{RoW})^T$ in Z, which will lead to reduced foreign emissions caused by the production of imported goods. Reduction in foreign emissions will be greater than the increased domestic emissions, which explains why the total emissions will decrease. It should be mentioned that as the CBAM and free allowances are phased in and out simultaneously, the market will never actually occur in $U, W,$ and Y.

As can be seen in figure 7, the total supply curve in the domestic market will also shift as all producers face their external costs after the CBAM is imposed on imports at the border. The new curve will be somewhat steeper than the original, as domestic suppliers will gain a relatively larger share of total supply. Since all producers face higher costs, it will be possible for them to increase the price in the domestic EU/EFTA market from $(p^W)^F$ to $(p^D)^T$. However, an increased price will likely reduce demand. Therefore, domestic consumption is expected to decrease from $(c^D)^F$ in W to $(c^D)^T$ in X, where overall emissions are reduced. Domestic production will likely increase from $(x^D)^F$ in U to $(x^D)^T$ in V, which will increase domestic emissions. At the same time, imports will decrease from $(im^D = ex^{RoW})^F$ in Y to $(im^D = ex^{RoW})^T$ in Z, which will lead to reduced foreign emissions caused by the production of imported goods. Reduction in foreign emissions will be greater than the increased domestic emissions, which explains why the total emissions will decrease. It should be mentioned that as the CBAM and free allowances are phased in and out simultaneously, the market will never actually occur in $U, W,$ and Y.

As domestic EU/EFTA demand for foreign goods generally is reduced due to the CBAM, the world market price will potentially decrease from $(p^W)^F$ to $(p^W)^T$. Thus, there will be a gap between the market price domestically and globally. When it comes to the cost increase for each foreign producer, the gap will be individually based on the carbon intensity of production and hence vary depending on what region the aluminum is produced in. As seen in table 3 the carbon intensities vary greatly, and some countries even have lower intensities than Norway and the weighted average of the EU/EFTA. It is thus assumed that third country producers with low carbon intensities, in addition to the EU/EFTA producers, can capture some extra market shares in the EU/EFTA market as the demand for the most carbon-intensive goods will decrease.

As the world market price decreases, foreign demand for foreign supply could potentially increase. This means that foreign consumption potentially can offset attempts to reduce domestic consumption of carbon-intensive goods. Besides, the phase-in of the CBAM will encourage the EU/EFTA countries to inquire a reduced use of fossil fuels in the production of its imported aluminum. Additionally, the phase-out of free allowances will lead to reduced consumption of fossil fuels in domestic aluminum production. Reduced prices of fossil fuels as a result of this could potentially lead to increased consumption of fossil fuels in the world market. This could potentially also contribute to domestic attempts of emissions reduction being offset.

6.2.3 Substitutes for Aluminum

Based on the discussion above, the price of aluminum in the EU/EFTA will likely increase after the phase-out of free allowances and phase-in of the CBAM. With this, the question arises of whether EU/EFTA customers will replace aluminum with other products. As previously mentioned, demand for aluminum is relatively inelastic. However, the literature is somewhat divided on exactly how inelastic demand is. In order to find the potential extent of cost pass-through to consumers, we will discuss possible substitutes for aluminum in the following paragraphs.

The area of application for aluminum is vast. The metal is mainly used as an input factor in other goods such as in technical and electrical applications, packaging, and household goods (Hydro, 2020). Additionally, aluminum is used as an input in constructions, marine products, machinery, buildings, and different means of transportation (Hydro, 2020; Stuermer, 2017).

Over the course of history, as the world has become more industrialized, aluminum has substituted for materials such as composites, copper, steel, glass, paper, wood, and plastics in manufacturing production (Radetzki, 2008 and Chandler, 1990, as referred in Stuermer, 2017; Wade Architectural Systems, n.d.). However, these products can reversely substitute aluminum (Fernandez, 2018). Additionally, magnesium, titanium, and vinyl are considered substitutes for aluminum (Fernandez, 2018). Howbeit, these materials differ significantly in terms of use. Some can be used as a substitute in packaging, while others in household goods or in constructions. However, aluminum is an especially applicable good which in many cases may be undesirable to replace with other materials. As one of the lightest metals in the world, in addition to being durable, ductile, and corrosion-resistant, aluminum offers a rare combination of valuable abilities (Rusal, n.d.a). It is thus reasonable to believe that substituting aluminum can be challenging.

The world economy is in an epoch where demand for high technology applications is increasing. This may imply that demand for aluminum will not decrease even though the price of the metal increases, as it is used as an input in many technical applications. This is especially due to its lightweight and functionality. The metal is used in phones, computers, aircraft, and cars, among others (Rusal, n.d.a). As the world is moving into the fourth industrial revolution, it is hard to believe that demand for aluminum as an input factor in high-tech products will decrease.

As a part of the green transition, aluminum has become a natural material choice in many low-carbon goods (Hydro, 2020). Among others, this is due to aluminum being an infinitely recyclable material (Søreide, 2021). Besides, as aluminum production is highly energy-intensive, emissions can be significantly reduced if the source of energy is renewable (Senanu, 2021). Intending to reach the EU's climate ambition, there has also become an increasing need to improve fuel efficiency and range extension in the transportation sector. This is driving demand for aluminum as an input in manufacturing of cars, trains, and trucks (Hydro, 2020). As a more lightweight alternative to copper and steel, aluminum has become a natural choice when manufacturing these means of transportation. Hence, if manufacturers consider substituting aluminum with more heavy-weight products after the implementation of the CBAM, they have to compare the cost savings from not paying the CBAM tariff with the increased transport- and CO_2 costs because of increased fuel use. Regardless, products of steel will also be affected by the CBAM and will likely not be commodities considered for substitution when the CBAM is introduced.

Discussing whether or not plastic is a substitute for aluminum, one cannot leave out that plastic often is considered an environmentally hostile material. Since July 2021, there has even been imposed a ban on single-use plastics in the EU (European Commission, n.d.c). Thus, plastic may not be a significant substitute to fear as the EU is on its path towards the green transition.

Although consumers, in the long run, are able to find substitutes for goods, this seems not to be of any particular concern for aluminum. In fact, aluminum appears to be of increased importance as an input factor in manufacturing in years to come. As the CBAM is a new policy tool in the EU/EFTA market, it is hard to know how high the cost pass-through potentially will be. However, based on the discussion above, it looks like there are great opportunities to push the increased costs from the phase-out of free allowances and the phase-in of the CBAM onto consumers. Empirical evidence based on the phase-out of free allowances from the power market in 2013 found a cost pass-through to consumers of 80% (Hintermann, 2014). If aluminum producers also can pass this share of the costs onto consumers, the phase-out of free allowances would not be so harmful to the domestic industry after all.

6.2.4 Global Effects of the CBAM

Based on the discussion in the previous sections, it is clear that the aluminum market will adjust to a new market equilibrium when the free allowances are phased out, and the CBAM is phased in. Based on the policy proposed by the EC, it is also clear that domestic producers have to reduce their emissions. However, the exact response from foreign producers is more challenging to forecast. Hopefully, they will as well improve their technology and optimize their MAC to regain their market shares in the EU/EFTA market, which will lead to reduced global emissions. Nevertheless, there is a risk of opposition from the third countries.

For instance, resource shuffling may occur. This leads foreign producers to export their least carbon-intensive products to the EU/EFTA and their most carbon-intensive products to the RoW market, while holding their overall carbon intensities constant. Even though this would lead to reduced carbon emissions of the EU/EFTA consumption, it could potentially lead to higher carbon leakage and hence reduce the effectiveness of the CBAM. Notwithstanding the preceding, foreign producers have to make an effort to at all be able to export low carbon-intensive products to the EU/EFTA market, for instance, by investing in clean technologies. This would, in fact, be positive from a climate perspective as the overall emissions in the world could decrease. This positive effect would be more prominent the more relevant the EU/EFTA market is for the exports in a particular country. Third countries could also impose a counteracting mechanism, such as a counter-tariff on EU/EFTA exports. This could potentially lead to a trade war and reduce social welfare.

If third countries choose to oppose the climate ambition of the EU/EFTA, the attempts of global emissions reduction could, in other words, be harmed. Additionally, the competitiveness of the EU/EFTA producers in the world market could be reduced, as consumers would not be willing to pay for an increased price, which will be present in the EU/EFTA market. However, this could also create an opportunity for the EU/EFTA producers to gain a first mover advantage, as they invest to be equipped for the green and digital transition once the EC's climate policy is tightened. These investments could be supported by the revenues from the CBAM. As of now, the EC has advocated for generating most of the revenues from the CBAM to the EU budget (European Commission, 2021). It is, however, questionable whether the revenues could be entirely used as a source of EU income, as it could make the CBAM contradict the WTO regulations (Assous, Burns, Tsang, Vangenechten, & Schäpe, 2021). To solve this problem, the revenues could be specifically distributed to investments of decarbonization within the

EU/EFTA. Even though the EU is at the forefront of taking environmental responsibility, climate ambitions in the rest of the world will likely increase in the future. If this happens, EU/EFTA producers can potentially be very competitive in the world market as they already will have reduced their emissions. Thus, in the long run, phasing out the free allowances and phasing in the CBAM can be the beginning of strengthening EU/EFTA producers' position globally.

7 Analysis of Norwegian Imports

The aim of the following chapter is to analyze the direct impacts of the CBAM on imports to Norway, all other factors held constant. Imports of cement, fertilizer, iron & steel and aluminum will be included in our analysis. First of all, we will find the carbon intensities of scope 2 emissions of all sectors included. The direct impacts of implementing the CBAM at the Norwegian border are then found for both the alternative of including scope 1 and including scope 1+2 emissions in the CBAM policy. In order to find these impacts, we calculate the CBAM tariffs, changes in imports, and the reduction in carbon content of imports. The efficiency of the two alternatives presented is discussed by the end of this chapter.

7.1 Carbon Intensities of Scope 2 Emissions

To be able to compare inclusion of scope 1 and scope 1+2 emissions in the CBAM, we start our analysis by calculating carbon intensities of scope 2 emissions, following the methodology presented in section 5.2. The carbon intensities of scope 1+2 are presented in table 7 together with the carbon intensities of scope 1 emission already presented in table 3. All intensities are given as CO_2 equivalents emitted per $MEUR$ of production. Our calculations of carbon intensities from scope 2 emissions account for the difference between scope 1+2 and scope 1. Table 7 shows the carbon intensities for all foreign countries exporting to Norway, the intensity of Norwegian production, and the average carbon intensity of EU/EFTA producers weighted on the gross output. Some of the cells remain empty because there is no import from these regions to Norway in our data of imports.

Table 7: Carbon intensities of scope 2 emissions, measured in tons of CO_2 equivalents emitted per MEUR produced. Data source: Exiobase. Our calculations.

	Cement		Fertilizer		Iron & Steel		Aluminum	
	Scope 1	Scope 1 + 2	Scope 1	Scope 1 + 2	Scope 1	Scope 1 + 2	Scope 1	Scope 1 + 2
Australia					128	161	453	1 198
Brazil			374	378	1 024	1 086	1 845	3 118
Canada	5 473	5 723	567	580	545	614	257	407
China					958	1 074	154	917
India			398	398	2 089	2 089	395	437
Indonesia					250	259	122	212
Japan	8 905	9 529	945	967	266	377	9	89
Mexico					298	443	2 441	2 489
South Korea					186	344	36	1 176
Russia			2 080	2 081	676	677	1 007	1 016
South Africa	3 524	3 558			507	538	4 675	5 066
Turkey					344	350	357	368
United States	1 414	1 536	1 123	1 231	134	285	78	282
United Kingdom	767	874	1 053	1 072	270	333	57	142
RoW Africa					69	123	267	502
RoW America			2 897	3 024	240	301	100	359
RoW Asia and Pacific	12 921	13 090			355	447	391	814
RoW Europe					2 892	3 090	614	1 807
RoW Middle East	5 481	5 780	620	739	274	452	507	1 157
Weighted average EU/EFTA	958	991	783	802	299	360	233	314
Norway	1 852	1 853	607	607	499	500	233	236

The carbon intensities vary widely among both sectors and regions. Same as for the carbon intensities of scope 1 emissions in table 3, the differences among regions can, for example, be explained by heterogeneity in products belonging to the same sector or differences in development and technology among the regions. Low carbon intensities of scope 2 emissions can as well be due to energy used in production rather stemming from sources owned or controlled by the company itself. This leads to the energy mix being accounted for in scope 1 emissions rather than in scope 2. Low scope 2 values can also be explained by a high rate of renewable energy in production. The relative values of carbon intensities from scope 2 emissions to carbon intensities from scope 1 emissions also reveal that some sectors have relatively lower scope 2 than scope 1 emissions in production than others.

First, the relative increase in the carbon intensities when scope 2 is added is rather low in the cement sector. This result seems to be in line with the fact that the majority of emissions in the production of cement stem from calcination, while the minority stems from heating and transportation (Norcem, n.d.). The relative increase is albeit largest for the United Kingdom, which is the region where Norway imports the second most of its cement from. The carbon intensity of scope 2 emissions in imports from this country is one-seventh of the carbon intensity of scope 1 emissions. Even though the relative change in the values is small, it is worth noticing that the absolute values of the carbon intensities from scope 2 emissions in cement manufacturing are quite large. This means the scope 2 emissions are far from insignificant in terms of GHG emissions.

The inclusion of scope 2 values, relative to the scope 1 values, also seems to be of small importance in fertilizer production. Although, the absolute values are also, in this case, quite large. The largest share of the extra-EU/EFTA imports of fertilizer to Norway comes from Russia, which has the second lowest carbon intensity added from scope 2 emission, only one-fiftieth of scope 1. In contrast, the relative increase is the most significant for the United States and RoW Middle East, where the intensity from scope 2 respectively is approximately one-tenth and one-sixth of the intensity from scope 1 values. Nevertheless, imports from these regions to Norway are minor.

For iron & steel, there are three regions that double or almost double carbon intensities when including scope 2. These are the United States, South Korea and RoW Africa. Of these, Norway imports a significant amount from South Korea and the United States. From our calculations, based on the transaction matrix from Exiobase, we see that both South Korea and the United States use a significant amount of oil and gas. The large share of non-renewable sources in their purchased energy mix can also be seen in figure 1.

Aluminum stands out as the sector where scope 2 emissions have the greatest impact on the carbon intensities of production relative to the intensities of scope 1 emissions. In Chinese production, the carbon intensity of scope 2 emissions is almost five times the intensity of scope 1 emissions. Hence, scope 2 emissions account for approximately 80% of all emissions associated with Chinese aluminum production. Based on our calculations, approximately 80% of these scope 2 emissions are related to the generation of electricity from coal. The regions where we find the highest relative increase are South Korea, Japan and RoW America. However, the imports to Norway from these regions are rather low. The very lowest value of carbon intensity from scope 2 is found in Russia. This is the country where Norway imports the most aluminum from. This is in line with the statement of Russia's largest aluminum producer, Rusal, which claims that 90% of their aluminum is produced with renewable energy (Rusal, n.d.b).

7.2 CBAM Tariffs Imposed on Imports

Based on the approach for the CBAM calculation defined in section 5.1, we calculate the potential CBAM tariffs at the Norwegian border. The CBAM tariff is a percentage share of the original value of imports, based on units of emissions, added on top of the original value for importers. All calculated tariffs, both when including scope 1 and scope 1+2, are presented in table 8 together with the weighted average CBAM tariff for each of the sectors, weighted on imports from each country relative to the total. The countries represented in the table are all third countries exporting commodities covered by the CBAM to Norway. EU/EFTA countries are excluded as there will be no CBAM on their export to Norway.

Table 8: CBAM tariffs on imports to Norway, as a percentage of the original value of imports. Data source: UN Comtrade and Exiobase. Our calculations.

	Cement		Fertilizer		Iron & Steel		Aluminum	
	Scope 1	Scope 1 + 2	Scope 1	Scope 1 + 2	Scope 1	Scope 1 + 2	Scope 1	Scope 1 + 2
Australia					0,8 %	1,0 %	2,7 %	7,2 %
Brazil			2,2 %	2,3 %	6,1 %	6,5 %	11,1 %	18,7 %
Canada	32,8 %	34,3 %	3,4 %	3,5 %	3,3 %	3,7 %	1,5 %	2,4 %
China					5,7 %	6,6 %	0,9 %	5,6 %
India			2,4 %	2,4 %	12,5 %	12,5 %	2,4 %	2,6 %
Indonesia					1,5 %	1,6 %	0,7 %	1,3 %
Japan	53,4 %	57,2 %	5,7 %	5,8 %	1,6 %	2,3 %	0,1 %	0,5 %
Mexico					1,8 %	2,7 %	14,6 %	14,9 %
South Korea					1,1 %	2,1 %	0,2 %	7,2 %
Russia			12,5 %	12,7 %	4,1 %	4,2 %	6,0 %	6,1 %
South Africa	21,1 %	21,3 %			3,0 %	3,2 %	28,1 %	30,4 %
Turkey					2,1 %	2,1 %	2,1 %	2,2 %
United States	8,5 %	9,2 %	6,7 %	7,4 %	0,8 %	1,7 %	0,5 %	1,7 %
United Kingdom	4,6 %	5,2 %	6,3 %	6,4 %	1,6 %	2,0 %	0,3 %	0,9 %
RoW Africa					0,4 %	0,7 %	1,6 %	3,0 %
RoW America			17,4 %	18,2 %	1,4 %	1,8 %	0,6 %	2,2 %
RoW Asia and Pacific	77,5 %	78,8 %			2,1 %	2,7 %	2,3 %	5,1 %
RoW Europe					17,4 %	18,8 %	3,7 %	11,3 %
RoW Middle East	32,9 %	34,7 %	3,7 %	4,5 %	1,6 %	2,7 %	3,0 %	7,0 %
Weighted average	**36,3 %**	**38,3 %**	**12,7 %**	**13,0 %**	**1,9 %**	**2,7 %**	**6,0 %**	**6,7 %**

Our calculations show that the CBAM tariffs will vary both between sectors and regions. With the assumption that all countries outside of the EU/EFTA have a carbon price of zero, these variations will only be based on differences in the carbon intensities previously described. Imports with high carbon intensities have accordingly high CBAM tariffs. When only scope 1 emissions are included, the CBAM tariffs range from 0.1% for aluminum imported from Japan to 77.5% for cement imported from RoW Asia and Pacific. Besides, when looking at the weighted average for each of the sectors, we see the CBAM tariffs vary greatly between the different sectors, from 1.9% for iron & steel to 36.3% for cement. This underlines what was pointed out in section 4.4. when looking at the carbon intensities of scope 1 emissions; the cement sector has in almost all cases higher carbon intensities than the other sectors.

When including scope 2 emissions, we see a slight increase in most tariffs, indicating that there are carbon emissions related to the purchase of energy in the production processes. The CBAM tariffs, when based on scope 1+2 emissions, range from 0.5% for aluminum imported from Japan to 78.8% for cement imported from RoW Asia and Pacific. For imports from these regions, the absolute increase in tariffs when including scope 2 emissions is not very notable. However, while the relative increase in tariff on cement from RoW Asia and Pacific is minor, the tariff on imports of aluminum from Japan when including scope 2 is approximately five times the tariff when only including scope 1. The very highest relative increase in the CBAM tariff is found in the imports of aluminum from South Korea, where the inclusion of scope 2 leads to a 36 times higher CBAM tariff compared to when only scope 1 is included.

In total, we observe the greatest relative increase in the CBAM tariffs with the inclusion of scope 2 in the sector of iron & steel and aluminum. However, the weighted averages of the CBAM tariffs show that the increase will have the relatively largest impact on the imports of iron & steel to Norway. The averages are weighted on the imports from each respective region. Hence, as the import mix of iron & steel includes relatively higher carbon intensities with the inclusion of scope 2, the relative increase in the weighted average will be greater in this sector. The reason why the relative increase is lower in the aluminum sector is due to a great share of the import mix is coming from Russia, which has a minor increase in carbon intensity when including scope 2 emissions.

Compared to the weighted averages found by Kuusi et al. (2020), our CBAM tariffs are overall higher. This can possibly be explained by several factors. First of all, we use estimated data points of 2018 from Exiobase, while their analysis is based on emissions data from 2011. Second, the carbon price used for calculations differs between the studies. Kuusi et al. (2020) use a carbon price of 25 EUR per ton CO_2 equivalents emitted, while we use a carbon price of 60 EUR per ton CO_2 emitted. Additionally, the inclusion of more categories of emissions from Exiobase, as described in section 4.2, can possibly explain some of the differences in our results. The gap between the estimates is especially notable for cement, fertilizers, and aluminum. In our calculations on cement, "CO_2 – non-combustion – air" is included. In the case of fertilizers, we have also included N_2O emissions and PFC emissions are included for aluminum production. In contrast, Kuusi et al. (2020) only include CO_2 in their calculations. Last, as the averages of the tariffs are weighted on the imports from the various countries, the differences will partly be explained by different patterns of imports.

7.3 Direct Impacts on Imports

Because we assume all trade elasticities used for calculations are negative, the imports to Norway will decrease as a direct consequence of the CBAM tariff, all other factors held constant. This also means all carbon intensities are assumed to remain unchanged. The reductions in imports, relative to the initial imports, are presented in table 9. These calculations are also based on the approach defined in section 5.1.

Table 9: Changes in imports after imposing the CBAM on imports at the Norwegian border. Data source: UN Comtrade and Exiobase. Our calculations.

	Cement		Fertilizer		Iron & Steel		Aluminum	
	Scope 1	Scope 1+2	Scope 1	Scope 1+2	Scope 1	Scope 1+2	Scope 1	Scope 1+2
Australia					-2 %	-3 %	-18 %	-47 %
Brazil			-9 %	-9 %	-18 %	-19 %	-72 %	-100 %
Canada	-100 %	-100 %	-13 %	-13 %	-9 %	-11 %	-10 %	-16 %
China					-17 %	-19 %	-6 %	-36 %
India			-9 %	-9 %	-36 %	-36 %	-15 %	-17 %
Indonesia					-4 %	-4 %	-5 %	-8 %
Japan	100 %	-100 %	-22 %	-22 %	-5 %	-7 %	0 %	-3 %
Mexico					-5 %	-8 %	-95 %	-97 %
South Korea					-3 %	-6 %	-1 %	-46 %
Russia			-48 %	-48 %	-12 %	-12 %	-39 %	-39 %
South Africa	-100 %	-100 %			-9 %	-9 %	-100 %	-100 %
Turkey					-6 %	-6 %	-14 %	-14 %
United States	-45 %	-49 %	-26 %	-28 %	-2 %	-5 %	-3 %	-11 %
United Kingdom	-24 %	-28 %	-24 %	-25 %	-5 %	-6 %	-2 %	-5 %
RoW Africa					-1 %	-2 %	-10 %	-20 %
RoW America			-67 %	-70 %	-4 %	-5 %	-4 %	-14 %
RoW Asia and Pacific	-100 %	-100 %			-6 %	-8 %	-15 %	-32 %
RoW Europe					-50 %	-54 %	-24 %	-70 %
RoW Middle East	-100 %	-100 %	-14 %	-17 %	-5 %	-8 %	-20 %	-45 %
Total	-72 %	-73 %	-49 %	-50 %	-6 %	-8 %	-37 %	-40 %

First of all, our calculations show that imports in some sectors from specific regions seem to be completely phased out once the CBAM is imposed. Except for this, the reduction in imports varies greatly, but the largest effects are not surprisingly found where high CBAM tariffs are combined with high trade elasticities. As outlined in figure 7 in chapter 6, the imposed tariff will potentially increase the domestic price in the case of aluminum. As the price elasticity for this good is relatively inelastic, this price increase will not reduce domestic consumption to a large extent. Nevertheless, the negative trade elasticity implies that the imports are largely reduced. It is, therefore, believed that a large share of domestic consumption is offset by domestic production or foreign production with lower carbon intensities. Whether this holds for the other CBAM sectors will not be examined in our thesis. Howbeit, it is reasonable to believe that consumption in these cases neither will change as much as the imports are reduced.

Imports of cement to Norway, which both have high CBAM tariffs and a high trade elasticity, are estimated to be severely affected by the proposed CBAM. Imports to Norway from Canada, Japan, South Africa, RoW Asia and Pacific, and RoW Middle East are estimated to be eliminated. Only the imports from the United States and the United Kingdom are estimated to be maintained to some extent. For comparison, these imports only have one-tenth and one-fifteenth respectively of the carbon intensity of scope 1 present in imports from RoW Asia and Pacific.

Concerning both fertilizer and iron & steel, it does not appear that any of the imports to Norway will be eliminated. Besides, these are the two sectors with the lowest trade elasticities. Nevertheless, the CBAM again affects the imports the most, where the carbon intensity is the highest. Albeit, in absolute terms, a larger share of imports in the iron & steel sector will be removed as imports are initially larger.

In the case of aluminum, South Africa is the only country where the import is entirely eliminated when scope 1 is included in the calculation. Nevertheless, imports from Mexico will as well be almost eliminated even though the carbon intensity is only half the value of the intensity of aluminum imported from South Africa. If scope 2 also are included in the calculation, the imports from Brazil are additionally eliminated. It is also worth pointing out that the total relative reduction in imports of aluminum is very similar to the calculated reduction of imports from Russia. This underlines the importance of Russian imports in this sector.

The results above reflect the fact that a CBAM is capable of reducing imports to Norway from regions with high carbon intensities. When the importers are faced with a price on the carbon content of their imports on top of the original value, they will likely consume goods that rather are produced domestically or in third countries with lower carbon intensities of production. This contributes to reducing the risk of carbon leakage.

Income from the CBAM will only come from imports that are maintained after deducting the reduced imports, presented in table 9, from the original imports, presented in table 2 in section 4.4. If the income from the CBAM is distributed to each individual EU/EFTA country rather than to the EU/EFTA budget, this income could potentially create a source of revenue for the Norwegian government. Based on our calculations, the income from the CBAM paid on the maintained imports to Norway will approximately be 40 $MEUR$ if only including scope 1, and 50 $MEUR$ if including scope 1+2. Considering that the consumers increase their demand for foreign goods with lower carbon intensities, this income may be higher than shown in our calculations. If this revenue is distributed to the Norwegian government, it could, for instance, be located in a fund where the money is earmarked to support investments in cleaner technology.

7.4 Scopes of Emissions Included in the CBAM

In order to evaluate whether the alternative of including scope 1 or scope 1+2 will be more efficient, the environmental benefits of including scope 2 emissions in the CBAM policy must be seen in conjunction with the disadvantages of expanding the policy. When looking at the benefits of including scope 2, it is desirable to observe the reduction in the carbon content of imports for both alternatives relative to the initial content of scope 1+2 emissions of Norwegian imports. The disadvantages are discussed in light of administrative costs and the complexity of the policy.

Table 10: Change in imports and the carbon content of imports after imposing the CBAM on imports at the Norwegian border. Data source: UN Comtrade and Exiobase. Our calculations.

	Scope 1			Scope 1+2		
	Carbon Content (Tons)	% Carbon Content	% Import	Carbon Content (Tons)	% Carbon Content	% Import
Cement	- 371	-91 %	-72 %	- 391	-96 %	-73 %
Fertilizer	- 97 342	-49 %	-49 %	- 101 801	-51 %	-50 %
Iron & Steel	- 52 381	-9 %	-6 %	- 73 049	-13 %	-8 %
Aluminum	- 179 882	-42 %	-37 %	- 203 669	-48 %	-40 %
Total	- 329 976	-27 %	-15 %	- 378 910	-31 %	-17 %

First of all, the ranking of percentage reduction in the carbon content of imports among the sectors is the same regardless of which scopes are included in the CBAM calculation. Cement is the sector that has the greatest relative reduction in the carbon content of imports: 91% when including scope 1 and 96% when including scope 1+2, compared to the scope 1+2 carbon content. However, looking at absolute values, this reduction does not account for a significant amount of the total reduction in the carbon content of Norwegian imports. The reason is that cement is initially imported in the smallest quantities among the sectors included. On the other hand, the absolute reduction in carbon content is highest in the aluminum sector, although the relative reduction only is 42% when including scope 1 and 48% when including scope 1+2.

When looking at the environmental benefits of including scope 2 emissions in the CBAM policy, the relative additional reduction in the carbon content of imports is greatest in the iron & steel sector. It was also for this sector we found that imports to Norway will be relatively most affected by the inclusion of scope 2. The absolute value of reduction is nevertheless larger in the aluminum sector. While the CBAM based on scope 1 emissions in total reduces the carbon content of imports by 27% relative to the original scope 1+2 content, the inclusion of both scope 1+2 in the CBAM reduces the carbon content by 31%. The absolute reduction in carbon content when including scope 1 is 329 976 tons, while if including scope 1+2 the reduction is 378 910 tons. Simultaneously, imports are reduced by 15% when including only scope 1 emissions and 17% when including scope 1+2. This means the carbon content and imports are reduced respectively by an additional 15% and 13% relative to the reduction when only including scope 1. In other words, the inclusion of scope 1 yields an approximate 2:1 ratio of reduction, in favor of the carbon reduction, while the inclusion of scope 2 will make the ratio between the two factors of reduction approximately 1:1. Even though the carbon content of the imports is more reduced with the inclusion of scope 2, the ratios show that the efficiency of including scope 2 is lower than if only including scope 1.

The additional reduced carbon content of imports, with the inclusion of scope 2, must also be seen in comparison to the administrative costs and complexity of expanding the policy. First, the administrative costs could assumingly increase with more scopes included, especially since the scope 2 values could be harder to monitor than the scope 1 values as it is not owned or controlled by a company itself. Second, the chances of getting a counteracting reaction from third countries could as well be greater if more scopes, and also more sectors, are included in the CBAM. Third, the financial compensation for indirect emissions must be phased out if scope 2 is included in the CBAM policy, which could add even more complexity to the system. Besides, phasing out this compensation scheme could lead to greater opposition from the domestic industry as their competitiveness in the world market potentially could decrease even further. The environmental benefits seen in conjunction with the disadvantages of expanding the policy give reasons to believe that the inclusion of scope 2 in the CBAM implemented at the Norwegian border will not considerably increase the efficiency. This is based on observing the isolated effects of the CBAM.

8 Weaknesses

Due to a dynamic and fluctuating market, in addition to some uncertainty in our data, it should be noted that our analysis has some limitations and weaknesses, which may have implications for the accuracy of our findings.

First, the carbon intensities from Exiobase show somewhat strange data points in some cases. By this, we mean that the carbon intensities vary significantly between countries in the same sector. We find this especially noteworthy in the cases where developing countries have substantially lower values than developed countries. This applies, for instance, to iron & steel production in RoW Africa with a carbon intensity of 69 tons of CO_2 equivalents emitted per $MEUR$ produced, compared to Norway, which has an intensity of 499. Our initial thought would be that developed countries use more modern technology than developing countries, which minimizes the emissions in the production process. A reason why the difference in carbon intensities occurs may be because developing countries do not have the same requirements for logging their emissions as developed countries. If this is the case, the emission intensities from Exiobase may not be perfectly accurate. In addition, the carbon intensities between developed countries also differ significantly in some cases. Aluminum production in Japan has a carbon intensity of 9, while in Norway, the intensity is 299. This makes reason to believe that the products are more heterogeneous than initially thought. Imprecise estimates could also be due to minor data points. These limitations of the data could potentially pose weaknesses to our analysis.

Second, all our calculations are based on the CBAM entering 100% into force once implemented, reflecting the 2035 scenario from the EC's proposal. However, trade patterns in 2035 may look very different from the ones in 2019. Besides, abatement mechanisms and technologies may have developed greatly within this year, and costs of such may have decreased significantly. Thus, the gradual phase-in of the CBAM and the phase-out of free allowances could, in reality, give a completely different result than what our findings show due to dynamic changes in the market. As the CBAM policy presented on the 14th of July 2021 was a consultation proposal, the policy may as well become modified in years to come.

Third, the carbon price used in our calculations is based on a rough average from the fall of 2021. However, the carbon price in the EU ETS fluctuates greatly, especially considering the year 2021. On the 18th of January, the price was 31.6 EUR per ton of CO_2 equivalents emitted, while on the 8th of December, the price peaked at 88.9 (Ember, 2021). As the free allowances are phased out and the overall cap of quotas decreases, there are reasons to believe that the price will increase even more in the future. If this happens, our analysis will show lower direct effects from the CBAM than what may occur in reality. Nevertheless, one must also bear in mind that our analysis does not include potential carbon costs paid by foreign producers in their country of origin. In many cases, carbon costs are imposed only for specific goods or for specific provinces or states. As the carbon costs are not universal for all producers, it will pose a slight weakness to our analysis to assume the carbon price paid by all third country producers is zero.

9 Conclusion

When tightening the climate policies in the EU/EFTA, the risk of carbon leakage arises, which both can harm the climate and the economy. In order to reduce this risk, the EC has proposed the CBAM as a part of their "Fit for 55" package. The CBAM, which is a tariff on the carbon content of imports, will be phased in simultaneously as free allowances are phased out, and the overall cap of quotas in the EU ETS is reduced. Together, this seeks to help the EU achieve the goal of the European Green Deal: climate neutrality within 2050.

This thesis has provided an overview of the EC's policy proposal of the CBAM in the EU/EFTA region, with the main focus on how it will affect Norwegian imports and production. Throughout the thesis, we have analyzed whether the CBAM will succeed in preventing carbon leakage, protecting the decarbonization initiatives in the EU/EFTA, incentivizing producers from third countries to reduce emissions, and ensuring the price of imports to the EU/EFTA reflects their carbon content.

First, we analyzed how the EU/EFTA aluminum market will adapt when the CBAM is phased in, and the free allowances are phased out. Our analysis shows that the policy measures will force all producers selling their products in the EU/EFTA market to face a carbon cost on their emissions. As the industry is faced with its external costs, no one but the industry itself and its customers will pay for the emissions caused by production. The CBAM will lead to a reduction in imports, and producers from the EU/EFTA and third countries with lower carbon intensities will thus be able to gain additional market shares. We find that Norwegian aluminum producers in total are able to gain a net income of $865\ MEUR$. This will lead to an overall reduction of consumption-related emissions in the EU/EFTA. Furthermore, the phase-out of free allowances will incentivize EU/EFTA producers to reduce their emissions by optimizing their MAC, as the phase-out will increase their carbon costs. When the phase-in of the CBAM is combined with the phase-out of free allowances, producers in the EU/EFTA are capable of investing in abatement measures or buying permits to emit without losing competitiveness. This is because they will be able to push most of the increased costs onto consumers through higher prices. As demand for aluminum seems to be relatively inelastic and not threatened by many substitutes, the opportunity for cost pass-through is well supported.

Second, we analyzed what direct impacts the CBAM potentially can have on Norwegian imports of cement, fertilizer, iron & steel, and aluminum. Our calculations present a comparison of two alternatives of the CBAM: including only scope 1 emissions or including scope 1+2 emissions. The result shows that the inclusion of scope 2 in the policy will not increase the efficiency of the mechanism considering Norwegian imports. However, including scope 1 alone will eliminate the most carbon-intensive imports, as the carbon content of imports will decrease by 27%, while the value of imports will decrease by 15%.

To estimate the exact effects of the CBAM is challenging when not knowing the response from third countries. The response can be positive for the climate if third country producers get strong enough incentives to make their production cleaner. However, third countries could oppose, for example with resource shuffling or counter-tariffs on EU/EFTA exports. Once third countries are not responding by increasing their level of climate ambition in parallel with the EU/EFTA, the competitiveness of domestic supply in the foreign market will most probably decrease. However, this could also open up the opportunity for domestic producers to gain a first-mover advantage, especially if the income of the CBAM is used for investments in cleaner technology.

For further research on the CBAM, we find it particularly interesting to investigate the response from third countries. Will they increase their level of climate ambition and, for instance, introduce a mechanism similar to the CBAM? And will this reduce global emissions? Additionally, based on the same approach as ours, the analysis could give a more accurate result using the correct price levels of carbon in all regions and sectors covered, and as well accounting for the dynamic and simultaneous phase-in of the CBAM and phase-out of the free allowances.

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Appendix

A1 Sector Classifications

A1.1 Sector classifications.

CBAM Sector	Initial Shortlist Presented by the EC	HS Classification	NACE Classification
Cement	Clinker Portland cement	252310 - Cement clinkers (whether or not coloured)	Cement, lime and plaster
		252321 - Cement; portland, white, whether or not artificially coloured	
		252329 - Cement; portland, other than white, whether or not artificially coloured	
		252390 - Cement; hydraulic kinds n.e.c. in heading no. 2523	
Fertilizer	Ammonia Urea Nitric acid AN (Ammonium Nitrate)	280800 - Nitric acid; sulphonitric acids	N-fertiliser
		2814 - Ammonia; anhydrous or in aqueous solution	
		283421 - Nitrates; of potassium	
		3102 - Fertilizers; mineral or chemical, nitrogenous	
		310510 - Fertilizers, mineral or chemical; in tablets or similar forms or in packages of a gross weight not exceeding 10kg	
		310520 - Fertilizers, mineral or chemical; containing the three fertilizing elements nitrogen, phosphorus and potassium	
		310530 - Fertilizers, mineral or chemical; diammonium hydrogenorthophosphate (diammonium phosphate)	
		310540 - Fertilizers, mineral or chemical; ammonium dihydrogenorthophosphate (monoammonium phosphate) and mixtures thereof with diammonium hydrogenorthophosphate (diammonium phosphate)	
		310551 - Fertilizers, mineral or chemical; containing nitrates and phosphates	
		310559 - Fertilizers, mineral or chemical; containing the two fertilizing elements nitrogen and phosphorus, other than nitrates and phosphates	
		310590 - Fertilizers, mineral or chemical; n.e.c. in heading no. 3105	
Iron & Steel	Iron & steel primary forms Hot rolled & further steps Coated hot rolled & further steps Forged, extruded and wire	7201 - Pig iron and spiegeleisen in pigs, blocks or other primary forms	Basic iron and steel and of ferro-alloys and first products thereof
		7203 - Ferrous products obtained by direct reduction of iron ore and other spongy ferrous products, in lumps, pellets or the like; iron having a minimum purity of 99.94%, in lumps, pellets or similar forms	
		7205 - Granules and powders, of pig iron, spiegeleisen, iron or steel	
		7206 - Iron and non-alloy steel in ingots or other primary forms (excluding iron of heading no. 7203)	
		7207 - Iron or non-alloy steel; semi-finished products thereof	
		7208 - Iron or non-alloy steel; flat-rolled products of a width of 600mm or more, hot-rolled, not clad, plated or coated	
		7209 - Iron or non-alloy steel; flat-rolled products, width 600mm or more, cold-rolled (cold-reduced), not clad, plated or coated	
		7210 - Iron or non-alloy steel; flat-rolled products, width 600mm or more, clad, plated or coated	
		7211 - Iron or non-alloy steel; flat-rolled products, width less than 600mm, not clad, plated or coated	
		7212 - Iron or non-alloy steel; flat-rolled products, width less than 600mm, clad, plated or coated	
		7213 - Iron or non-alloy steel; bars and rods, hot-rolled, in irregularly wound coils	
		7214 - Iron or non-alloy steel; bars and rods, not further worked than forged, hot-rolled, hot drawn or hot-extruded, but including those twisted after rolling	
		7215 - Iron or non-alloy steel; bars and rods, n.e.c. in chapter 72	
		7216 - Iron or non-alloy steel, angles, shapes and sections	
		7217 - Wire of iron or non-alloy steel	
		7218 - Stainless steel in ingots or other primary forms; semi-finished products of stainless steel	
		7219 - Stainless steel; flat-rolled products of width of 600mm or more	
		7220 - Stainless steel; flat-rolled products of width less than 600mm	
		7221 - Stainless steel bars and rods, hot-rolled, in irregularly wound coils	
		7222 - Stainless steel bars and rods, angles, shapes and sections	
		7223 - Stainless steel wire	
		7224 - Alloy steel in ingots or other primary forms, semi-finished products of other alloy steel	
		7225 - Alloy steel flat-rolled products, of a width 600mm or more	
		7226 - Alloy steel flat-rolled products, of a width of less than 600mm	
		7227 - Steel, alloy; bars and rods, hot-rolled, in irregularly wound coils	
		7228 - Alloy steel bars, rods, shapes and sections; hollow drill bars and rods, of alloy or non-alloy steel	
		7229 - Wire of other alloy steel	
		7301 - Iron or steel sheet piling, whether or not drilled, punched or made from assembled elements; welded angles, shapes and sections, of iron or steel	
		7302 - Railway or tramway track constructions of iron or steel; rails, check and track rails, switch blades, crossing frogs, point rods, sleepers, fish-plates, chair wedges, sole plates, bedplates, ties and the like	
		730300 - Cast iron; tubes, pipes and hollow profiles	
		7304 - Tubes, pipes and hollow profiles, seamless, of iron (other than cast iron) or steel	
		7305 - Iron or steel (excluding cast iron); tubes and pipes (e.g. welded, riveted or similarly closed), having circular cross-sections, external diameter of which exceeds 406.4mm, not seamless	
		7306 - Iron or steel (excluding cast iron); tubes, pipes and hollow profiles (not seamless), n.e.c. in chapter 73	
		7307 - Tube or pipe fittings (e.g. couplings, elbows, sleeves), of iron or steel	
		7308 - Structures of iron or steel and parts thereof; plates, rods, angles, shapes, sections, tubes and the like, prepared for use in structures	
		7309 - Reservoirs, tanks, vats and similar containers; for any material (excluding compressed or liquefied gas), of iron or steel, capacity exceeding 300l, whether or not lined or heat insulated	
		7310 - Tanks, casks, drums, cans, boxes and similar containers, for any material (excluding compressed or liquefied gas), of iron or steel, capacity not exceeding 300l, whether or not lined or heat-insulated	
		7311 - Containers for compressed or liquefied gas, of iron or steel	

Aluminum	Aluminium unwrought Aluminium unwrought alloyed Aluminium products Alloyed aluminium products	7601 - Aluminium; unwrought	Aluminium and aluminium products
		7603 - Aluminium; powders and flakes	
		7604 - Aluminium; bars, rods and profiles	
		7605 - Aluminium wire	
		7606 - Aluminium; plates, sheets and strip, thickness exceeding 0.2mm	
		7607 - Aluminium foil (whether or not printed or backed with paper, paperboard, plastics or similar backing materials) of a thickness (excluding any backing) not exceeding 0.2mm	
		7608 - Aluminium; tubes and pipes	
		760900 - Aluminium; tube or pipe fittings (e.g. couplings, elbows, sleeves)	

A2 Region Classifications

A2.1 Region classifications.

RoW Africa
Algeria
Angola
Cabo Verde
Cameroon
Congo
Côte d'Ivoire
Djibouti
Equatorial Guinea
Ethiopia
Gabon
Ghana
Kenya
Libya
Madagascar
Mauritius
Morocco
Mozambique
Namibia
Nigeria
Senegal
Tunisia
Zambia
Liberia
Other Africa, nes
Sudan
Tunisia
Uganda
United Rep. of Tanzania
Zambia

RoW America
Argentina
Bahamas
Bermuda
Chile
Colombia
Costa Rica
Cuba
Curaçao
Dominican Rep.
Ecuador
El Salvador
Haiti
Honduras
Panama
Paraguay
Peru
Saint Maarten
Suriname
Trinidad and Tobago
Uruguay
Venezuela

RoW Asia and Pacific
Afghanistan
Armenia
Azerbaijan
Bangladesh
Brunei Darussalam
Cambodia
Central African Rep.
French Polynesia
Kazakhstan
Kyrgyzstan
Malaysia
New Caledonia
New Zealand
Other Asia, nes
Pakistan
Philippines
Singapore
Sri Lanka
Tajikistan
Thailand
Tokelau
Uzbekistan
Viet Nam

RoW Europe
Albania
Andorra
Belarus
Bosnia Herzegovina
Faeroe Isds
Georgia
Gibraltar
Montenegro
North Macedonia
Rep. of Moldova
San Marino
Serbia
Ukraine

RoW Middle East
Bahrain
Egypt
Iran
Israel
Jordan
Kuwait
Lebanon
Oman
Qatar
Saudi Arabia
State of Palestine
Syria
United Arab Emirates

A3 Energy Classifications

A3.1 Energy classifications.

Form of Energy	Energy Classification
Electricity by coal	Non-renewable Electricity
Electricity by gas	
Electricity by nuclear	
Electricity by petroleum and other oil derivatives	
Electricity by hydro	Renewable Electricity
Electricity by wind	
Electricity by biomass and waste	
Electricity by solar photovoltaic	
Electricity by solar thermal	
Electricity by tide, wave, ocean	
Electricity by Geothermal	
Electricity nec	Other Electricity
Steam and hot water supply services	Other Energy