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EU's suggested carbon border adjustment mechanism

Impact on Norwegian industries

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Preface

This project is financed by the Ministry of foreign affairs under the framework agreement for research and development (2021-2025) that is joint between the Research department at Statistics Norway and Vista Analyse. In addition to the authors, Senior Partner Haakon Vennemo at Vista Analyse has contributed with comments and to discussions, and Professor Christoph Böhringer, University of Oldenburg has contributed with framing of the analyses and modelling assistance. We will also thank Taran Fæhn, Knut-Einar Rosendahl, Cathrine Hagem and Linda Nøstbakken for useful comments to an earlier draft.

Statistics Norway, 7 November 2022

Linda Nøstbakken

Abstract

The EU has recently proposed carbon tariffs at the border (CBAM – Carbon Border Adjustment Mechanism) as part of its Fit for 55 policy. Norway's climate policy is linked to the EU's. This report addresses the direct and indirect impacts of a carbon tariff policy on Norwegian industries and the general economy when Norway's climate policies are linked to the EU's. The purpose of a carbon border tariff is to counteract potential carbon leakage from the sectors that are part of the EU's emission quota trading system (EU ETS). Through a carbon tariff, importers of goods to the EU will have to buy carbon certificates for all greenhouse gas emissions at a price corresponding to the quota price in the EU ETS. If non-EU producers can show that they have already paid a price for the carbon emissions for the imported goods from a country outside the EU, the corresponding cost should be deducted. The carbon border tariff should cover a broad range of imports of products and commodities covered by the EU ETS, including when embedded in intermediate or final products. Initially, the suggested carbon tariff policy will only be applied to direct greenhouse gas emissions from use of fossil fuels in production. Indirect emissions from production of electricity may be included when a reporting system has been established.

To analyse effects of a carbon border tariff for Norway, the project use Statistics Norway's World model, SNOW-Global, which is a global multi-region multi-sector computable general equilibrium model based on GTAP (Global Trade Analyses Project) data, with Norway as a separate country. While the database includes 140 regions and 57 sectors, the project mainly studies the effects on Norway and the EU, with key trading partners. All industries that are subject to or affected by the carbon tariff are explicitly represented in this study. The effects on the Norwegian economy and industries of introducing a carbon tariff are compared to a reference simulation of the global economy in the year 2030. The reference simulation includes existing carbon policies in the EU and Norway, and the nationally determined (emission reductions) contributions (NDCs) under the Paris Agreement for all other countries and regions. The current EU ETS includes free allocation of quotas proportional to output (Output-Based Allocation) for industries with high risk of carbon leakage, such as cement, steel, aluminium, paper, glass, chemicals, refined oil products and fertilisers. In the EU's fit for 55 proposal free quotas are intended to be phased out by 2035.

Three policy scenarios are analysed: The TARIFF scenario that introduces a carbon tariff and removes all free quotas, the NOLEAK scenario without any explicit anti-leakage policy measures, i.e., without carbon tariff and free quotas, and the HYBRID scenario where the carbon tariff applies at a rate of 50 per cent while the free quota rate is reduced to 50 per cent of the reference simulation full rebate. The HYBRID scenario represents the scheduled phase-out of free quotas and phase-in of CBAM in 2030. We find that the effects on output of introducing a carbon tariff as in the TARIFF scenario are positive for sectors that do not receive free quotas initially such as electricity that increases its output by 0.5 per cent, while sectors initially receiving free quotas mainly reduce their production when their 100 per cent free quotas is substituted by a carbon tariff on direct emissions. The negative activity effect ranges from -0.7 per cent for refined petroleum products and non-ferrous metals, -1.2 per cent for Iron and steel, to -2 per cent for chemical products. On average the effects are quite similar for both Norway and the EU. Some production of goods and emissions in ETS sectors are reallocated from Norway to EU. Global emissions are slightly reduced.

In the HYBRID scenario the effects on the carbon tariff sectors lie somewhere in between the reference simulation and the TARIFF scenario for the sectors that have free quotas in the reference. Electricity has full carbon tariff and no free quotas in the HYBRID scenario since they have no free quotas initially and experience a similar production increase as in the TARIFF scenario. While the global emissions fall in both the TARIFF and HYBRID scenario, the macroeconomic effects for Norway and EU are very small in all the policy scenarios, including minor changes in the EU ETS quota price between the scenarios.

Sammendrag

EU har nylig foreslått karbontariffer (CBAM – Carbon Border Adjustment Mechanism) som en del av «fit for 55» politikken. Norges klimapolitikk er knyttet til EUs. Denne rapporten tar for seg de direkte og indirekte effektene av å innføre slike karbontariffer på norske industrisektorer og norsk økonomi. Formålet med karbontariffer er å motvirke mulig karbonlekkasje fra sektorer som er med i EU sitt kvotehandelssystem (EU ETS), som også Norge er en del av. Ved en karbontariff vil importører av varer til EU og Norge måtte kjøpe karbonsertifikater for alle klimagassutslippene til en pris som tilsvarer kvoteprisen i EU ETS. Hvis en produsent utenfor EU og Norge kan vise at den allerede har betalt en pris for karbonutslippene fra produksjonen av de importerte varene i et land utenfor EU, skal den tilsvarende kostnaden trekkes fra. I prinsippet bør en karbontariff dekke all import av produkter og varer som omfattes av EU ETS, inkludert når de brukes som innsatsvarer i sluttproduktet. EU foreslår at en karbontariff i utgangspunktet kun legges på direkte utslipp av CO_2 fra bruk av fossile brensler i produksjonen.

For å analysere effekter av å innføre en karbontariff for Norge har prosjektet brukt Statistisk sentralbyrås verdens modell (SNOW Global), som er en global fler-region og fler-sektor generell likevektsmodell med Norge som eget land, basert på GTAP (Global Trade Analysis Project) data. Den regionale inndelingen dekker Norge og EU sammen med sentrale handelspartnere. Når det gjelder sektorinndelingen, er alle bransjer som er underlagt EU ETS og dermed en karbontariff eksplisitt representert. Effektene på norsk økonomi og industri av å innføre karbontariffer sammenlignes med en referansesimulering av verdensøkonomien i 2030 med vedtatt karbonpolitikk i EU og Norge og de nasjonalt fastsatte bidragene til utslippsreduksjoner (NDC-ene) under Parisavtalen for alle andre land og regioner. Gjeldende EU ETS inkluderer gratis kvoter basert på produksjon for bransjer med høy risiko for utflytting som sement, stål, aluminium, papir, glass, kjemikalier, raffinerte oljeprodukter og gjødsel. I EUs «fit for 55» politikk foreslås det at gratiskvoter skal avskaffes innen 2035.

Tre politikkscenarier analyseres: TARIFF-scenarioet som introduserer karbontariffer og fjerner alle gratiskvoter, NOLEAK-scenarioet hvor det ikke er noen eksplisitte anti-lekkasjetiltak, dvs. uten karbontariffer og gratis kvoter, og HYBRID-scenarioet der karbontariffen kun gjelder ved en sats på 50 prosent mens andelen gratis kvoter reduseres til 50 prosent. HYBRID-scenarioet representerer den planlagte utfasingen av gratiskvoter og innfasingen av karbontariffer. Vi finner at produksjonseffekten av å innføre karbontariffer som i TARIFF-scenarioet er positiv for ETS-sektorer som ikke mottar gratis kvoter i utgangspunktet, som elektrisitet (0.5 prosent) og mineralske produkter (0.4 prosent, mottar svært lite gratis kvoter), mens produksjonen faller i ETS-sektorer som i utgangspunktet mottar gratis kvoter, som raffinerte oljeprodukter og ikke-jernholdige metaller (-0.7 prosent), jern og stål (-0.7 prosent) og kjemiske produkter (-2 prosent) når gratiskvoter erstattes av karbontariffer på direkte utslipp. Effektene er ganske like for Norge og EU. Noe produksjon innenfor ETS-sektorene og tilhørende utslipp omfordeles fra Norge til EU. Globale utslipp faller svakt.

I HYBRID-scenarioet blir effektene på produksjonen for sektorene som pålegges karbontariffer liggende et sted mellom produksjonseffektene i referansesimuleringen og TARIFF scenarioet for de sektorene som har 100 prosent gratis kvoter i referansesimuleringen. Elektrisitet har står overfor 100 prosent karbontariff og ingen gratiskvoter i HYBRID-scenarioet siden de ikke har noen gratiskvoter i utgangspunktet, og de positive produksjonseffektene er de samme som i TARIFF scenarioet. De makroøkonomiske effektene er svært små både for Norge og EU i alle de tre scenariene.

Contents

1. Introduction

The EU has recently proposed carbon tariffs at the border (CBAM – Carbon Border Adjustment Mechanism) as part of its Fit for 55 policy[1], European Parliament (2021). Norway's climate policy is linked to EU's and Norway participates in the EU emission trading system (ETS), see Ministry of Climate and the Environment (2022) for details. This report addresses the direct and indirect impact of the CBAM on Norwegian industries and the general economy. The purpose of the CBAM is to counteract potential carbon leakage from the EU and Norway to the rest of the world.

Through the CBAM, importers of goods to the EU will have to buy so-called carbon certificates for all greenhouse gas emissions (GHG) at a price corresponding to the quota price in the EU's emissions trading system. If non-EU producers can show that they have already paid a price for the carbon emissions content of the imported goods in a country outside the EU, the corresponding cost should be deducted.

The European Parliament (2021) states that, in principle, the CBAM should cover all imports of products and commodities covered by the EU ETS.[2] This includes embodied carbon in intermediate or final products. As a starting point (from 2023) the European Parliament suggest that "a CBAM should cover the power sector and energy-intensive industrial sectors like cement, steel, aluminium, oil refinery, paper, glass, chemicals and fertilisers, which continue to receive substantial free allocations, and still represent 94 per cent of EU industrial emissions".

The existing main EU ETS anti-leakage policy instrument is free ETS quotas allocated proportionally to the enterprises' output, i.e., output-based allocation (OBA). To ensure a level playing field in the EU market between the EU producers and importers, the Commission's suggested CBAM design (European Commission, 2021a) reflects the proposed revisions of the EU ETS, which among other things proposes a reduction in available free quotas in sectors that are suggested to be covered by CBAM from 2026. From 2026, and until free quotas are completely phased out in 2035, the suggested CBAM will only apply to the proportion of emissions that does not benefit from free quotas under the EU ETS. The Commission describes in July 2021 that the CBAM in the introduction period should only include iron and steel, cement, fertilizers, aluminium and electricity production (European Commission, 2021a), and only be applied to direct emissions of GHG caused by combustion of intermediate fossil fuel inputs as well as from process-based emissions of the product in question. The aim is to put in place a reporting system for direct and indirect carbon emissions from 2023, and gradual phasing in the CBAM tariffs from 2026 (European Parliament, 2021). The CBAM will be re-considered during the introduction period, to better understand if it should be extended to apply to more goods and services, and "indirect emissions" arising from the production of electricity; see European Parliament (2021) for further specification of the proposal.[3] The current plan from the EU does not include an export rebate, only carbon tariffs on the imports.

To analyse effects of the CBAM for Norway the project has made use of Statistics Norway's World model, SNOW-Global, which is a global multi-region multi-sector computable general equilibrium (CGE) model with Norway as a separate country, see e.g. Fæhn and Yonezawa (2021) for an application. For the current project, the results mainly emphasise Norway and the EU, with key trading partners. As to sectoral aggregation, all industries that are subject to or affected by the CBAM are explicitly represented. The effects on the Norwegian economy and industries of

[1] EU Fit for 55 strategy (2021): https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661
[2] At the time of writing this report there remain some uncertainty regarding the development of the EU policies against carbon leakage. Specifically, as compared with the EU commission, the European Parliament wants to raise the level of ambition on the coverage of the CBAM, and also a much faster phase-out of the free emission quotas (complete phase-out four years before 2035, as suggested the EU commission and the European Council, see Farstad (2022).
[3] An update of the status of EU's fit for 55 policy following the Commission's suggestions from October 2022 (European Commission, 2022) is found in Farstad (2022).

introducing a CBAM inspired by the Parliaments proposal are compared to a reference simulation of the global economy in 2030. This reference simulation includes existing carbon policies in the EU and Norway and the nationally determined (emission reductions) contributions (so-called NDCs) under the Paris Agreement (2015) for all other countries and regions. The NDCs in each region is met by a regional emission price. The current EU ETS includes large shares of free quotas based on output (OBA) for industries with high risk of relocation, such as cement, steel, aluminium, paper, glass, chemicals, and fertilisers. In the current CBAM proposal the free quotas are intended to be phased out by 2035.

Based on the carbon policies and CBAM design suggested by the EU Commission and the Parliament, we design and analyse three policy scenarios: A TARIFF scenario that introduces CBAM and removes all OBA, the NOLEAK scenario without any explicit anti-leakage policy measures, i.e., without CBAM or OBA, and the HYBRID scenario where the carbon tariff only applies at a rate of 50 per cent while the OBA rate is reduced to 50 per cent of the baseline full rebate. The HYBRID scenario represents the scheduled phase-out of OBA and phase-in of CBAM (European Parliament, 2021). The NOLEAK scenario isolates the effects of only removing OBA, which is a necessary decomposition in order to better grasp the mechanisms in the TARIFF scenario. We compare the policy scenarios to a reference simulation with current policies in the EU and Norway, and NDCs in the rest of the world.

The outline of the report is as follows: Section 2 describes the modelling of CBAM and OBA. Section 3 briefly describes the global database GTAP (Global Trade Analysis Project), the SNOW-Global model, the choice of sector and regional aggregations that are relevant for analysing CBAM, and the reference simulation. Section 4 presents the different policy scenarios and describes results. Section 5 concludes and discusses some possible extensions.

2. Modelling EU's carbon leakage instruments: CBAM and OBA

2.1. Carbon border adjustment mechanisms: CBAM

The aim of the CBAM is to limit carbon leakage by equalizing the cost of carbon emissions between domestic regulated and foreign non-regulated products. The European Parliament (2021) has three key assessment criteria for the sectoral scope of a CBAM: (*i*) relevance in terms of greenhouse gas emissions, both with respect to direct and indirect emissions, (*ii*), exposure to a significant risk of carbon leakage, and (*iii*) practical feasibility aspects.

An import tariff should be based on the relevant carbon price and, ideally, firm- or at least region-specific emission intensities (Böhringer et al., 2017a). The European Commission's (2021b) CBAM proposal states that the carbon price underlying the tariff should be the quota price in the ETS, adjusted for the carbon price that the firms in the exporting region potentially pay, while the emission intensities in the tariff should be based on direct emissions for each importing good. In the case of lack of reliable and updated data on product-specific emission intensities by country, the Commission also suggests that the emission coefficients in the tariff should be based on the 10 per cent dirtiest EU producers (European Commission, 2021b).[4] The CBAM rates that we analyse are based on product specific direct emission intensities in the EU and region-specific carbon prices based on the NDCs (NDC, 2021). The modelled tariff is exogenous for producers outside the EU and Norway, and the higher the tariff, the less will be imported from that region.

Table 2.1 Initial shortlist of products for CBAM

Sector	Materials or material products
Cement	Clinker. Portland cement
Iron and steel	Iron and steel primary forms. Hot rolled and further steps. Coated hot rolled and further steps. Forged, extruded and wire.
Aluminium	Aluminium unwrought. Aluminium unwrought alloyed. Aluminium products. Alloyed aluminium products.
Fertilisers	Ammonia. Urea. Nitric acid. AN (Ammonium Nitrate)
Electricity generation	Electricity

Source: European Commission (2021b)

2.2. Output-based allocation: OBA

It is still somewhat unclear how the CBAM will affect the future of OBA.[5] We observe, however, that in the absence of CBAM, industrial sectors like cement, steel, aluminium, oil refinery, paper, glass, chemicals and fertilisers would likely continue to receive substantial free allocations of emission quotas. Free allocation of quotas focuses on sectors with the highest risk of relocating their production out of the EU. These sectors receive large shares of their emission quotas for free.[6] For less exposed sectors, free allocation is foreseen to be phased out after 2026. The list of sectors deemed to be at the risk of carbon leakage was updated in 2019 and will be valid for the period 2021-2030.[7] Until free allocation of quotas end in 2035, the CBAM will only apply to the proportion of emissions that do not receive free quotas under the EU ETS.

[4] This will abstract from very large differences in emission intensities of sectors across regions (see e.g. Böhringer et al., 2022).
[5] See, e.g., https://www.energymonitor.ai/policy/opinion-eu-parliaments-cbam-spat-could-delay-a-carbon-border-tax-by-years
[6] 100 per cent free quotas for the 10% best performing firms in the sectors, and less for less effective firms (European Commission, 2011).
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D0708&from=EN

3. Data and method: The global SNOW model

3.1. GTAP data

The SNOW-Global model is based on GTAP (Global Trade Analysis Project) data, which describes goods/sectors and associated emissions in detail. GTAP features national economic (input-output) accounts and bilateral trade flows for up to 140 regions (incl. Norway) and 57 goods in its version 9 with the base year 2011 (Aguiar et al., 2016). The database also reports associated energy flows and CO_2-emissions from fossil fuel combustion.[8] The GTAP data can be readily used to quantify the average base year's direct and indirect carbon content in bilateral trade.

3.2. Sector aggregation and sectoral scope of CBAM

The sectoral aggregation is essential for modelling CBAM in a realistic way and to distinguish energy goods by emission intensity and degree of substitutability (Fæhn and Yonezawa, 2021). The level of aggregation is a trade-off between real world realism and practical aspects like data availability, model transparency and computational limitations. In this report we have chosen a sector aggregation that is reasonably detailed regarding the sectors impacted by the CBAM, and a high level of aggregation for more peripheral sectors like agriculture and transport. As pointed out in the Introduction, it is expected that the CBAM will be extended to cover more sectors in the future. In this respect, the Parliament (European Parliament, 2021) states under general remarks 12: "Considers that in order to prevent possible distortions in the internal market and along the value chain, a CBAM should cover all imports of products and commodities covered by the EU ETS, including when embedded in intermediate or final products; stresses that as a starting point (already by 2023) and following an impact assessment, the CBAM should cover the power sector and energy-intensive industrial sectors like cement, steel, aluminium, oil refinery, paper, glass, chemicals and fertilisers, which continue to receive substantial free allocations, and still represent 94 % of EU industrial emissions."

In our analysis design we have therefore chosen to apply the CBAM to all the EU ETS sectors, except for the resource extraction sectors (crude oil, gas and coal), and aviation that are not supposed to be part of CBAM. We analyse this broad version of the CBAM mainly because our focus is the year 2030, when the CBAM may apply to more goods than in 2026. The list of aggregated sectors in SNOW-Global (together with their three-letter acronym) for this project is given in table 3.1. This table also indicates which sectors are part of the EU ETS and the current system of OBA, and whether the relevant sector qualifies as part of the CBAM. Note that aluminium is in the non-ferrous metals category, cement is in non-metallic mineral products, and fertilizers are in chemical products. See table A.1 in appendix A for sector details.

[8] Note that GTAP lacks information on CO_2 process emissions (see also Bednar-Friedl et al., 2012).

Table 3.1 Sectors and regulations

SNOW sector	ETS	OBA	CBAM
Coal (col)	X		
Crude oil (cru)	X		
Natural gas (gas)	X		
Refined petroleum products (oil)	X	X	X
Electricity (ele)	X		X
Non-ferrous metals (nfm)	X	X	X
Iron and steel (i_s)	X	X	X
Non-metallic mineral products (nmm)	X	X	X
Chemical products (crp)	X	X	X
Paper products – publishing (ppp)	X	X	X
Air transport (atp)	X		
Water transport (wtp)			
Other transport (otp)			
Agriculture (agr)			
All other manufacturing (mfr)			
Services (ser)			

Free quotas (OBA) are allocated to industries characterized as emission-intensive and trade-exposed industries in the EU ETS, see table 3.1. Note that the firms receive the free quotas regardless of where the product is sold. Hence, OBA levels the playing field between domestic and foreign firms in both foreign and domestic markets (Böhringer et al., 2017b; Kaushal and Rosendahl, 2020). This contrasts with EU's suggested version of the CBAM, which only levels the playing field in the domestic EU (and Norway) market. Another key difference between the CBAM and the current system with OBA is that electricity generation is included in the suggested CBAM, even if it is not considered as a particularly trade-exposed industry.

We aggregate the non-ETS (NETS) sectors into five main sectors: water transport, other transport, agriculture, all other manufacturing, and all other services (see Fæhn and Yonezawa, 2021). The NETS sectors in the model includes some ETS emissions, but the error from this rough categorization of ETS versus NETS sectors was around 6 per cent of Norwegian CO_2 emissions in 2018.

3.3. Regional aggregation

The regional aggregation follows mainly from Fæhn and Yonezawa (2021), but with some adjustments. Specifically, we let United Kingdom (GBR) be a separate region, removed from the EU that is now EU27. The regional specification used in this report is sufficiently detailed to reflect the main trading partners for Norway and the EU, and is as follows:

- Africa (AFR)
- Australia and New Zealand (ANZ)
- Brazil (BRA)
- Canada (CAN)
- China (CHN),
- Europe (EUR)
- India (IND)
- Japan (JPN)
- South Korea (KOR)
- Middle East (MEA)
- Norway (NOR)

- Other Americas (OAM)
- Other Asia (OAS)
- Russia (RUS)
- United Kingdom (GBR)
- United States (USA)
- ROW 'Rest of the World',

where EUR includes EU27 and EFTA members[9] except for Norway.

3.4. Non-technical SNOW model summary

The SNOW-Global model is a multi-region multi-sector static computable general equilibrium (CGE) model specially developed to quantify the economic impacts of environmental and climate policies.[10] The economy-wide setting accounts for supply and demand reactions of economic agents in a comprehensive manner and are based on empirical data. Particularly important in our context are the price-responsive input-output relationships among firms that transmit cost effects across industries and countries. The multi-sector, multi-region CGE framework enables us to address policy impacts on global emissions and carbon leakage, industry-specific competitiveness and trade patterns, as well as global cost-effectiveness and economic incidence of EU's unilateral emissions regulation. The SNOW-Global model incorporates the economic incentives for representative firms outside the regulated regions (in this case, the EU and Norway) when exporting to the regulated regions. Different versions of the model have been used in climate policy analyses in recent years, including carbon tariffs, see for example Böhringer et al. (2017a) and Fæhn and Yonezawa (2021).

Factor and commodity markets within each region are characterized by perfect competition. Primary factors of production include labour, capital and fossil fuel resources. Labour and capital are intersectorally mobile within a region but immobile between regions. Fossil fuel resources are specific to fossil fuel production sectors in each region.

Production in each industry and each region is represented by a representative firm using an "average" technology. Firms producing commodities other than primary fossil fuels are modelled with three-level constant elasticity of substitution (CES) cost functions describing the price-dependent use of capital, labour, energy and materials (see figures A.4-A.6 in appendix A for details of nesting structures). At the top level, a composite of intermediates trades off with an aggregate of energy, capital and labour. At the second level, a CES function describes the substitution possibilities between intermediate demand for the energy aggregate and a value-added composite of labour and capital. At the third level, the capital and labour composite are substituted with an energy composite of coal, gas, oil, and electricity. In the production of fossil fuels, all inputs except for the sector-specific fossil fuel resource, are aggregated in fixed proportions. This aggregate of non-resource specific input trades off with the sector-specific fossil fuel resource at a constant elasticity of substitution.

Final consumption demand in each region is determined by the representative agent who maximizes welfare subject to a budget constraint with fixed investment (i.e., a given demand for savings) and exogenous government provision of public goods and services. Total income of the representative agent consists of net factor income and tax revenues net of subsidies. Consumption demand of the representative agent is given as a CES composite that combines consumption of

[9] https://www.efta.int/
[10] SNOW-Global is programmed in GAMS/MPSGE (GAMS, 2020; Rutherford, 1999). The MPSGE framework uses CES nesting structures, see Böhringer et al. (2017a), appendix A for an example of an algebraic model summary quite similar as SNOW-Global.

composite energy and an aggregate of other (non-energy) consumption goods. Substitution patterns within the energy bundle as well as within the non-energy composite are reflected by means of CES functions.[11]

Bilateral trade is specified following the Armington's differentiated goods approach, where domestic and foreign goods are distinguished by origin (Armington, 1969). Prices of goods may then develop differently among regions. All goods used on the domestic market in intermediate and final demand correspond to a CES composite that combines the domestically produced good and the imported good from other regions. The base-year trade deficit/surplus is kept constant for each region between the scenarios to ensure that the current account/balance of payment is constant.

CO_2 emissions are linked in fixed proportions to the use of fossil fuels, with CO_2 coefficients differentiated by the specific carbon content of fuels. Restrictions to the use of CO_2 emissions in production and consumption are implemented through a CO_2 tax or as an (equivalent) exogenous emissions constraint. CO_2 emissions abatement takes place by fuel switching (interfuel substitution) or energy savings (either by fuel-non-fuel substitution or by a scale reduction of production and final consumption activities).

3.5. Reference simulation

The effects and costs of climate policies in the years to come depend crucially on the chosen reference, or more precisely, the economic and emission projections. We follow Fæhn and Yonezawa (2021) and model a reference simulation (REF) in 2030 with future GDP growth, energy demand, energy prices and corresponding CO_2 emissions in 2030 from the International Energy Outlook (IEO) 2017 (EIA, 2017). In addition, we include the following climate policies[12] in 2030 in the reference:

A) Existing climate policies in the EU and Norway:
- ETS sectors: i) EU and Norway trade quotas in the ETS, ii) free quotas equal to 100% OBA in 6 ETS sectors, see Table 3.1.
- Non-ETS sectors: EU trade non-ETS emission quotas internally. Norway has a unilateral target with no trade with EU for the non-ETS sectors.

B) The Paris Agreement (2015) of global emission reductions in 2030:
- We implement the updated Nationally Determined Contributions (NDC, 2021) from 2020-2022 for all regions and countries.

With these climate policies, different regional CO_2 prices are realized in 2030. For the EU and Norway three CO_2 prices are calculated: one common price in the ETS sectors covering Norway and the EU, one price in the non-ETS sectors for the EU, and one price in the non-ETS sectors for Norway. For all other regions and countries outside the EU and Norway, the NDCs are reached by assuming domestic (regional) quota markets that give one CO_2 price in each region or country. With these assumptions, the SNOW global model yields a quota price of $138 per ton CO_2 (in 2011$) in the EU ETS. The CO_2 prices in regions outside the EU and Norway range from nearly zero in regions with very low NDCs to EU ETS price levels for regions with strict NDCs.[13] In the policy scenarios (see section 4) these CO_2 prices are taken as given from the reference simulation and the calculated tariff rates on the imported goods to EUR and Norway are the difference between the EU ETS price and these regional CO_2 prices. This implies that in the policy scenarios we switch from quantity-based to

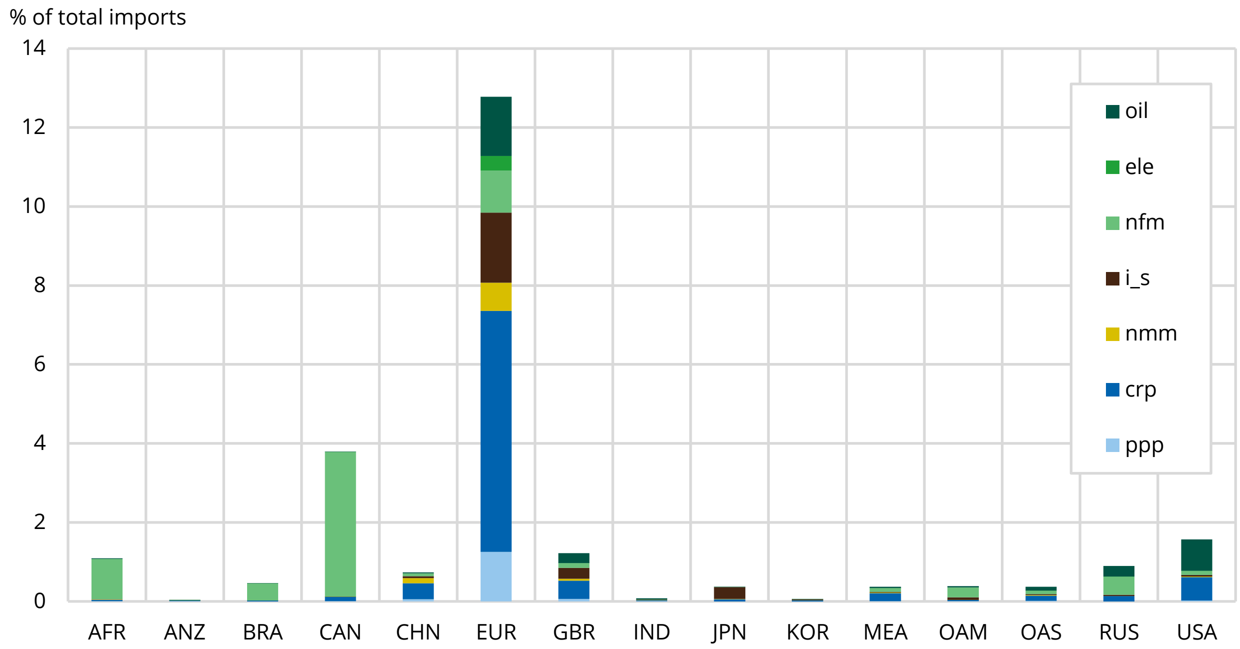
[11] The nested CES structure for consumption is as in figure A.4, but without labour and capital input.
[12] We assume that the income from quota sales in ETS is returned to the representative household in each modelled region. We also disregard the CO_2 compensation scheme for electricity prices in the ETS.
[13] The CO_2 prices range from $6 to $130 per ton CO_2 (in 2011 $).

price-based regulations in all regions outside the EU ETS. The switch from quantity based (CO_2 quota trading) to price based (CO_2 tax) regulation outside the EU ETS endogenizes global emissions, while still retaining the approximate ambitions in the respective regions NDCs.[14] After all, there is no reason for EU anti-leakage policies such as OBA or CBAM if emissions abroad are exogenously given by binding emission caps, because leakage will then not occur.

Bilateral trade and emission intensities in ETS-sectors

Two key determinants for the effects of CBAM policies are trade exposure and emission intensities for EU27 and Norway in the reference simulation.

Figure 3.1 Norwegian (NOR) import shares, CBAM sectors[1], REF, 2030

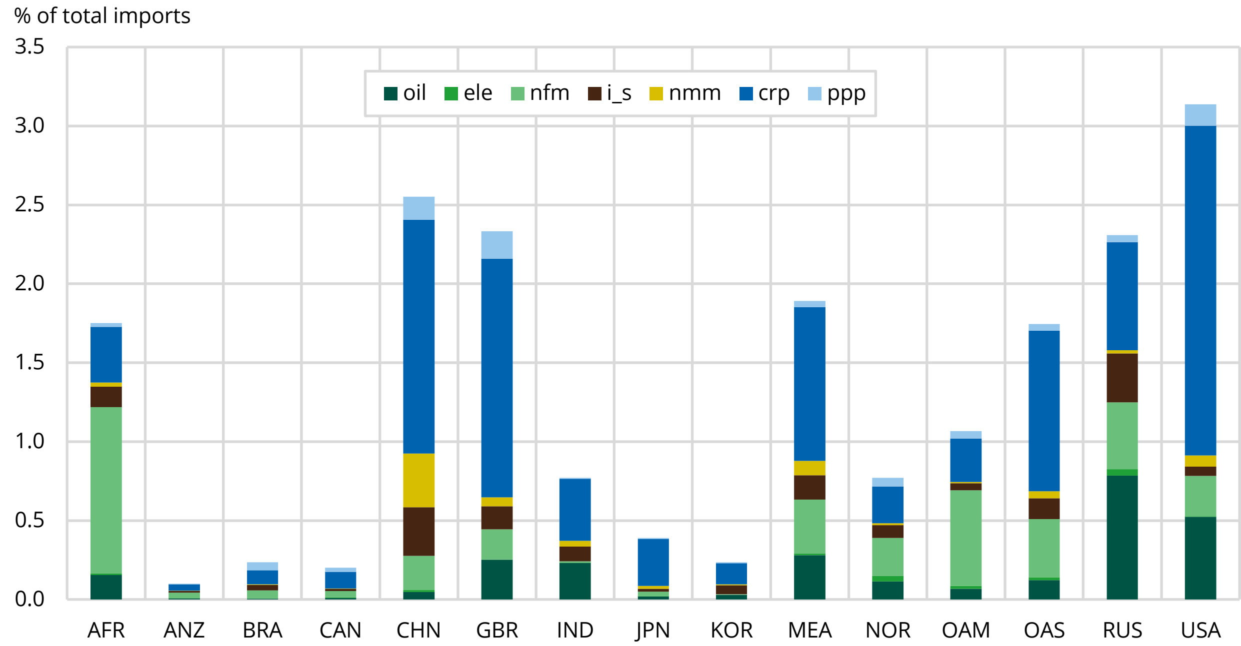


[1] See table 3.1 and section 3.3 for sector and region abbreviations

Figure 3.1 graphs Norwegian (NOR) imports in sectors subject to the CBAM in the reference simulation (see table 3.1 for sector abbreviations). We observe that, except for imports of non-ferrous metals (nfm) from Canada, the lion's share of Norwegian imports in the CBAM sectors is from Europe. Therefore, the CBAM will only directly apply to a limited share of Norwegian imports. There will be indirect effects though, as imports of these goods from outside the EU ETS will face the CBAM tariff, implying a higher price on these goods in the EU after introduction of the CBAM. Further, it is the intention that the CBAM will replace the OBA. OBA makes emission-intensive and trade-exposed goods cheaper and more competitive. This competitive advantage will be reduced with the removal of OBA and introduction of the CBAM. It is noteworthy that CBAM only protects goods sold in the European markets, whereas the OBA protects all production. This may be relevant for EU (and Norwegian) exporters in the CBAM sectors, as replacing OBA with the CBAM implies that they no longer receive any compensation for their cost of EU ETS compliance for exports out of the EU and Norway.

[14] Many countries use CO_2 taxes as climate policy instruments instead of imposing a cap on CO_2 emissions, supporting the assumption of given carbon prices in other regions.

Figure 3.2 Europe (EUR) import shares, CBAM sectors[1], REF, 2030



[1] See table 3.1 and section 3.3 for sector and region abbreviations

Figure 3.2 graphs European (EUR) imports in the CBAM sectors in the reference simulation. The figure may give some indication of what to expect when introducing the CBAM. For example, a substantial amount of chemical products (crp) from China (CHN), United Kingdom (GBR) and the United States (USA) will be subject to the CBAM. When interpreting figure 3.2, it is important to remember that the CBAM rate will differ between the regions exporting to Europe and Norway due to different regional carbon prices in the reference simulation. For example, the CBAM rate applied to goods from United Kingdom is negligible since the CO_2 price there is high, meaning that imports from United Kingdom will not be significantly affected by the CBAM. On the other hand, the CBAM rate applied to goods from regions with low CO_2 prices, e.g., Africa (AFR) and Middle East (MEA) is substantial. There is a tendency for the CBAM rate to be lower on goods imported from developed countries, as these countries tend to have more stringent greenhouse gas emissions regulation and then higher CO_2 prices, as compared to less developed countries.[15]

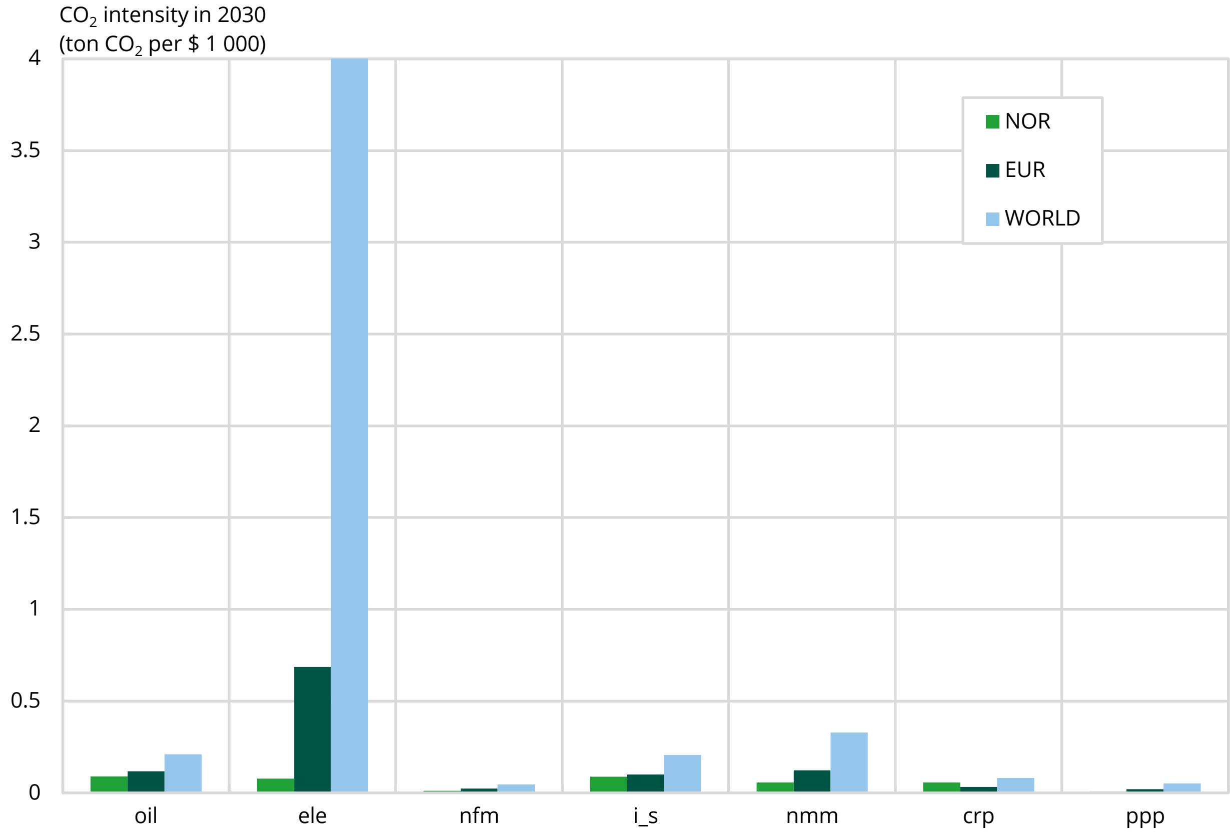
Both Norway and EUR have significant imports of non-ferrous metals and chemical products from regions outside Norway and EUR. Imported and own produced non-ferrous metals and chemical products are also used as intermediates in the sectors producing non-ferrous metals and chemical products; see figure 4.2 and appendix A, figure A.3 for input shares in production of main sectors for Norway and EUR, respectively. With CBAM there will be a tariff on imports of such goods from outside the EUR and Norway. In the production of non-ferrous metals, the input share of non-ferrous metals is larger than 50 per cent, see figures 4.2 and A.3. When the import of non-ferrous metals from regions outside EUR and Norway is substantial, CBAM will give higher input costs both for Norway and EUR.[16]

Norwegian and European export shares are depicted in appendix A, figures A.1 and A.2. Whereas exports are somewhat less relevant for CBAM, they are relevant for understanding the effects of removing OBA.

[15] The calculated CBAM rates (EU ETS price – regional CO_2 price) are in the range of \$6 to \$130 per ton CO_2 (in 2011 \$).
[16] Böhringer et al. (2015) analyse the effects of CBAM when such imported input effects are present for non-ferrous metals for Switzerland and shows that CBAM can have large negative output effects.

Regional and sector specific emission intensities in the reference simulation are given in figure 3.3. They differ substantially between sectors and regions. Norway is at the lower end of the range. Specifically, the emission intensity for electricity is markedly higher outside of Norway and EUR, due to the EU ETS and a high share of fossil fuels input in the production of electricity outside Europe and Norway. Hence, extending the CBAM to include indirect emissions from electricity production may have substantial effects, see e.g. Böhringer et al. (2015) and Böhringer et al. (2017a).

Figure 3.3 CO_2 intensity (metric ton CO_2 per $ 1 000 output) for Norway (NOR), EU (EUR) and Rest of world average (WORLD)[1], REF, 2030



[1] See table 3.1 and section 3.3 for sector and region abbreviations

4. Policy scenarios and results

4.1. Policy scenarios

Limiting carbon leakage is a key motivation for implementing anti-leakage measures such as CBAM and OBA. Importantly, OBA is the current EU anti-leakage policy and, hence, a part of the reference simulation in this report. In the EU suggestion, CBAM is intended to replace OBA, and OBA is therefore scheduled to be gradually phased out over the period 2026-2035 as the CBAM takes its place. One implication of this setup is that the comparison between the REF and CBAM must be done with some care. Specifically, the difference between the REF and CBAM scenarios is not only caused by the implementation of CBAM, but also by the removal of the current OBA policy. To disentangle these effects, we run the following three policy scenarios (in 2030, see table 3.1 for the policies' sector coverage):

- **TARIFF**: A scenario that introduces 100 per cent CBAM and removes all OBA. This is closest to the intended EU proposals of the Parliament and the Commission.
- **NOLEAK**: A scenario without any anti-leakage policy measures such as OBA or CBAM.
- **HYBRID**: A scenario where the carbon tariff only applies at a rate of 50 per cent, while the OBA rate is reduced to 50 per cent of the reference simulation full rebate. For electricity a 100 per cent carbon tariff is introduced since they have no OBA initially.

Table 4.1 Overview: Reference simulation and three policy scenarios.

	REF	NOLEAK	HYBRID	TARIFF
Output-Based Allocation/Free Quotas (OBA)	100%	0%	50%	0%
CBAM	0%	0%	50%	100%

We measure the effects of all policy scenarios as percentage changes from the reference simulation (**REF**) in 2030. The TARIFF scenario allows us to examine the effects of introducing the full CBAM that will replace OBA, while the NOLEAK scenario disentangles the effects of only removing OBA. The isolated effects of CBAM (disregarding OBA) are derived comparing TARIFF and NOLEAK. Finally, the HYBRID scenario may be the best description of the EU anti-leakage policy as expected to be implemented in the simulation year 2030 since it represents the scheduled gradual phase-out of OBA, and phase-in of CBAM.[17]

4.2. Discussion of results

The results of the different policy scenarios for Norway and EUR are given in tables 4.2 to 4.5. Results for activity levels in Norway are discussed in section 4.2.1 below, whereas section 4.2.2 examines effects on the EU ETS and Europe (EUR).

[17] OBA and CBAM will coexist during the transition phase from OBA to CBAM (i.e., the years 2026-2035) as intended by the EU proposal (European Commission, 2021a).

Table 4.2 Activity (output) and CO_2 emissions in CBAM sectors in Norway, per cent change from REF, 2030.

	TARIFF		NOLEAK		HYBRID	
	Activity	CO_2	Activity	CO_2	Activity	CO_2
CBAM sectors	-0.7	-1.0	-1.0	-1.2	-0.4	-0.6
Refined petroleum products (oil)	-0.7	-1.3	-1.2	-1.6	-0.3	-0.7
Electricity (ele)	0.5	0.9	-0.2	0.6	0.6	0.6
Non-ferrous metals (nfm)	-0.7	-0.9	-0.3	-0.2	-0.4	-0.6
Iron and steel (i_s)	-1.2	-0.8	-2.4	-1.6	-0.6	-0.5
Non-metallic minerals (nmm)	0.4	0.3	-0.1	0.2	0.2	0.1
Chemical products (incl. fertilizers) (crp)	-2.0	-2.3	-2.2	-2.3	-1.0	-1.3
Paper products – publishing (ppp)	0.0	-0.5	0.0	-0.2	0.0	-0.3

Table 4.3 Activity (output) and CO_2 emissions in CBAM sectors in EUR, per cent change from REF, 2030.

	TARIFF		NOLEAK		HYBRID	
	Activity	CO_2	Activity	CO_2	Activity	CO_2
CBAM sectors	-0.5	0.3	-0.9	0.1	-0.3	0.1
Refined petroleum products (oil)	-1.4	-1.9	-2.1	-2.5	-0.7	-1.0
Electricity (ele)	0.3	1.0	-0.2	1.1	0.4	0.6
Non-ferrous metals (nfm)	-1.4	-1.4	-1.1	-0.9	-0.8	-0.9
Iron and steel (i_s)	-0.9	-0.9	-1.9	-1.7	-0.5	-0.5
Non-metallic minerals (nmm)	-0.0	-0.2	-0.8	-0.6	-0.0	-0.2
Chemical products (incl. fertilizers) (crp)	-0.5	-0.7	-0.9	-0.8	-0.3	-0.4
Paper products – publishing (ppp)	-0.2	-0.3	-0.2	0.1	-0.1	-0.2

Table 4.4 Macroeconomic effects for Norway and EUR, per cent change from REF, 2030.

	TARIFF	NOLEAK	HYBRID
NOR			
GDP	0.03	0.04	0.01
Private consumption	0.04	-0.02	0.02
Price of capital	-0.1	-0.1	0
Price of labour	-0.1	-0.1	-0.1
EUR			
GDP	-0.03	-0.05	-0.01
Private consumption	-0.01	-0.05	0
Price of capital	-0.2	-0.1	-0.1
Price of labour	-0.2	-0.1	-0.1

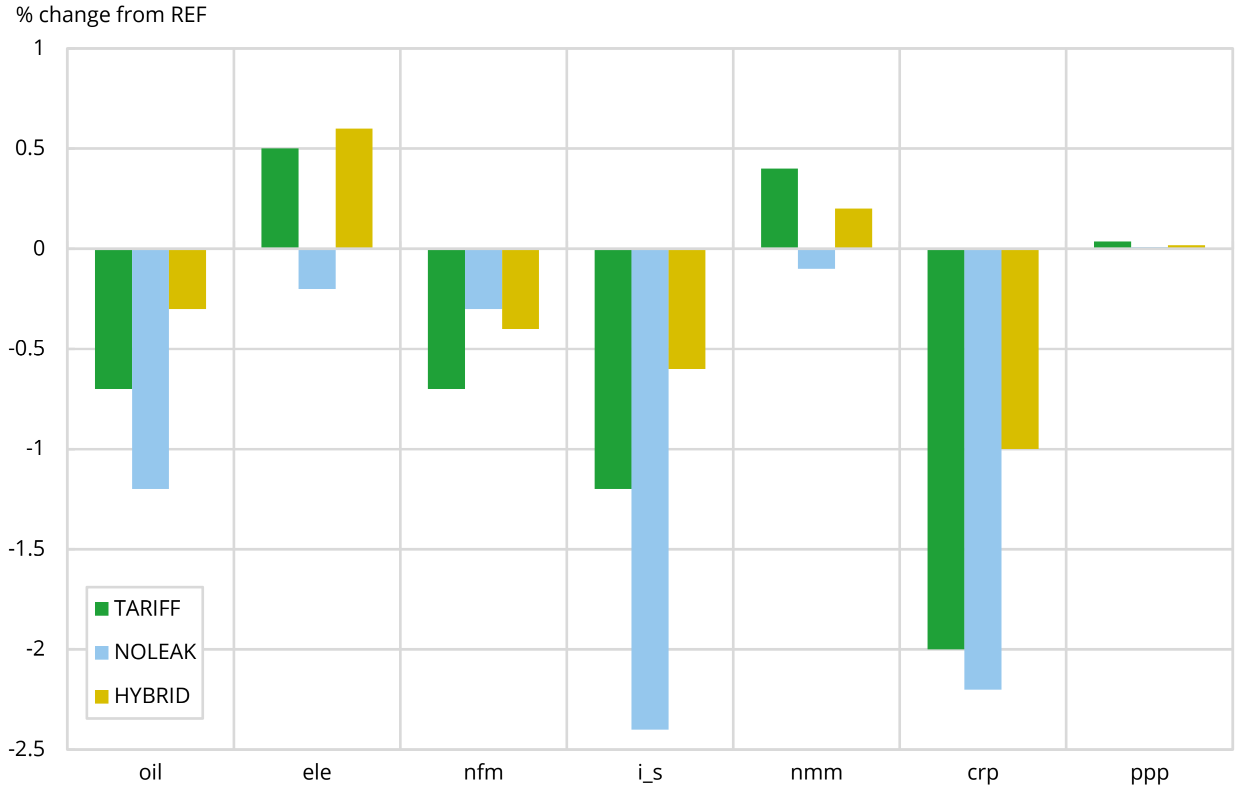
Table 4.5 ETS price ($) and global emission effects, per cent change from REF, 2030.

	REF	TARIFF	NOLEAK	HYBRID
EU ETS price	$138	$137	$135	$138
Global CO_2 emissions excl. EUR and NOR		-0.06	0.02	-0.05

4.2.1 Effects for Norway

The effects on output for the Norwegian CBAM sectors are given in figure 4.1.

Figure 4.1 Activity (output) in CBAM sectors in Norway[1], per cent change from REF, 2030



[1] See table 3.1 for sector abbreviations

As previously mentioned, the TARIFF scenario features two simultaneous policy shifts relative to the REF simulation: (*i*) removal of OBA and (*ii*) implementation of the CBAM. We begin with the isolated effects of removing the OBA, as captured by the NOLEAK scenario.

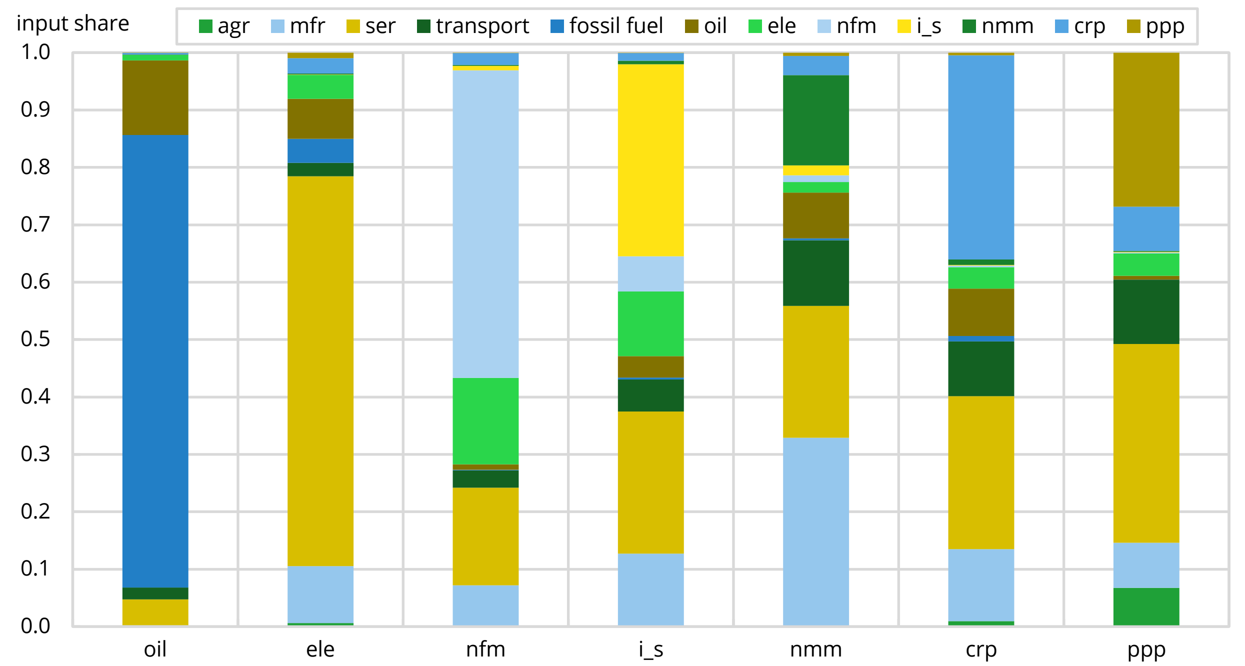
For Norway, activity in all CBAM sectors is lower in the **NOLEAK scenario**, as compared with the reference simulation (REF), see table 4.2 and figure 4.1. This is not surprising, given that OBA constitutes an implicit subsidy to production. There are two main reasons why the effects differ between the six OBA sectors (see table 3.1): First, the sectoral impact of removing OBA in general increases in the sectors' initial emission intensity. The reason is that the OBA rate is proportional to the sectors emission intensity (see figure 3.3). That is, the larger the amount of free emission quotas received per dollar of output produced, the larger is the negative impact on output of removing OBA. Second, the sectoral effects depend on how the price of input factors used in production is affected by the removal of OBA. When OBA is removed, the producer faces the cost of all emission quotas. This shifts the supply curve upwards and increases the equilibrium product prices on OBA goods, including intermediates used in production, as compared to the reference simulation. Hence, sectors which use OBA goods extensively as intermediates tend to reduce production more when the OBA is removed.

Specifically, output is 2.4 per cent lower for iron and steel and 2.2 per cent lower for chemical products in the NOLEAK scenario in Norway. These are both sectors that are emission intensive, and hence receive relatively high OBA rates. They also have large shares of intermediate input from other CBAM sectors, including self-demand, that experience higher costs and product prices when OBA is removed. Figure 4.2 illustrates the input shares of the different intermediates in production in the CBAM sectors.

We also observe that the demand for labour and capital falls due to lower activity in the OBA sectors when OBA is removed. Hence, the wage rate and the rental rate of capital is lower in NOLEAK as compared with the reference simulation (see table 4.4). The isolated effect of this is reduced production costs in all sectors, and lower equilibrium prices on non-OBA goods as electricity and all production that are not part of the EU ETS, in NOLEAK as compared to the reference simulation.

Non-metallic minerals have a large share of intermediate input from non-ETS sectors, such as public transport and other services. Output of non-metallic minerals is therefore only 0.1 per cent lower in Norway in NOLEAK as compared with REF. Last, the OBA sectors are electricity-intensive and the demand for, and output of, electricity is lower in the NOLEAK scenario. Aggregate CBAM sector output is 1 per cent lower with no anti-leakage policies.

Figure 4.2 Shares of intermediate input, CBAM sectors[1], Norway, REF[1], 2030



[1] See table 3.1 for sector abbreviations

In the **TARIFF scenario**, CBAM replaces OBA as the policy instrument for ameliorating carbon leakage. The CBAM helps counteracting the negative effects on activity levels in the sectors receiving OBA in the reference simulation following the removal of the free emission quotas. The reason is that imports of goods subject to CBAM face carbon tariffs, which makes foreign goods less competitive in the domestic market. This helps levelling the playing field between foreign and domestic goods (subject to emission regulation) in the EU domestic market for the relevant ETS sectors, which is the key motivation for introducing the CBAM. Except for electricity, non-metallic mineral products and paper and pulp, we see in figure 4.1 and table 4.2 that the activity levels in the OBA sectors remains below those of the reference simulation also in the TARIFF scenario, with refined oil products and non-ferrous metals 0.7 per cent lower, iron and steel 1.2 per cent lower and chemical products 2.0 per cent lower. The reason is that the negative impact on output following the removal of OBA dominates the positive effect on output caused by the implementation of CBAM for these sectors.

Another effect of CBAM is to increase the price on those intermediates used in production that are covered by the CBAM.[18] The reason is simply that the price on these goods increase when imports of them are subjected to the CBAM. This mechanism applies whether the goods are imported or produced domestically (the equilibrium price increases).

In Norway, non-ferrous metals have a high share of input of non-ferrous metals in intermediates, see figure 4.2. The import shares of non-ferrous metals are also significant, both from Europe (EUR) and regions outside EUR (see figures 3.1 and 3.2). The costs of these input factors increase with the introduction of CBAM. Although domestic sales and Norwegian exports of non-ferrous metals to EUR receive higher prices after introduction of the CBAM, the total effect of the CBAM is a negative impact on Norwegian non-ferrous metal activity levels, see figure 4.1. One reason for this, besides the cost increase caused by higher price on CBAM intermediates, is that a substantial share of Norwegian non-ferrous metal production is exported outside of EUR and Norway (cf., figure A.1 in appendix A). This export does not benefit from the introduction of CBAM.

Reduced activity lowers demand for labour and capital, and both the wage rate and rate of capital return is 0.1per cent lower in TARIFF as compared with REF, see table 4.4. Costs are therefore lowered for sectors that have no anti-leakage policy initially, and the output effect is positive for electricity and non-metallic minerals (where the OBA effect is but minor), see figure 4.1 and table 4.2. All in all, the aggregated output effect for the Norwegian CBAM sectors is 0.7 per cent lower with the TARIFF scenario, but the output effect differs substantially between the sectors.

The costs for the non-ETS sectors are also reduced following lower wage rate and return on capital, but the overall output effects on non-ETS sectors are negligible. The effects on GDP and private consumption are also very small, see table 4.4. However, more ETS emissions are abated in Norway following lower activity in the emission-intensive part of the CBAM sectors.

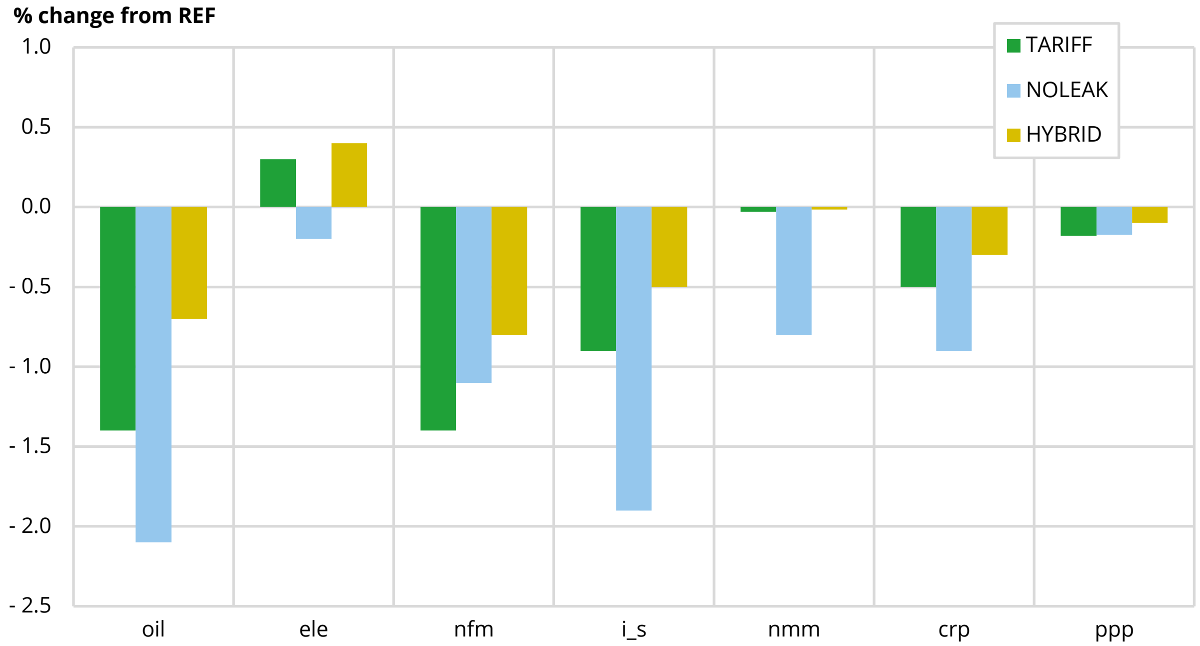
In the **HYBRID scenario** the effects on the CBAM sectors lie in between the reference simulation and the TARIFF scenario for the sectors that have 100 per cent OBA in REF. Electricity has full CBAM and no OBA in the HYBRID scenario since they have no OBA initially, and the positive output effect is slightly larger than in the TARIFF scenario. Combined with smaller reductions in output in the sectors receiving OBA, aggregate output in the Norwegian CBAM sectors falls by only 0.4 per cent. Higher activity in the electricity intensive CBAM sectors has a positive effect on the demand and supply of electricity, compared to the TARIFF scenario, see table 4.2.

4.2.2 Effects in EUR and EU ETS

Whereas total EU ETS emissions remain constant, there is a slight fall in Norwegian ETS emissions, and a corresponding increase in EUR's ETS emissions. In the **NOLEAK** scenario, removing OBA has negative output effects on all seven CBAM sectors for EUR, especially for iron and steel and chemical products, as is also the case for Norway. In EUR, the largest negative impact on output is for refined petroleum products, see figure 4.3 and table 4.3. Total output in the CBAM sectors is 0.9 per cent lower in EUR and output is reallocated between CBAM sectors to less emission intensive activities, such as electricity and paper and pulp in EUR as in Norway, given the EU ETS emission cap. For more emission intensive sectors, such as iron and steel, chemical products and refined oil products, production is reallocated to regions outside of EUR and Norway and global emissions slightly increase (0.02 per cent) in the NOLEAK scenario. The ETS price falls from $138 to $135 since emission intensive production is moved outside the EU ETS. However, the GDP effect is negligible in EUR as in Norway in the NOLEAK scenario.[19]

[18] Note that the sectors in SNOW Global are aggregates of several GTAP goods, domestic produced and imported, see table A.1 in appendix A.
[19] More details on import and export effects are given in tables A.2, A.3 in Appendix A.

Figure 4.3 Activity (output) in CBAM sectors in EUR[1], percentage change from REF, 2030



[1] See table 3.1 for sector abbreviations

When introducing the **TARIFF scenario** and CBAM replaces OBA as the anti-leakage policy instrument, the CBAM contributes to counteract the negative effects of removing OBA. However, as for Norway the CBAM is not sufficient to outweigh the negative output effects of removing OBA and all EUR sectors with OBA in the reference simulation reduce their output, see figure 4.3 and table 4.3. Non-ferrous metals and refined petroleum products have the largest output reduction (-1.4 per cent). As for Norway, removal of the OBA increases production costs in these industries and output is reduced. Introduction of the CBAM tariff reallocates demand to Norwegian and EUR products, but this is not large enough to outweigh the negative supply effects of removing OBA. Reduced activity lowers demand for labour and capital, and the wage rate and rate of capital return therefore both fall with 0.2 per cent, twice the fall in Norway, see table 4.4. Total output for the CBAM sectors is 0.5 per cent lower than in REF and the electricity sector is the only CBAM sector with higher activity (0.3 per cent), modifying the negative output effects in the other CBAM sectors. Even with a larger fall in the wage rate and rate of return on capital, the effects on the NETS sectors are negligible (zero), as for Norway.

Global CO_2 emissions (excl. EUR and Norway) is 0.06 per cent lower with the TARIFF scenario (see Table 4.5). This is approximately 0.8 per cent of the total CO_2 emissions in Norway and EUR. Hence, introducing CBAM in EUR and NORWAY while all other regions keep their CO_2 price fixed, will slightly reduce global emissions. Import of all goods that are subject to CBAM falls in Norway and EUR and the output of CBAM sectors in Norway and EUR are also lower. Total activity measured by GDP in both Norway and EUR are almost unchanged, see table 4.4. Some global production activities are moved from more carbon-intensive regions outside EUR and Norway to less carbon-intensive regions as the EUR. The ETS price is $137, slightly lower than in REF.

In the **HYBRID scenario** the effects on the CBAM sectors lie in between the reference solution and the TARIFF scenario for the sectors that have 100 per cent OBA in REF. We see that the same effects on the activity levels are present in EUR as in Norway when comparing the HYBRID with TARIFF. Total output in the CBAM sectors in EUR is 0.3 per cent lower than in REF, see table 4.3.

4.3. Sensitivity

The trade modelling in SNOW-Global assumes that products traded internationally are differentiated by the region of origin and the end users have preferences for a given bundle of these products (Armington, 1969). The trade (Armington) elasticity represents the elasticity of substitution between products produced in different regions. A higher trade elasticity implies that the goods are more substitutable and become more exposed to trade. The potential for carbon leakage increases. Obviously, the trade elasticities are key determinants for the effects of CBAM. We have performed a sensitivity of the trade elasticities for the ETS sectors in Norway. In this sensitivity we double the trade elasticities for the ETS sectors in Norway. As expected, the effects of the different leakage policies are strengthened with increased preferences for trade, but the effects are small.

5. Concluding remarks

This project deals with the EU’s recent proposal of carbon tariffs (CBAM - Carbon Border Adjustment Mechanisms) and potential direct and indirect effects for the Norwegian economy and affected industries. The purpose of CBAM is to counteract potential carbon leakage from the EU ETS sectors following the tightening of the emission cap in EU ETS and the planned phase out of free output-based emission quotas (OBA). We analyse the effects of introducing a CBAM proposal based on the European Commission’s preliminary suggestions, by using the global CGE model (SNOW-Global) where Norway is a region. We find that the effects of introducing CBAM as in the TARIFF scenario are positive for sectors that are part of the EU Emission trading system (ETS) that do not receive free quotas initially as electricity, while sectors initially receiving free emission quotas as non-ferrous metals, iron and steel, chemical products and refined oil products experience a negative output effect when their free quotas is substituted by CBAM on direct emissions. The effects are quite similar for both Norway and the European region. Some ETS output and emissions are reallocated from Norway to Europe. Global production activities are moved from more carbon-intensive regions outside Europe to less carbon-intensive regions as Europe and global emissions are reduced, but the effect is small. Hence, introducing CBAM on direct emissions is mainly a policy to level the playing field for trade exposed industries, with minor effects on global emissions.

EU suggests including indirect emissions in the CBAM in the future. For many goods, electricity is an important input into production, accounting for a significant share of the total carbon footprint of producing these goods. There are huge differences in emission intensities in the electricity sector between the regions with Norway as the lowest with nearly 100 per cent renewable production, compared to EU and in particular the rest of the world where fossil fuels as coal and gas are still significant inputs in the electricity sector. Analyses in the literature of different carbon tariff designs confirm that the most efficient in reducing carbon leakage and economic costs for the strictest regulated region is to include indirect emissions (Böhringer et al., 2015; Böhringer et al., 2017a).

In contrast to free emission quotas, a carbon tariff only protects goods sold in the domestic (EU and Norway) markets. EU also discusses export rebates for domestic producers that export their products to non-regulated or less regulated regions outside the EU and Norway. This rebate is intended to compensate the domestic producer for the costs of carbon emissions that foreign producers do not pay and, thus, competitive neutrality in the foreign market will be maintained. The current plan from the EU does not include an export rebate, but only carbon tariffs on the imports. Export rebates could potentially conflict with the WTO agreement. Both the effects of including indirect emissions in the CBAM and an export rebate can be analyzed in a modified version of the SNOW-Global model used for the analyses in this report.

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Appendix A: Figures

Figure A.1 Norwegian (NOR) export shares, CBAM sectors, REF, 2030

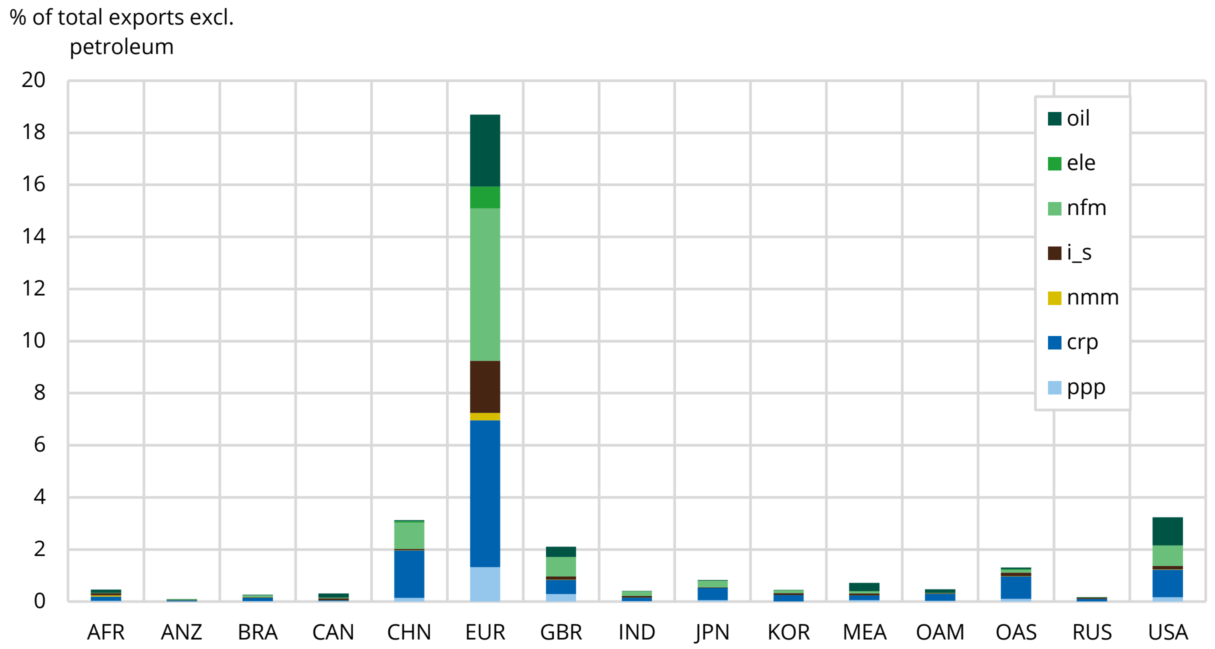


Figure A.2 Europe (EUR) export shares, CBAM sectors, REF, 2030

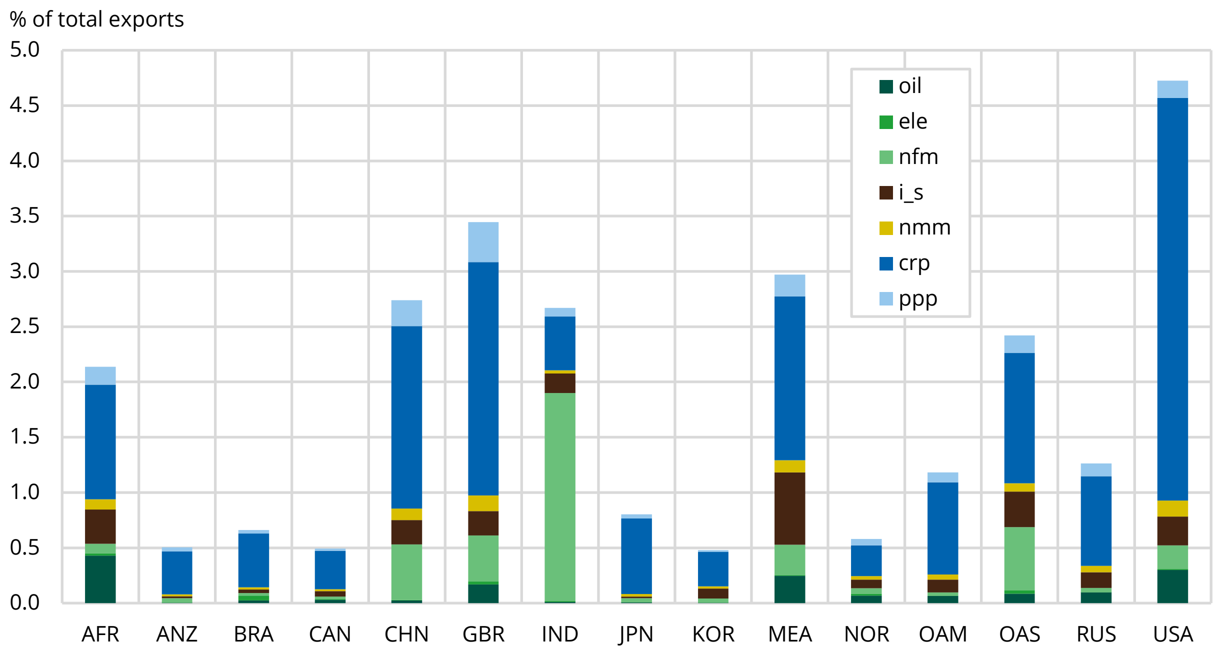


Figure A.3 Shares of intermediate input, CBAM sectors, EUR, REF, 2030

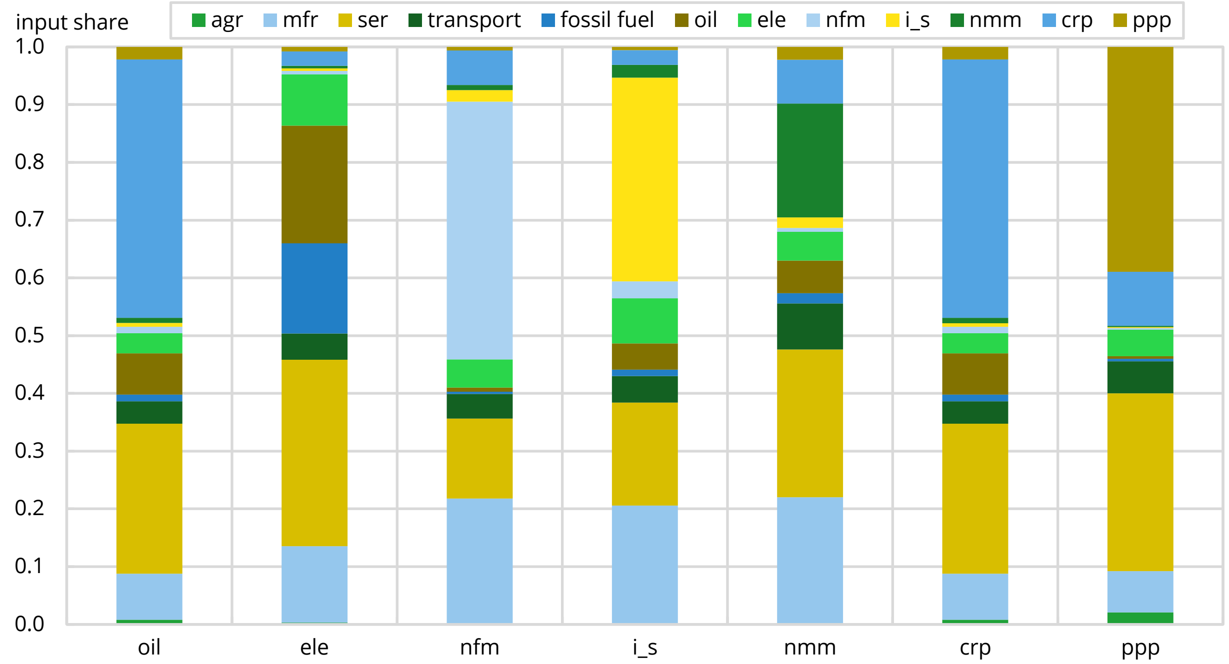


Table A.1 CBAM sectors and GTAP goods

Code	Description
oil	Petroleum & Coke: coke oven products, refined petroleum products, processing of nuclear fuel
ele	Electricity: production, collection and distribution
nfm	Non-Ferrous Metals: production and casting of copper, aluminium, zinc, lead, gold, silver
i_s	Ferrous metals: Iron & Steel: basic production and casting
nmm	Non-Metallic Minerals: cement, plaster, lime gravel, concrete
crp	Chemical Rubber Products: basic chemicals, other chemical products, rubber and plastic products
ppp	Paper & Paper Products; includes printing and reproduction of recorded media

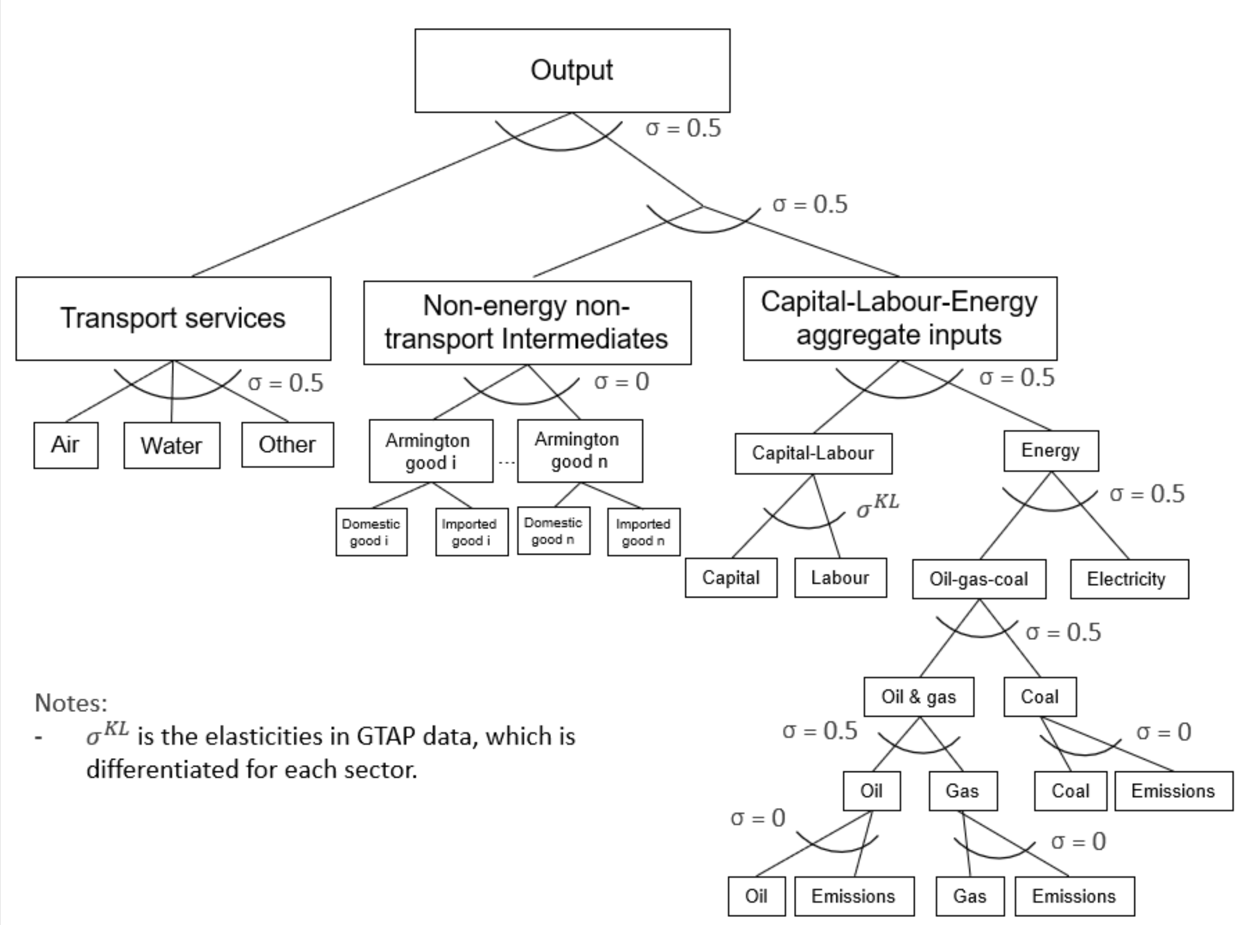
Table A.2 Import and export for main CBAM sectors in Norway, per cent change from REF, 2030

	TARIFF		NOLEAK		HYBRID	
	Import	Export	Import	Export	Import	Export
Refined petroleum products (oil)	-1.5	-0.9	-0.3	-1.4	-0.8	-0.5
Electricity (ele)	-5.8	2.8	-0.4	-0.1	-5.6	2.8
Non-ferrous metals (nfm)	-0.5	-0.7	-0.3	-0.3	-0.3	-0.4
Iron and steel (i_s)	-0.2	-1.3	-0.1	-2.7	-0.1	-0.6
Non-metallic minerals (nmm)	-2.2	1.5	-0.4	0.1	-1.1	0.8
Chemical products (incl. fertilizers) (crp)	0.0	-2.5	0.2	-2.7	0.0	-1.3
Paper products – publishing (ppp)	-0.5	0.2	-0.3	0.2	-0.2	0.1

Table A.3 Import and export for main CBAM sectors in the EU, per cent change from REF, 2030

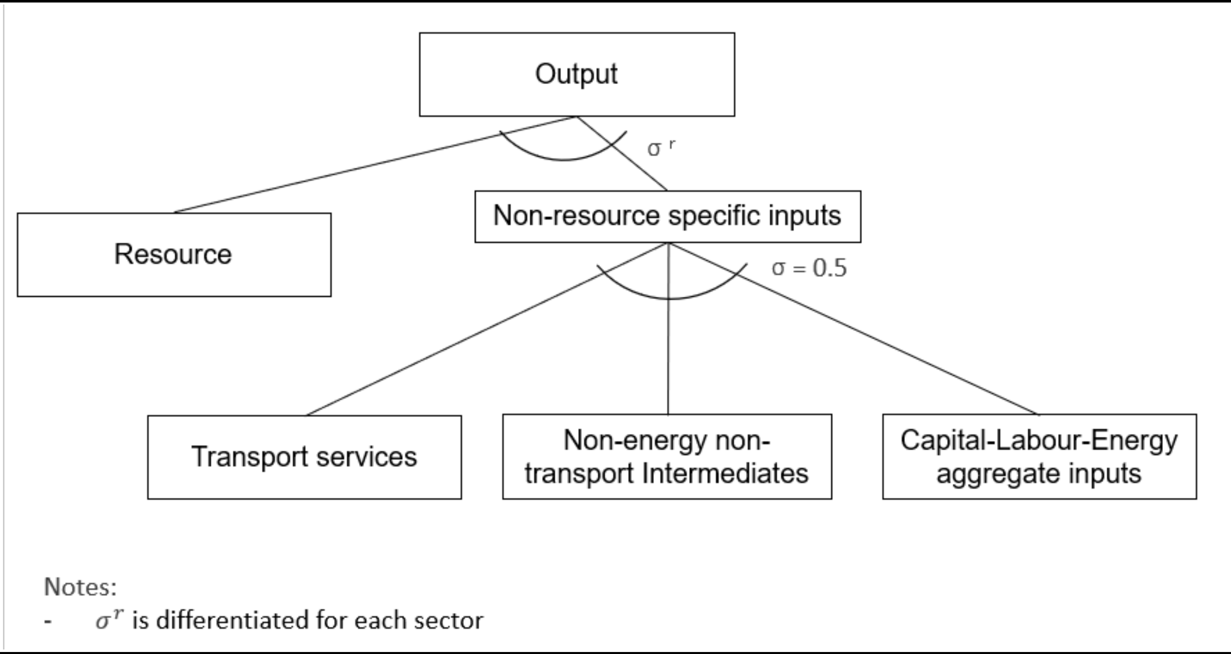
	TARIFF		NOLEAK		HYBRID	
	Import	Export	Import	Export	Import	Export
Refined petroleum products (oil)	-0.3	-2.7	1.2	-3.6	-0.1	-1.4
Electricity (ele)	-6.6	2.4	-0.3	-0.1	-6.5	2.5
Non-ferrous metals (nfm)	-0.5	-1.5	-0.3	-1.1	-0.3	-0.8
Iron and steel (i_s)	-0.6	-1.4	0.3	-2.5	-0.3	-0.7
Non-metallic minerals (nmm)	-1.5	-0.3	0.9	-1.6	-0.8	-0.2
Chemical products (incl. fertilizers) (crp)	-0.4	-0.7	-0.2	-1.0	-0.2	-0.4
Paper products – publishing (ppp)	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1

Figure A.4 Nesting in Non-Fossil-Fuel Production



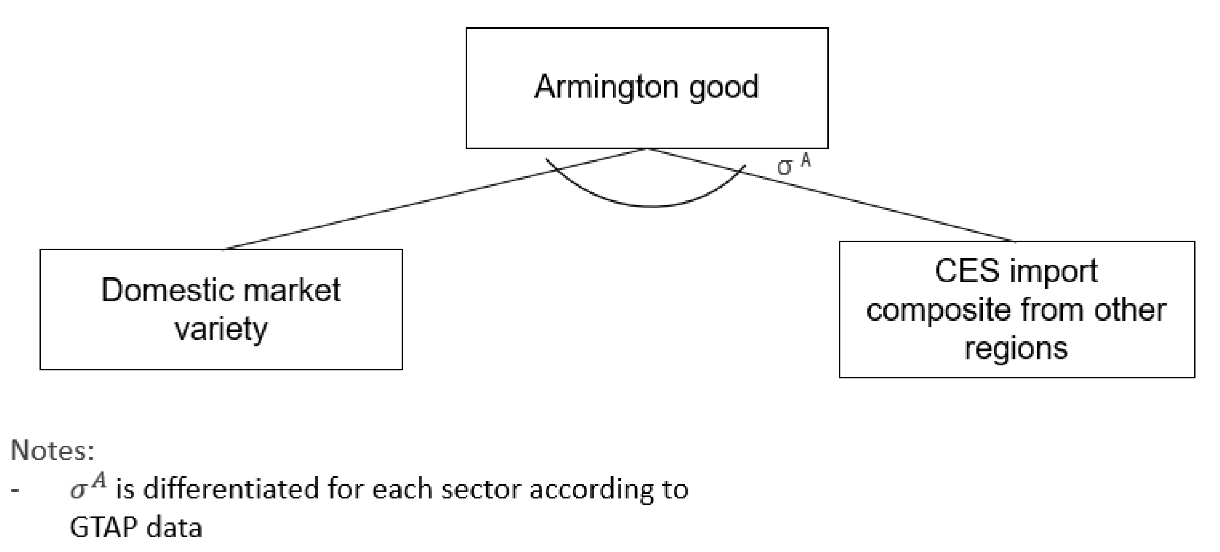
Note: CES=constant elasticity of substitution.

Figure A.5 Nesting in Resource specific Production



Note: CES=constant elasticity of substitution.

Figure A.6 Nesting in Armington production



Note: CES=constant elasticity of substitution.

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