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The Effects of CBAM on Russian Exports

By

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In 2021, the EU announced the introduction of a carbon border adjustment mechanism (CBAM) to address the carbon leakage problem, which hampers its efforts to mitigate climate change. One of the CBAM requirements is that if an export party can provide that it paid for used carbon domestically, the corresponding amount will be deducted from the EU importers. After the announcement, Russia, one of the major EU trading partners, announced the development of domestic carbon taxation. In this paper, I analyse three scenarios of possible developments for Russia after CBAM implementation. Scenario 1 considers the maximum effect of CBAM on Russian exports. Scenario 2 assumes the impact of the Russian domestic carbon tax on CBAM carbon certificates. The last scenario assumes that China would introduce a mechanism, like CBAM, domestically to protect its producers from the competition, given that Russia could divert its exports destined for the EU to China. The findings of this paper are in line with the expectations. Scenario 1 shows the most impact on Russian exports. Analysing scenario 2, I find that the sole carbon tax benefits only the Russian government, not considering social implications. However, the combination of a carbon tax with the decarbonisation of production facilities aids in the competitive advantage of Russian producers on the global market. Finally, the analysis of the third scenario leads to speculation stating that China might consider implementing CBAM to protect its producers from competition. The reason is that goods from Russia are cheaper while more carbon-intensive. In contrast, goods made in China are subject to a domestic carbon tax, which further increases the price of goods and hampers the competitiveness of Chinese manufacturers.

Key words: Carbon Border Adjustment Mechanism, EU ETS, carbon leakage, Russia

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List of Abbreviations

BCA - Border Carbon Adjustment

BCG – Boston Consulting Group

BPD - Barrels per day

CBAM – Carbon Border Adjustment Mechanism

CDM- clean development mechanism

CER - certified emission reduction

CHRTD - Chatham House Resource Trade Database

EPS - Electrical power stations

ERU - emission reduction units

ETS – Emission Trading System

EU – European Union

GHG – Greenhouse Gases

HSC - Harmonised System Classification

IEA - International Energy Agency

IFS - International Fertilisers Society

JI - joint implementation mechanism

MGSSI - Mitsui & Co. Global Strategic Studies Institute

MMK - Magnitogorsk Iron and Steel Works (Translated from Russian)

NLMK - Novolipetsk Steel Works (Translated from Russian)

UNFCCC - United Nations Framework Convention on Climate Change

UNGA - United Nations General Assembly

WEF – World Economic Forum

WTO - World Trade Organisation

1 - Introduction

1.1 – Carbon Border Adjustment

In December 2019, the EU Commission first announced its intention to introduce and, in July 2021, passed a proposal for the new Carbon Border Adjustment Mechanism (CBAM) (The Economist, 2021). Moreover, in March 2022, the EU Council agreed on a general approach regarding CBAM regulation (EU Council, 2022). CBAM is expected to mitigate the climate change problem and aid the EU in its efforts to reduce greenhouse gases (GHG) or CO2 emissions within the EU by at least 55% compared to 1990 by 2030 – the EU's 'Fit for 55' package. In full compliance with international trading rules, the CBAM's objective is to target carbon-intensive imports and prevent offsetting GHG reduction by taxing goods imported from countries with less strict environmental policies. CBAM will cover the most carbon-intensive industries, such as aluminium, iron and steel, fertilisers, cement, and electrical energy, including more sectors over time (EU Commission, 2021). The primary goal of CBAM is to address the problems that impede the functionality of other climate change mitigation mechanisms and systems by imposing additional import tax on imports from non-EU countries. This measure aims to level up the competitiveness of the EU producers and address the carbon leakage problem, which results from either production offshoring or different climate policies between trading partners. While weak carbon leakage implies a difference in carbon emissions across the countries, strong carbon leakage is caused due to differences in climate policies. (Nielsen et al., 2020). For the EU, carbon leakage, or, in other words, carbon outsourcing, is the result of loopholes in the functionality of the first EUs mechanism – the Emission Trading System (EU ETS). While the EU ETS targets EU firms, obligating them to reduce carbon emissions within the EU, the firms, in turn, offset their production to countries with less ambitious climate policies, causing carbon leakage. Therefore, the full potential of EU ETS functionality is hard to achieve due to the resulting carbon leakage problem, requiring the implementation of other climate mitigation mechanisms to aid the EU ETS.

However, the scope of CBAM is not limited to the carbon leakage issue. Like the EU ETS, the effect of CBAM aims to reduce global emissions not only within the EU but globally. "The European Commission's proposal for a Carbon Border Adjustment Mechanism (CBAM) puts forward a policy measure to prevent carbon leakage from domestic energy-intensive and trade-exposed industries by levelling production costs of European and international markets" (Bravo Gallegos et al., 2020, pp1). One of the main objectives of the CBAM is to incentive other countries and non-EU trading partners to green their production by either implementing similar to the EU ETS cap-and-trade systems or decarbonising their production facilities domestically. While the latter is the primary goal of CBAM, the former is the second main strength of the CBAM. According to the CBAM proposal (EU Commission, 2021), the EU importers will have to purchase carbon certificates, reflecting the EU ETS price per tonne of CO2 emissions emitted during the production of goods from the sector covered under the CBAM regulation.

Moreover, if an exporting party fails to register emissions embodied in the exporting good accurately, the EU importers would have to purchase the certificates at the default value. The importers would have to purchase maximum value carbon certificates for emissions embodied in the imported good as if the good were produced in the EU. However, if an exporting party can provide that it already paid for emissions emitted during the production (direct emissions), the relative amount paid for emissions would be refunded to the EU importers. The example is provided in the Literature Review section. This feature is of particular interest for this paper as it will analyse multiple development scenarios of CBAM for a specific EU trading partner – the Russian Federation[1] (Russia).

This research aims to address two questions regarding the implementation of CBAM. **This paper's first question will analyse the implications of the CBAM for the Russian Federation and how it will affect its exports and competitiveness with EU producers. The second question researched is how the mechanisms, like CBAM, incentivises other parties or countries to accelerate their actions in developing climate mitigating mechanisms or systems.**

1.2 – The case of Russia

The choice of Russia for this research is not arbitrary for several reasons. First, in June 2021, the Russian government passed a law, which came into effect on December 2021 - *07/02/2021, No. 296-FZ "On limiting greenhouse gas emissions" (Official portal of legal information (Translated from Russian), 2021).* The law obligates Russian manufacturing and any entrepreneurial activities associated with the release of greenhouse gas emissions to file reports, requiring them to register the number of emissions discharged during the production. Shortly after this, the Russian government announced the development of a domestic carbon tax mechanism (NASDAQ, 2021; Vedomosti, 2021). On the one hand, developing such a mechanism is expected to increase production costs for Russian producers. However, on the other hand, the corresponding costs would be deducted from the price of carbon certificates. According to CBAM proposal (EU Commission, 2021), as a result, the Russian government would collect a carbon tax instead of having EU importers purchase the full cost of the certificates at EU customs. Third, shortly after the announcement of the CBAM proposal, the Russian government passed a draft proposal for a trial, - "*On conducting a trial to establish special regulations of emissions and removals of greenhouse gases in the Sakhalin Region (Translated from Russian)*". The trial commenced on 1 January 2022. Such active interest from the Russian government in developing the legislation and the prosecution aimed to reduce emissions in overall emissions from the production of export materials leads to a conclusion that the Russian government is concerned about implementing CBAM by the EU.

Finally, according to European Commission (2022), after joining WTO in 2012, in 2020, Russia became the first exporter to the EU, accounting for 37.3% of the country's total trade in goods. In addition, MGSSI (2021) states that exports from sectors covered by CBAM from

[1] The first part of this research considers Russia as the EU's trading partner before the war with Ukraine

Russia account for 6.4% of total imports to the EU. Moreover, independent consultancy companies, such as BSC (2020) and VYGON Consulting (Golyashev et al., 2021) provided multiple analyses accounting for the effects of carbon border adjustment on the exports from Russia to the EU. Though their study demonstrates different implications for Russia, the analyses entail several flaws. One such flaw is that they account for outdated prices per tonne of CO2 under EU ETS. In 2022, the price for a tonne of CO2 has doubled from 2020. In addition, they account for exports from sectors not included in the CBAM proposal, implying much more significant consequences for Russian and European importers. These flaws undermine, in some respects, and overestimate, in others, the analysis of the effects of CBAM on Russia.

Moreover, their analyses did not consider the unfolding of the recent event, in which the EU and many others imposed severe sanctions against Russia. The recent invasion of Ukraine by Russian military forces changed the trade composition of Russia for an unpredictable duration. Imposed sanctions imply blocking most exports from Russia. Hence, following such development, Russia will seek to create new trading routes. During the UN security council on 2 March 2022, 141 Members of the United Nations General Assembly (UNGA) voted against Russia, while 35 abstained from voting and 12 did not vote (Pamuk et al., 2022). The voting results show that Russia still has some support from many countries, including major global players such as China and India. Therefore, it is crucial to account for the likely future re-direction of exports from Russia to one of the supporting countries.

To access more detailed information regarding the Sakhalin trail, I interviewed an individual who took a role in the development of the Sakhalin trail. The Sakhalin trail is the Russian government's pilot project to test the first domestic carbon tax system, designed to achieve carbon neutrality of the region. Apart from taking a role in the development of the project, the interviewee is one of the individuals who takes an active role in decarbonisation projects globally. The interview allowed me to access more detailed information regarding the project not stated in the draft proposals. The interview was conducted in Russian and further was translated to English. The interview introduction and several other questions and their answers are presented in the appendix.

1.3. – Purpose of this research

The primary purpose of this research is to analyse the attempts of the EU in its efforts to achieve the targets set in the EU's Green Deal. According to The Economist (2021), the EU's Green Deal is the most ambitious attempt to date to counter climate change and environmental degradation. The main objective of the Green Deal is to achieve net-zero emissions by 2050. This ambition aligns with global efforts to limit global warming to 1.5 - 2 ^{o}C above pre-industrial averages. Moreover, the European Committee set the Green Deal as a core strategy for future growth (Mazzucato, 2019). One of the main features of the green deal is an investment strategy in innovative practices, such as investments in low carbon technologies, aiding the EU on its road to Carbon Neutrality. "Early deployment of low carbon technologies is key to making them globally competitive with high carbon technologies" (Tagliapietra et al., 2020, para. 6). Finally, Elkerbout et al. (2020) support the idea of green investments, arguing that the EU's Green Deal proposals can assist regions post-covid19 economic recovery. "[Green Deal] offer a unique opportunity for the EU to live up to the Green Deal's promise of economic modernisation along with the Paris decarbonisation objectives" (Elkerbout et al.,2020, p1).

However, while the proposed Green Deal has received much positive feedback, many criticised it for being too narrow and requiring more global actions. Nordhaus (2020) states that some ecological and environmental policies create an initiative for free-riding and carbon leakage. Carbon leakage occurs when firms or businesses decide to substitute production for trade, reducing production to meet regional emissions targets and importing the reduced amounts from countries with less stringent environmental policies. Nogrady (2020) remarks that the EU heavily depends on agricultural imports, and increasing agricultural imports reduces stress on the farming sector in the EU. While EU trade agreements do not require the trading partners to produce exports sustainably, the agricultural imports come from countries with less strict environmental laws, resulting in the problem of carbon leakage. Eckert and Kovalevska (2021) criticise the Green Deal as an arrangement by the EU developed to shape the EU's image as a 'green' leader. However, they argue that the discourse formed to attest that the paradigm shift from unsustainable to a sustainable society will lead to higher social and economic inequality in the future, as it does not oppose unsustainable practices.

However, the implementation of CBAM as a part of the EU's Green Deal addresses the criticisms raised above. At first, through CBAM implementation, the EU intends to solve carbon leakage by imposing additional import duties on all goods from the five most polluting sectors. Then over time, by adding more sectors such as agriculture and transport to the list of sectors covered by the CBAM, the effect of CBAM will extend to more sectors and countries (EU Commission, 2021). Furthermore, it shows the determination of the EU to continue as a flagship region in sustainable practices, demonstrating the example to other nations in the world. **Hence, adding to sustainable policies and innovations literature, this research will analyse Russia's situation and options after the EU has implemented CBAM. Secondly, this research will serve as the reference for future research to analyse the development of a new mechanism designed to address environmental and climate-related problems.**

Moreover, many argue that CBAM is an opportunity to start the first climate club in history. The EU Council (2022) remarks that other CBAM-related matters are yet to be addressed, not to mention CBAM's proposal, including international cooperation with third countries and establishing a climate club. Furthermore, in their study, Tagliapietra and Wolff (2021) argue that both technological and political conditions are the best to establish the first climate club. They explain that in the proposed climate club, the members will commit to domestic climate measures and agree on the coordinated introduction of CBAM. In addition, the technological advancements in sustainable and green energy reduce total costs for such technologies (IEA, 2020). On the other hand, the US, China, Japan, Canada and the EU, emitting more than half of all global emissions, are the ones who demonstrate the strongest initiative in mitigating climate change. The combination of both these factors with the recently developed EU's

CBAM may seem a perfect opportunity to overcome such problems as free-riding and carbon leakage. **Therefore, this paper will add to the scientific literature by analysing developments and effects of other mechanisms designed to mitigate the climate change problem.** The topic of climate club will be further addressed in the literature review section.

1.4 – Research structure

Analysing the implications of CBAM on Russia, this paper will account for three scenarios. These scenarios will consider multiple effects that will account for different variations in how Russia may react to the effects of CBAM on its exports. These scenarios are: (i) no-action scenario; (ii) implementation of domestic carbon tax scenario; and (iii) redirection of exports scenario.

The first, the no-action scenario, will consider the effect of CBAM on Russian exports, considering that the Russian government will decide to take no action regarding the introduction of CBAM. For all exports from Russia from the aluminium, iron and steel, electricity, cement, and fertiliser sectors, the exported goods will assume to embody a default amount of direct emissions. While the EU importers will pay the maximum value for the emissions embodied in goods, the maximum price increase for Russian exports will make Russian producers less competitive than producers from the EU. The development of this scenario has a maximum negative effect, in monetary value, on Russian exports to the EU.

The second scenario, the implementation of a domestic carbon tax scenario, will consider the effect of CBAM on Russian exports. This scenario is divided into two parts: (i) considering effects solely of a domestic carbon tax, and (ii) effects of a domestic carbon tax combined with the modernisation of production facilities. For this scenario, I interviewed one of the individuals involved in the design of the project – the Sakhalin trial – designed to test the first Russian domestic carbon tax mechanism. Therefore, this scenario estimates the effect of the domestic carbon tax and decarbonisation of production facilities on the price of carbon certificates purchased by EU importers for goods imported from Russia.

The last, scenario 3, will analyse the cost-effectiveness of re-directing exports destined to the EU from Russia to China. Over the last decade, China tested multiple mechanisms, similar to EU ETS, in different provinces (Da Zhang et al.,2014). The primary objective is to speculate whether the re-directing of the exports from Russia to China will lead to a mechanism design like CBAM within China. This speculation pitches an idea assuming that imports from Russia may decrease the competitiveness of the domestic producers in China after implementing the domestic cap-and-trade system. Secondly, it assumes that this may also lead to a carbon leakage issue. Hence, this scenario will comparatively analyse the possibility of China introducing a mechanism similar to CBAM if deciding to accept Russian imports initially destined for the EU.

This paper is structured as follows. The following section will describe the detailed aspects of EU ETS and CBAM and their origins. Section 3 will describe the data and methodology used in this paper to access the estimates used for the analysis. Section 4 will provide the results and analysis of the estimates obtained from work conducted with data, describing the development of all three scenarios derived for the analysis. Section 5 contains discussions based on the results of each scenario from the preceding section. The final, section 6, will conclude and summarise the findings of this paper.

2. Theoretical Framework

2.1 EU ETS

The main cornerstone of the European strategy to address the climate change problem is the ETS. Since 2005, the EU ETS has been operating to reduce greenhouse gas emissions in the European region. EU ETS is the first successfully implemented and is the most extensive emission trading system – 'the EU ETS covers more than 11,000 power stations and industrial plants in 31 countries, and flights between airports of participating countries" (EU Commission, 2015, p.4). The scale of the ETS overlaps multiple industries and regions in the effort to mitigate climate change.

The roots of the EU ETS system can be traced back to 1997 - COP3 by United Nations Framework Convention on Climate Change (UNFCCC). During COP3, UNFCCC developed a Kyoto Protocol, in which pledged members, usually industrialised countries and economies in transition, were expected to reduce their GHG emissions according to agreed individual targets (UNFCCC, 1997). However, the most important innovation of the Kyoto Protocol is an initiative to develop the international cap-and-trade system. Countries could buy and sell emissions under the individually assigned cap in the first proposed cap-and-trade system (UNFCCC, 2008). The main idea of this innovation was to create an incitive for countries, companies, and governments to reduce their overall emissions at the lowest cost.

The EU ETS was first implemented in 2005 and has undergone several changes. The functionality of the mechanism is divided into four phases. Between 2005 and 2007, The EU tested the first pilot phase of the project. At the initial stage, the main targets were to assess the price formation and establish the necessary infrastructure to track emissions. As there was no reliable data available during the pilot phase of the mechanism, the caps were based on emissions estimates (EU Commission, 2015). The primary purpose of this stage implied that EU members of the Kyoto protocol would meet their commitment goals, ensuring and demonstrating the effectiveness of the EU ETS. Essential aspects of EU ETS are the clean development mechanism (CDM) and joint implementation mechanism (JI) (UNFCCC, 2022). These mechanisms were developed to allow a business to earn emission reduction credits to meet its obligations under EU ETS. The CDM mechanism allowed businesses to earn certified emission reduction (CER) credits, under the Kyoto protocol, by implementing emission reduction projects in developing countries. The joint implementation mechanism allowed to earn emission reduction units (ERUs) from emission-reduction or emission-removal projects in another country. Though businesses were only allowed to earn CER credits during the first stage, as the JI mechanism was not yet available for them, both aimed to increase cooperation between countries to mitigate climate change.

The second phase covers the period between 2008 and 2012 – "the same period as the first commitment period under the Kyoto Protocol." (EU Comission, 2015, para. 10). During this phase, businesses were allowed to earn credits from joint implementation projects. This addition made EU ETS the largest source of demand for CDM and JI reduction units (EU Comission, 2015). Towards the end of phase 2, the EU ETS was expanded to include the aviation industry in the system. Therefore, the second stage was a big step in increasing the range of EU ETS mechanisms, including one of the largest polluting industries and adding a new way for businesses to earn climate migration credits generated under the Kyoto Protocol.

The third phase of the EU ETS was between 2013 and 2020. From phase one to phase two, there was just an addition of a new element to the EU ETS mechanism functionality, such as lowering emissions cap and lowering of free allocation of proportion, adding aviation to the list of regulated industries. However, the changes to stage three were more significant. The main aspects are a development of a single EU-wide cap on emissions, changing allowances allocation from free-allocation to auctioning allowances, and including more sectors and gases. Another essential mechanism was developed in the late stages of phase three – Market stability reserve (EU Comission, 2015). This mechanism was designed as a long-term measure to the reducing surplus of emissions allowances (the surplus of emissions amounted to approximately 3 billion tons of CO2 in 2009 and was reduced to 1.78 in 2015). Between 2014 and 2016, the Commission backloaded 900 million tons of emissions surplus until 2019-2020. The backloaded surplus was transferred into the reserve in 2019. Market stability reserve was a necessary action as it could affect the ability of ETS to meet more demanding reduction targets cost-effectively in the long term. This phase demonstrated the commitment of the EU to the mitigation of climate change and its determination to achieve the reduction of GHG emissions by 55% compared to 2005 levels.

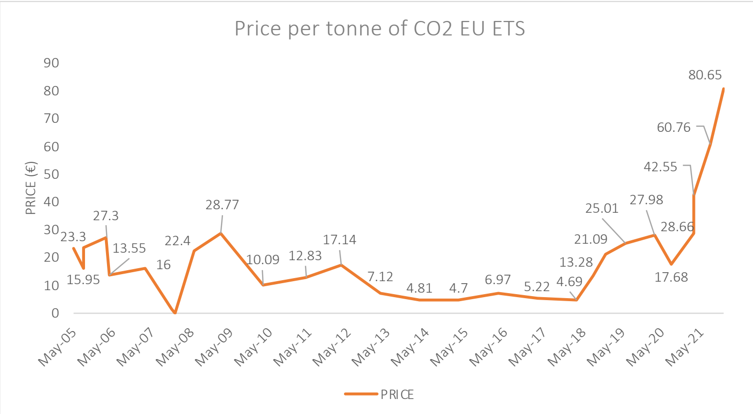

Figure 1 - Price per tonne of CO2 Under EU ETS; Source – Trading Economics (2022)

Phase four started in 2021 and will continue until 2030. EU commission (2021) states that the EU ETS does not have an estimated final phase. The changes of phase four included an increased emission allowances rate of 2.2% annually from 2021. This phase is the most ambitious of all previous ones as it will demonstrate the effectiveness and ability of the EU to meet the emissions reduction targets by 2030, reducing emissions by 43% compared to 2005 levels. Another ambition in the strengthening strategy of EU ETS during phase four is to double the number of emissions reserves to 24% of emissions in circulation. Moreover, the number of emissions held in reserve will be updated yearly – "from 2023 onwards, the number of allowances held in reserve will be limited to the auction volume of the previous year" (EU commission, 2021, p.2). This stage again demonstrates the commitment of the EU to mitigating the climate change problem, as it implies phasing out emissions allowances when the CBAM is fully operational, tightening GHG in the regions even further.

Generally, the EU ETS successfully operates within the EU and is one of the most powerful EU tools for mitigating climate change. Figure 1 demonstrates price fluctuations (in €) per tonne of CO2, showing that since COVID-19, the price per tonne of CO2 has increased more than thrice. However, globally, EU ETS is struggling due to other players' common lack of interest, pointing out a free-riding and carbon leakage problems (Nordhaus, 2020). The following section will describe the EU's attempt as a newcomer to developing an offshoot mechanism to address the climate change problem globally, incentivising its trading parties to implement similar to the EU ETS mechanisms.

2.2 CBAM

CBAM or Carbon Border Adjustment Mechanism is a complementary measure designed by the EU to mitigate climate change. The CBAM is designed in compliance with rules by World Trade Organisation (WTO). While EU ETS is primarily intended to reduce GHG emissions in the EU region (more precisely - in 36 states of EEA) under the Kyoto protocol, the CBAM expands the actions of the EU on a global level.

The functionality of CBAM is fairly simple. In CBAM's proposal, the EU commission (2021) provides that the EU importers will be required to purchase carbon certificates corresponding to the carbon price as if the exported goods were produced in the EU or any region covered under EU ETS. However, if a non-EU producer can confirm that they already paid for the carbon used during the production of the exported goods domestically, the cost for a certificate will be fully deducted from the EU importer. This condition would hold if the exporters paid the price for the used carbon mirroring the EU ETS'. However, if the domestic carbon tax of exporting party is lower than that of the EU ETS, the importers would have to pay for the difference (buy certificates equal to the difference between the price for tCO2 under EU ETS and exporters' domestic tax). For example, considering current price per tonne of CO2 (tCO2) in the EU is €80, and the current rate of tCO2 in Canada is $50 (€37). The additional duty for imports, covered by CBAM, from Canada would amount to €43 per tCO2. Moreover, in 2022, the EU council (2022) introduced the minimum CBAM threshold, which excepts from obligations imports with a value less than €150. "Their aggregate value and quantity represent a negligible part of greenhouse gas emissions of total imports" (EU council, 2022, para. 8).

This design demonstrates the primary initiative of the EU to influence the development of the climate mitigation mechanisms

The CBAM design is expected to address two major issues hindering the functionality of the EU ETS – carbon leakage and free-riding problems (EU Council, 2022). Carbon leakage, also known as carbon outsourcing, the problem has been seen as one of the major causes of achieving climate change mitigating targets (Nordhaus, 2015; Nordhaus, 2020; Hovi et al., 2016). While some countries try to reduce the GHG emissions by greener their production and consumption or reducing energy intensity through innovations, others relocate their energy-intensive production to the countries' less strict emissions policies, resulting in strong carbon leakage (Nordhaus, 2015; Baumert, 2019; Jacob, 2021). Furthermore, while strong carbon leakage results from outsourcing production to countries with less ambitious environmental attitudes, weak carbon leakage can result from structural changes, which lead to reduced competitiveness (Nielsen et al., 2020). Instead of outsourcing production to other countries, like in strong carbon leakage, they reduce their production and import a deficit. Thus, CBAM will address both trends.

Moreover, free-riding is another problem that significantly hinders the functionality of other climate migration mechanisms (Norhaus 2020). Heitzig et al. (2011) explain that international collaboration to reduce greenhouse gas emissions is hampered due to free-riding incentives. Nordhaus (2020) states that free-riding occurs when some countries rely on the reduction policies of other countries without contributing to emissions reduction themselves. While resulting from flaws in EU ETS functionality, both problems demonstrate the negative effect on existing mitigation mechanisms and the importance of the CBAM developed to address these two problems directly.

However, CBAM is not an entirely innovative mechanism developed by the EU. California, the United States' richest state, is the pioneer region, first implementing the border carbon adjustment mechanism. California is currently using a border carbon adjustment (BCA) mechanism to address the carbon leakage into Western Electricity Coordinating Council. Their cap-and-trace domestic system requires electricity importers to specify the source of their contracts and submit credits based on the emissions rate of that supplier (CARB, 2014). Otherwise, a generic price for emissions is imposed. In their paper, Xu and Hobbs (2021) conducted a study to advance the understanding of the effectiveness of local carbon policies. At first, they find that for the year 2034, if there is no mechanism such as BCA but the price on carbon emissions, California's emissions will decrease. But the rest of the emissions increase more than California's reduction, showing that the carbon tax on its own is not efficient on a larger scale. Furthermore, comparing different BCA models (facility-based and facility-neutral BCAs), they find that the facility-neutral BCA will lower emissions and costs without increasing the energy price and lead to a decline in emission leakage. Therefore, their study shows that BCA (CBAM in Europe) has great potential to reduce and control emissions.

The European version of the carbon border mechanism (CBAM) will operate slightly differently from California's version. The primary aim of the CBAM is to complement EU ETS

– "the CBAM will be based on a system of certificates to cover the embedded emissions in products being subsequently imported into the EU" (EU Comission Q&A, 2021, para. 9). CBAM is not a cap-and-trade system; it departs from EU ETS in certain areas. However, the price for certificates will mirror that of the ETS. Furthermore, the certificate cost will depend on the "weekly average auctioning price of the EU ETS allowances expressed in € / tonne of CO2 emitted" (EU Comission Q&A, 2021, para. 11). Thus, CBAM is expected to the resolution of the carbon leakage problem by compelling other nations to comply with and participate in the EU ETS, levelling the pricing between domestic and international production.

Furthermore, the EU has developed multiple pricing CBAM methods, which importers must follow (EU Commission, 2021). CBAM will price certificates differently between emissions embodied in simple and complex goods. Simple goods are those produced using input materials and fuels having zero embedded emissions, while complex goods require the input of other simple goods in their production process. In both these cases, only direct emissions produced during the production process will be accounted for as actual embedded emissions, meaning that emissions produced during the production process will be subject to CBAM duties. However, if the data regarding direct emissions embodied in the production process is not adequately provided, the default value will be charged, and the literature value will be used. For example, if exporters from country X will not be able to provide adequate data regarding direct emissions embodied in the exported product, importers would have to purchase certificates according to the value as if the goods were produced in the EU. Such a pricing strategy aims to force producers and exporters to maintain accurate data during the production process.

The first phase of the CBAM is expected to commence in 2023 – Transitional Phase. The transitional phase will occur between 2023 and 2025 (PWC, 2021). During this period, importers would only be required to report the emissions embodied in the imported products without being required to pay for certificates. Furthermore, during the transition phase, only five sectors – cement, iron and steel, fertilisers, aluminium, and electricity production sectors – due to their high risk of carbon leakage and carbon emissions and would be required to report emissions embodied in their imports. This phase will prepare EU and non-EU businesses for a smoother transition (EU Commission, 2021). In 2026, the system will become fully operational. EU importers will be required annually to surrender certificates, which correspond to imported goods quantity and emissions embodied in the imported goods from the preceding year. Further, over time functionality of CBAM will cover more sectors, and the emission price to increase even further (EU Commission Q&A, 2021). Therefore, while companies could still take advantage of a transitional phase and maximise their imports before CBAM duties are imposed, CBAM is expected to significantly reduce carbon leakage risk.

Though CBAM seems to have great potential and is expected to aid the EU in its Green Deal, it was also subject to criticism. According to The Economist (2021), the scope of the CBAM is too small. They state that emissions embodied in trade account only for 10% of total emissions, showing CBAM's narrow scope. Moreover, they explain that certain countries address the policy as discriminatory and regressive, referring to it as the EU's protectionist policy. However, one of the strongest uncertainties addressed regarding CBAM is that the mechanism will mostly affect developing and least developed countries. According to Berahab (2022), the CBAM will penalise the countries that are the least responsible for the climate crisis but the most affected by it. This annotation shows that the CBAM's functionality is subject to some limitations, even hindering the situation in some cases.

2.3 CBAM vs Climate club

The CBAM is a mechanism developed by the EU to mitigate climate change under the 2015 Paris Agreement, contributing to the EU efforts in cutting GHG emissions in the region by 55% compared to 1990s levels. The idea of the CBAM mechanisms was previously mentioned as a sub-concept of climate clubs' theory. In addition, the climate clubs' concept itself was an offshoot from clubs' theory, described as an institutional innovation developed to address climate change problems and challenges under Paris Agreement and Kyoto Protocol.

The climate club theory states that economies involved in climate club mitigation will form a club in which, through the common contribution, they will be able to find a solution to environmental and climate problems. The climate club takes origin in Buchannan's (1965) clubs' theory, describing the theory as collective membership with possible exclusion. Later, Potoski and Prakash (2005) introduced the concept of the green clubs, and further, Potoski and Prakash (2007) differentiated between Buchannan's clubs and voluntary clubs. They explained that Buchannan's concept clubs' theory does not consider the possibility of free riding, while voluntary clubs must benefit their members to incentive membership. While Hovi et al. (2016) state that providing benefits for the club members is a necessary measure for the club's growth, Nordhaus (2015) was the first who empirically tested the idea of the clubs, stating that climate clubs must benefit their members and punish non-members. Victor (2011) introduces the concept of the border tax adjustment as a protection measure for the club members from club trade disadvantages. The mentioned literature points out that the successful development of the climate club will have to benefit its members and punish non-members.

However, the Nordhaus climate club concept shows the most resemblance to the CBAM. Furthermore, The Economist (2021) and Nasdaq (2021) state that more economies, such as Japan, Canada, Russian Federation, China, and the US, plan to develop like CBAM and EU ETS mechanisms. If those countries successfully develop similar domestic mechanisms, this development seems to be a departing point for the first in the history climate club.

However, the development of the first climate club seems to be a little realistic. "There is little chance that an international alliance on carbon pricing or "climate club" can be set up within a timeframe compatible with the climate emergency." (Mathieu et al., 2021, p.5). Moreover, Lee and Baron (2021) state that the CBAM is not designed by the EU to address the decarbonisation of heavy industries globally but as a domestic response to ensure the effectiveness of the EU's carbon pricing system. Furthermore, they state that the climate club will require the development of many more complementary policies and approaches on an international level. "We can only hope the ill-advised carbon club discussion will lead to a realisation that industrial decarbonisation won't be straightforward, and policy discussions are needed rather urgently." (Lee and Baron, 2021, para. 11). This argument explains that although CBAM seems to be the first step in developing the world's first climate club. The feasibility of the first climate club is low as one of the climate club criteria is equilateral environmental policies. Unger and Theilges (2020) argue that ‘relevant members’ are essential for the club authority. “a club must include the “right” or “key” actors” (Unger and Theilges, 2020, p.5). However, even for a key actor like Canada, having the highest non-EU CO2 tax, establishing the same level of carbon taxation domestically as the EU would be tough. Thus, a long path is still to be undertaken in order to develop a global mechanism resembling the climate club.

3. Methodology and DATA

To analyse the potential impact of CBAM on Russia, I first calculated the total export revenue from Russia to the EU and other countries covered under CBAM (in euros) and weight (in tonnes). Secondly, applying the information provided from multiple sources, I calculated the direct emissions, emitted during the production process. Third, I estimate the revenue that potentially can be generated by the additional duty on imports. Finally, in per cent (%) and euros (€), I compare the additional cost for the Russia of the CBAM on its exports to the countries under the EU ETS.

3.1 Affected Exports

For this paper, I used the free-access data provided by the Chatham House Resource Trade Database (CHRTD), combined with UN Comdata trading data. This data allows calculating the monetary impact of CBAM on Russia. The CHRDTD database is a library of bilateral natural resource trade between over 200 regions. "[The] database includes the monetary values and masses of trade in over 1,350 different types of natural resources and resource products, including agricultural, fishery and forestry products, fossil fuels, metals and other minerals, and pearls and gemstones" (Chatham House, 2021, para. 2). I used this database to derive information regarding Russia's aluminium, iron and steel, cement, and fertiliser sectors' exports to the EU.

Five sectors will be affected by the CBAM implementation: Aluminium, Cement, Electricity, Fertilisers, and Iron and Steel. According to the CBAM proposal and Harmonised System Classification (HSC), the identified impacted products are:

- Cement: Portland cement and other white cement, and cement clinkers (2523)
- Iron and Steel (72)
- Aluminium (76)
- Fertilisers: Fertilisers, nitrogenous, chemical (3102)
- Electricity: Electrical Energy (2716)

3.2 Emissions Intensity

Though the CHRTD dataset does include embodied emission in trade for some industries, cement and aluminium, for other sectors, iron and steel and fertilisers, I had manually calculated the emission embodied in trade. To calculate emissions embodied in iron and steel production, I used Russia's average direct emissions generated during iron and steel production. Shul'ga (2021) provides a comparison among three Russian steelmaking producers – NLKM[2] (1.91 tCO2/t), MMK[3] (2.18 tCO2/t) and Severstal (2.08 tCO2/t). For my analysis, I used the average of these three plants, 2.05 tCO2/t, as the country's average emissions generated during iron and steel production. For the fertiliser industry, I used the information provided by the International Fertilisers Society (IFS). IFS (2019) provides that Russia's carbon intensity for fertilisers' production is 2.7 tC02/t.

To calculate the embodied CO2 emissions in export (ej) of product j, I used formula (1) where total exports (EX) of sector j are multiplied by the amount of CO2 produced per tonne of product j.

(1)

$$e_j = EX_j \times tCO_{2_j}$$

However, while the sources provide necessary information regarding emissions embodied described above products, the evidence suggests that different businesses have different production approaches and different technologies (Fernandez-Delgado et al., 2020; Hasanbeigi et al., 2014; Shul'ga, 2021). This argument remarks that different production plants will generate different emissions levels during production, hence, having a different number of emissions embodied in the product. However, this data is hard to be collected in open access due to limited access to data from Russian producers. Therefore, I computed the emissions embodied in products from fertilisers and iron and steel sectors under the assumption that all these products were produced using the same technique and machinery, generating the same average of emissions, 2.05 tCO2/t from iron and steel and 2.7 from fertilisers, during production.

3.3 Electricity sector

I used the ATLAS of Economic Complexity database provided by the Harvard Kennedy School of Government for the electricity sector. The ATLAS data allowed me to investigate global trade flows between markets, follow these patterns through time, and uncover new growth opportunities for each country (ATLAS, 2019). However, this data provides only monetary value (in US dollars) of the trades for every exported country. Therefore, I had to go through an additional search to find necessary information which would allow me to calculate the actual amount of electricity (in KWh) exported from Russia to the EU countries covered under EU ETS.

[2] NLMK - Novolipetsk Steel Works (Translated from Russian)
[3] MMK - Magnitogorsk Iron and Steel Works (Translated from Russian)

The additional data sources for the electricity supply data collection are RIA rating (2021) and Enerdata (2021). RIA rating is an official Russian agency that collects energy data within the country under the RIA corporation. Enerdata is an energy consulting firm specialising in the analysis and modelling of the global energy markets, and its drivers yearly provide statistics regarding energy. These sources, in combination, allowed me to collect the data to estimate the total electricity exported.

Table 1.1 - CO2 emissions' factors for different fossil fuels, gram CO2/MJ

Coal	92
Oil	74
Natural Gas	56

Source: Kander et al (2013), p.278; Lavander (1991), p.8

To calculate the amount of electricity exported to the EU ($EL(KWh)_{EU}$) in KWh, I derived the formula (2) as follows:

(2)

$$EL(KWh)_{EU} = \frac{\sum_{EL}(EX_{RUS}) \times \sum_{EL}(EX_{EU})}{\sum_{EL}(EX_{RUS})}$$

Where, $\sum_{EL}(EX_{RUS})$ is a total electricity export from Russia in KWh, $\sum_{EL}(EX_{EU})$ is total electricity exports from Russia to the EU in $US, is divided $\sum_{EL}(EX_{RUS})$ by total electricity exports from Russia in $US.

Table 1.2 - Average carbon intensity from electrical energy production per region in kgCO2/KWh

Country/Region	kgCO2/KWh
Chelyabinsk region	0.87
Russia	0.55
U.S.	0.56
China	0.71
India	0.81
South Africa	0.77
EU	0.38
Japan	0.32
Brazil	0.06

Source: Divin et al., (2011)

It is important to remark on the underlying assumption while calculating the electricity exports. According to Tihonov (2021) the production of electricity in Russia is divided into six energy-generating methods – nuclear, fossil fuels (coal and gas), wind-, solar- and hydropower generating processes. Moreover, Tihonov states that, in Russia, the lowest price for electricity generation is by using natural gas fuel. Kander et al. (2013) provide information regarding emissions emitted while burning different fossil fuels (TABLE 1.1), implying that amount of CO2 emitted during electricity production from multiple energy sources varies substantially.

Moreover, though there are multiple sources to generate electricity in Russia, BP (2021) reported in a statistical review that most of the electricity generated in Russia is produced using fossil fuels. Their report shows that 1 per cent, 45 per cent, and 14 per cent of electricity is generated using oil, natural gas, and coal, respectively. While the other 40 per cent is generated using nuclear and renewable power (20% and 20%). In their paper, Divnin and Karimulina (2011) assess the average CO2 emissions generated from electrical energy production from three different electrical power stations (EPS) in Russia, the Chelyabinsk region, one of the most industrial Russian regions. They explain that some power stations use different technologies and energy inputs to generate electrical energy (EPS1 – 0.6, EPS2 -0.92, and EPS3 – 1.07 kgCO2/KWh). First, they provide that some facilities (EPS1) are generating electricity 95% from natural gas and 5% from coal, some (EPS2) 40% from natural gas and 60% from coke, and some (EPS3) are still producing electricity from only burning coke. Secondly, the average CO2 emissions for that region are 0.87 kgCO2/KWh, while Russia's average is 0.55 kgCO2/KWh. Further, they also provide the average for Russia and compare it to other countries, including China and the EU. This data demonstrates that, as Chelyabinsk's average emissions from electricity generation differ from those of the national average, all the Russian regions apply different technologies and fuel inputs for electrical energy generation nationwide. Hence, the CO2 emissions embodied in the electrical energy exported from Russia to the EU are calculated considering emitting the national average of CO2 per KWh, as provided in table 1.2.

3.3 Impacts on Revenues

To calculate the impacts on the revenue of the Russian exporters, I calculated multiple estimates that will demonstrate how CBAM will affect the final price. The estimates are the total additional export duty T_{e_j} (3), the new export price $N(EX)_j$ (4) and the price increase in per cent (5).

The formulas used are as follows:

(3) $$T_{e_j} = \sum EX_j \times \$/tCO_2$$

Where, $\sum EX_j$ is total exports of product j are multiplied by the price per tonne of CO2 under EU ETS, which is €80

(4) $$N(EX)_j = \sum_j (EX_{EU}) + T_{e_j}$$

Where, $\sum_j (EX_{EU})$ is total exports from sector j to the EU, added to total additional export duty.

(5) $$P(\%)_{increase} = (\frac{N(EX)_j - \sum_j(EX_{EU})}{N(EX)_j}) \times 100$$

Finally, all these estimates are calculated assuming that EU producers use more environmentally friendly and less carbon-intensive inputs and technologies to produce the same goods. This assumption is crucial for the CBAM mechanism because, when EU ETS free allowances are phased out, the EU ETS would also require EU producers to pay the same amount per tonne of carbon used in the production process as CBAM would require non-EU producers. If it turns out otherwise, EU efforts to reduce carbon leakage will be ineffective, and non-EU export prices will be lower than those from the EU. This assumption will be addressed and further discussed in the "Discussions" section.

4 - Analysis

4.1 Scenario 1 – 'No Action'

Scenario 1 describes the effects of CBAM on Russia, assuming that no domestic carbon tax system or mechanism was implemented in Russia. According to the CBAM proposal, if the exporting country does not implement any system or mechanisms like CBAM or EU ETS to tax GHG emissions domestically, the EU importers would have to purchase carbon certificates corresponding to the default price per tonne of CO2 emissions. In that case, the EU importers would have to purchase CBAM certificates according to the default value of CO2 emissions per sector; the price value per tonne of CO2 under EU ETS, which is approximately €80 in April of 2022. The price used to calculate additional import duty values is taken from "Ember" (2022), an independent energy think tank which provides the latest updates on tCO2/t prices under EU ETS. Therefore, scenario 1 will consider the maximum additional cost for the EU importers after the implementation of CBAM.

4.1.1 - Aluminium sector

Analysing the development of scenario 1 for the Aluminium sector, the additional cost for exports will significantly increase the final price for the EU importers. Table 5.1 demonstrates the estimation results. In 2020, the cost for 1.3m tonnes of aluminium was €2.3billion for the EU importers. However, the price for aluminium after implementing the CBAM will increase to €2.9billion, or by 21.2%.

Table 2.1 - Aluminium exports from Russia to countries covered by EU ETS

Total exports (€)	€ 2,321,892,429.96
Total exports (1000kg)	1,306,417.08
Actual emissions embodied	7,812,570.97
Actual CBAM price (€)	€ 625,005,677.55
New price (€)	€ 2,946,898,107.51
% Increase in price	21.21%

Source: UN comtrade (2021)

According to the provided data, 7,8 million tonnes of direct emissions are embodied in the aluminium products imported from Russia. This amount of GHG emissions would cost the EU importers an additional €625m, equal to 25.92% of the total export value from the Aluminium sector in 2020. The results for the aluminium sector show that no respective action from the Russian government would result in a price increase of €625m, which would have to be purchased by the importers from the EU commission.

4.1.2 - Cement sector

Though Russia is not the biggest cement exporter to the EU, neither are most countries to which it exports the cement products, like Belarus, Ukraine, and Moldova, which are within the EU territory but are not under the EU ETS regulation. The development of scenario 1 for the cement demonstrates that after implementing the CBAM, the cost for exports will increase the price significantly. According to conducted estimation, the cement sector is not the most polluting but with the highest cost to revenue ratio.

Table 2.2 – Cement exports from Russia to countries covered by EU ETS

Total exports (€)	€ 3,802,339.91
Total exports (1000kg)	69,732.32
Actual emissions embodied (t)	58,575.14
Actual CBAM price (€)	€ 4,686,011.39
New price (€)	€ 8,488,351.30
% Increase in price	55.21%

Source: UN comtrade (2021)

Table 5.2 demonstrates that in 2020 Russia exported slightly under 70 thousand tonnes of cement worth approximately €3.8 million, while the emissions embodied in the production of cement are approximately 59 thousand tonnes of CO2 worth €4.6 million, demonstrating a 0.83 CO2 tax on exports ratio or 83%, considering €80 per tonne of CO2 under the EU ETS. Finally, the estimates demonstrate under CBAM that the new price for the cement exports to the EU would increase the cost of cement to €8.4 million or 55.2%. Therefore, while the cement sector is neither the one that accounts for the highest exports nor the most polluting one, the aspect ratio (exports revenue/CO2 tax) is one the highest among the sectors covered by the CBAM.

4.1.3 - Iron and Steel

According to export data, Iron and Steel sector has the highest export revenues among all the sectors covered under the CBAM. In 2020, Russia's total iron and steel exports amounted to 10.6 million tonnes, equal to approximately €2.7 billion in monetary value. However, apart from being one of the most valuable exports (in economic value), the iron and steel industry is also one of the most polluting ones covered by CBAM, after aluminium.

According to Shul'ga (2021), on average, the iron and steel industry emits on avarage 2.05 tCO2 per tonne of produced good. The estimated direct emissions equal 21.8 billion tonnes of CO2. Transforming estimates into monetary value, the emissions embodied in exports from the iron and steel industry will cost the EU importers approximately an additional €1.7 billion, resulting in the final price of almost €4.9billion under the current EU ETS price for CO2 emissions. Therefore, no action will increase the cost of iron and steel by approximately 38.8% for EU importers.

Table 2.3 – Iron and Steel exports from Russia to countries covered by EU ETS

Total exported (€)	€ 2,745,659,860.90
Total exported (in tonnes)	10,632,412.16
Actual emissions embodied (t)	21,796,444.93
CBAM price (€)	€ 1,743,715,594.54
% of total	63.51%
New Price (€)	€ 4,489,375,455.44
Price increase (%)	38.84%

Source: UN comtrade (2021); Shul'ga (2021)

4.1.4 - Fertilisers

While Iron and Steel is the industry that has the highest revenue from the exports, fertilisers are the industry with the second-highest export volume in weight. According to the export data, the EU importers from countries under EU ETS imported 7.6 million tonnes of fertilisers from Russia. The aggregate value of fertilisers' imports for the EU importers was equal to almost €1.6 billion. While this is lower than revenue from the exports of aluminium and iron and steel, it is still much higher in volume than aluminium, resulting in a higher number of direct emissions embodied in the imports of fertilisers.

Table 2.4 – Fertilizers exports from Russia to countries covered by EU ETS

Total exports (€)	€ 1,616,937,903.84
Total exports (1000kg)	7,634,751.92
Actual emissions embodied (t)	21,102,454.30
Actual CBAM price (€)	€ 1,688,196,344.03
% Of total	104.41%
New price (€)	€ 3,305,134,247.88
% Increase in price	51.08%

Source: UN comtrade (2021); IFS (2019)

Though the emissions to production ratio in fertilisers are lower than in the aluminium sector, in the fertilisers sector, the number of direct emissions embodied in exports from Russia is equal to 21.1 million tonnes of CO2, from producing 7.6 million tonnes of fertilisers. According to the international fertilisers society (IFS, 2019), the direct emissions embodied in the production of fertilisers are equal to 2.764 tCo2 per tonne of nitrogen input in the CIS region (Russian Commonwealth). This trend is significant for the EU importers in further price development because the final price for fertiliser imports will double. The additional import duty is equal to €1.7 billion, resulting in a 51.08% price increase, the highest additional import duty for the EU importers after CBAM implementation. The resulting final price will equal €3.3 billion, more than double the price for fertilisers' exports before CBAM implementation.

4.1.5 – Electricity export

Though Russia exports little electrical energy to the EU, only four countries are covered by EU ETS: Finland, Lithuania, Latvia and Norway; electrical energy is one of the sectors covered by CBAM and will have greater implications. In 2019, Russia exported 13.2 billion KWh to the EU, translating to €611,1 million in monetary value or approximately 2/3 of total electricity exports from Russia.

According to the Divin et al. (2011), on average, 550g of CO2 is emitted per produced kWh of electrical energy in Russia. However, it is important to consider that different fuels are used in producing electrical energy. For example, different coal types used in electricity generation have different energy outputs, as electricity generated from oil and gas generates different amounts of emissions during electricity production. Applying these estimates to exports from Russia, the result shows that 7.3 million tonnes of CO2 were generated during the production of electrical energy imported from Russia. This output is equal to €582 million of additional import cost or a 48.8% price increase for the EU importers, resulting in a final price equivalent to €1.2 billion.

Table 2.5 – Electricity exports from Russia to countries covered by EU ETS

Total electricity exported (€)	€ 611,135,307.36
Total electricity exported (billion KWh)	20.16
Total exported to the EU (KWh)	931,711,143.00
Amount exported to the EU (KWh)	13,227,878,752.29
CO2 emissions generated during production (t)	7,275,333.31
CBAM tax (€)	€ 582,026,665.10
New Price (€)	€ 1,193,161,972.46
Price change (%)	48.78%

Source: ATLAS (2021); Divnin et al. (2011)

4.1.6 – Summary

Summing up the findings under scenario 1, Table 2.6 provides the total export estimates from Russia to the EU countries under the EU ETS. Considering that Russia will not introduce any domestic climate mitigation mechanisms or CO2 emissions tax, the introduction of CBAM will result in a significant price increase for the EU importers.

In 2020, the exports from Russia from sectors covered by CBAM amounted to €7.3 billion. During the production of these exported goods, 58 million tonnes of CO2 were produced. Translating this into monetary value, the additional import duty for EU importers would be over €4.6 billion. Finally, the new price for total exports from Russian Federation would amount to €11.9 billion if the CBAM was introduced in 2020. This rate is 38.9% higher than the price that the EU exporters played for the imports from Russia in 2020.

Table 2.6 – Scenario 1: Total implications of CBAM on export from Russian to the countries covered by EU ETS

Total Exports (€)	€ 7,299,427,841.98
Actual emissions embodied (1000 kg)	58,045,378.65
Actual CBAM price (€)	€ 4,643,630,292.61
New price (€)	€11,943,058,134.59
% Increase in price	38.88%

Source: IFS (2019), UN comtrade (2021), Divin et al., (2011), ATLAS (2021), Shul'ga (2021)

4.2 - Scenario 2 - Domestic mechanism

While scenario 1 considers the maximum CBAM's maximum effect for the export country, in this case for Russian Federation, scenario 2 implies that the export country will implement any system or mechanism similar to CBAM or EU ETS to tax carbon emissions domestically. The development of this scenario will lead to a reduction in the price of carbon certificates for the EU importers - "Importers would have the opportunity to claim a reduction of the CBAM based on their carbon footprint and any carbon price paid in the country of production." (European Commission, 2021, p7). Therefore, analysing developments of scenario 2, this section will demonstrate how implementing the domestic carbon tax in Russia will reduce the price of carbon certificates for EU importers.

4.2.1- "Sakhalin Oblast" trial

"Sakhalin Oblast" (the Sakhalin region in English) trial is a project proposed by the Russian government, developed to test the first domestic carbon tax system. The Sakhalin region (figure 2) is the only Russian region composed of islands. The region's area is approximately 87.1 thousand KM², with a population of 490 thousand people and approximately 70% of the area covered by forestry. According to the Sakhalin government (2020), industrial production covers 70% of total production in the region. The region's GDP accounts for 1.4% of the total Russian GDP (NOGSA, 2021). Moreover, the region is abundant of oil, coal, gold, peat and other primary materials. The primary idea of the trial is to implement a carbon tax for the Sakhalin Oblast on all activities responsible for emitting GHG over the allowed yearly cap to achieve carbon neutrality in the region, accounting for forestry sink.

However, the trial involves other goals as well. One such goal is to stimulate the implementation of technologies and innovations aimed to reduce GHG emissions during the production of goods and overall GHG emissions in the region (Sakhalin trial proposal, 2021). This goal aligns with the EU's Green Deal proposal motivation – increasing investment in low-carbon technologies. Another important goal is to create an independent system that will obligate accounting for and recording the GHG emissions data. This system will require producers accurately record GHG data embodied in their production, considering international standards and regulations. This data management system's primary purpose is to establish the first domestic carbon tracking system, which will provide information regarding emissions embodied in exported products.

Figure 2 - Sakhalin Region; Source: Wikipedia.com (2015)

During the interview was established that the Sakhalin region was selected as a trial region to achieve carbon neutrality. The abundance of land, low population and high level of forestry make this region particularly suitable for testing projects designed to achieve carbon neutrality. A more detailed answer regarding the motivation for selecting the Sakhalin region for the trial is presented in the appendix.

In addition, one of the essential characteristics of this trial is that it prioritises sustainable socio-economic development of firms with low-carbon technologies, incentivising them to modernise their production facilities and techniques to reduce their carbon intensity. In their paper, Kanischev et al. (2021) argued that a project aimed to increase the carbon effectiveness of the manufacturing sector would spark further economic growth and improve the financial stability of Russia. They emphasised that among many possible strategies to mitigate climate change, the method best suits Russian needs is modernising the existing manufacturing sector. Improving carbon effectiveness (reducing carbon intensity) of national industrial sectors will aid in low-carbon strategy and national socio-technical policies regarding Russia's ecological development and climate change, fostering other environmental projects and quality of life improvement. This plot seems ambitious considering that, according to scenario 1, CBAM would increase the price for Russian exports by more than €4.6 billion or 38%. Therefore, modernisation and investment in a low-carbon strategy seem to be one of the main underlying goals of the Sakhalin trial.

However, another essential aspect of the Sakhalin trial is implementing an actual carbon tax. The project commenced its functionality on January 1st of, 2022. Between 2022 and 2023, the first year will perform the role of a pilot year, solely collecting data on the activities related to GHG emissions from the regions. Between 2023 and 2025, the regional government will impose a 150 thousand tonnes of CO2 cap[4] and reduce it to 50 thousand in 2024. All actors who produce emissions over the pre-established cap will be obligated to pay an additional 2000 rubbles (approx. €22) per each extra tonne of CO2 emitted. From 2025, this cap will be reduced to 20 thousand tonnes of CO2, reducing it by 60%, while the rate per extra tonne of CO2 will increase, though no forecast provides estimates of future tax level. Finally, the project assumes that all those who produced fewer emissions than given in the cap will be able to re-use those emissions in the next year, though the procedure is unclear for the transition years, like 2024 to 2025, in which the cap will reduce. Finally, if successful, the carbon tax aspect of the Sakhalin trial will be applied on the national level, fulfilling the condition given in CBAM. Hence, the cap reduction over time will stimulate a price reduction for the EU importers, forcing Russian producers to reduce their carbon intensity making Russian products competitive compared to those produced in the others non-EU countries with less strict environmental legislation.

4.2.2 – Scenario 2 – Results

The results from scenario 2 account for two possible developments: the effect of a carbon tax and the impact of modernisation. The following section will demonstrate the impact of the carbon tax on Russian exports, assuming the functionality of the Sakhalin trial diffused to the whole country. Hence, this development will consider the price reduction of 2000 rubbles (€22) per tonne of CO2 embodied in exported goods on the additional import duty imposed by CBAM. The second dichotomy of scenario two will consider the same development and account for the modernisation of the existing production facilities. Kanischev et al. (2021), in their study, presented the impact of decarbonising existing production facilities - a 20% reduction in carbon intensity. Therefore, the second dichotomy of scenario 2 will also consider a 20% reduction in CO2 intensity.

4.2.2.1 – Scenario 2.1

Considering the rate for CO2 emissions of 2000 rubbles (€22), TABLE 3.1 provides the results of the price change estimates according to the Sakhalin trial requirements. The iron and steel sector is the most impacted by the carbon tax. Exporting 10.6 billion tons of goods to the EU, Russian producers would have to pay €479.5 million in carbon taxes domestically. Additional domestic tax results in a 12% price reduction for the EU importers, or a decrease from €4.5 to €4 billion in final price.

Next are the aluminium, and fertilisers' industries. The domestic tax for fertilisers' producers will equal €464.3 and €171.8 for Aluminium producers, resulting in a final price decrease of 16.34% for fertilisers' and 6.19% for Aluminium producers. These two industries are the most polluting ones, demonstrating the highest tonne of output to a tonne of CO2 ratio among all sectors covered by the CBAM. Hence, such a trend indicates that the price reduction for the

[4] This statement was confirmed during the interview; the full answer is provided in the appendix.

EU importer is not as significant for the most polluting sectors as those that export greater amounts.

The estimates also demonstrate an impact on electricity exporters from Russia. The carbon tax implementation will result in a €160 million price reduction for the EU importers, or a 15.5% price decrease, from €1.19 to €1.03 billion, in final price. Finally, the final price reduces from €8.5 million to €7.2 million or 17.9% for the cement sector. This development shows the most significant price reduction, per cent wise.

Table 3.1– The effect of flat carbon tax on exports from sectors covered by CBAM in Russia

Sectors	Total carbon tax charged by Russia (€)	New Price (€)	Price change (%)
Cement	1,288,653.13	7,199,698.17	-17.90%
Fertilisers	464,253,994.61	2,840,880,253.27	-16.34%
Electrical Energy	160,057,332.82	1,033,104,639.64	-15.49%
Iron and Steel	479,521,788.46	4,009,853,666.98	-11.96%
Aluminium	171,876,561.33	2,775,021,546.19	-6.19%
Total Exports	1,276,998,330.35	10,666,059,804.24	-11.97%

Source: IFS (2019), UN comtrade (2021), Divin et al., (2011), ATLAS (2021),

The overall trend of scenario 2 is as follows. Suppose Russia implements the functionality of the carbon tax, like in the Sakhalin trial, for the whole country. The overall price for the exported goods will decrease by 12%, or from €11.9 to €10.6 billion for the EU importers. In other words, the total price for carbon certificates required to be purchased by the EU importers after CBAM operates in full force would be expected to decrease by almost €1.3 billion. However, Russian producers are expected to add the amount paid for the domestic carbon tax to the final price of exported goods. This trend will be further discussed in the 'Discussion' section.

The following section will describe the development of another dichotomy of the second scenario. While scenario 2.1 considers only price reduction due to the implementation of the domestic carbon tax, scenario 2.2 also considers the modernisation of existing production facilities, reducing their carbon intensity by 20%. Fulfilling both these conditions will result in increased competitiveness with the EU producers.

4.2.2.2 – Scenario 2.2

Considering the statistics provided by Kanischev et al. (2021), the modernisation of the existing production facilities will lead to an even greater reduction for the EU importers. Table 3.2 provides the final estimates obtained considering all conditions of scenario 2.2 – domestic carbon tax of 2000 rubbles (€22) and modernisation of the existing production facilities (reduction of carbon intensity by 20%). Table 3.3 provides the percentage comparison of scenario 2.2 with scenarios 1 and 2.1.

According to estimates provided in table 3.2, the same trend holds in scenario 2.1. Due to their extensive exports, the most impacted is the iron and steel. According to provided data, in 2020, Russian iron and steel producers emitted 21.8 million tonnes of CO2. However, if reducing carbon intensity through modernisation, this number decreases to 17.4 million tonnes of CO2. Thus, the final price for the EU importers decreases to €3.8 billion, 19.5% compared to scenario 1 or 6.7% compared to scenario 2.1.

The next is the fertilisers and aluminium industries. For the fertilisers industry, the second most polluting industry, the modernisation approach decreases direct emissions from 21.1 million tonnes to 16.9 million tonnes, and for the aluminium industry, from 7.8 million tonnes to 6.3 million tonnes of CO2. The domestic carbon tax for Russian aluminium producers will decrease from €171.9 million to €137.5 million, and for fertilisers' producers, the tax will fall to €371.4 million. Though aluminium industries demonstrate the lowest percentage change in the final price, compared to both scenario 1 and scenario 2.1, for both these industries, it seems a significant reduction in final export price due to its highly polluting production process.

Table 3.2 – The joint effect of CO2 tax and 20% reduction of carbon intensity on Russian exports to the countries covered by the EU ETS

Sectors	Actual emissions embodied (t)	Actual emissions embodied after modernisation (t)	Actual CBAM price (€)	Total carbon tax charged by Russia (€)	New price (€)[5]
Aluminium	7,812,570.97	6,250,056.78	€ 500,004,542.04	€ 137,501,249.06	€ 2,684,395,722.94
Cement	58,575.14	46,860.11	€ 3,748,809.11	€ 1,030,922.51	€ 6,520,226.52
Iron and Steel	21,796,444.93	17,437,155.94	€1,394,972,475.52	€ 383,617,430.77	€ 3,757,014,905.65
Fertilisers	21,102,454.30	16,881,963.44	€1,350,557,075.23	€ 371,403,195.69	€ 2,596,091,783.38
Electrical Energy	7,275,333.31	5,820,266.65	€ 465,621,331.84	€ 128,045,866.26	€ 948,710,772.94
Total Exports	58,045,378.65	46,436,302.92	€ 3,714,904,233.74	€ 1,021,598,664.28	€ 9,992,733,411.44

Source: *Source: IFS (2019), UN comtrade (2021), Divin et al., (2011), ATLAS (2021), Kanischev et al. (2021)*

The estimates for electrical energy producers demonstrate significant price fluctuations after modernisation implementation. However, these estimates assume that the Russian electricity producers will not shut down their fossil fuels electricity generation and will not refocus on only green-electricity exports. Like in scenarios 1 and 2.1, these estimates consider the average Russian emissions generated during electricity production, accounting for all electricity generation means – solar, wind, nuclear, hydro and fossil fuel. The estimates in table 3.2 demonstrate that modernisation will reduce overall direct emissions from electricity production to 5.8 million tonnes of CO2. Secondly, the carbon tax would decrease to €128 million, reducing the final price for the EU importers to €948.7 million. Compared to scenario 1 and scenario 2.1, the final price reduces by 25.8% and 8.9%, respectively.

The price reduction is the most significant for the cement producers, like in scenario 2.1, though only percent wise. The overall direct emissions from the cement sector will reduce from 58,6

[5] The new aggregate price per sector displays the price reduction for the EU importers considering the effect of both domestic carbon tax and modernisation of production plants. It does not consider whether Russian producers will add the amount paid for the used carbon domestically to the production cost.

thousand to 46.9 thousand tonnes of CO_2. In addition, the carbon tax for emissions will reduce to €1.03 million, reducing the price of carbon certificates for the EU importers. Compared to scenario 1 and scenario 2.1, the final price reduces by 30.2% and 10.4%, respectively.

Finally, the estimates for total exports of sectors covered by CBAM are as follows. After modernising Russian production, the overall direct emissions reduce from 58 to 46.4 million tonnes of CO_2. In addition, the domestic carbon duty reduces €1.02 billion, reducing the final export price to approximately €10 billion. Hence, the total export final cost reduces by 19.5% and 6.7% compared to scenarios 1 and 2.1.

Table 3.3 – Scenario 2.2 comparison with scenarios 1 and 2.1

Sectors	Price change (%) 1:3 (1)	Price change (%) 2:3 (2)
Aluminium	-9.78%	-3.38%
Iron and Steel	-19.49%	-6.73%
Electrical Energy	-25.77%	-8.90%
Fertilisers	-27.31%	-9.43%
Cement	-30.18%	-10.42%
Total Exports	-19.52%	-6.74%

Note: [6]

4.3 Scenario 3 – New trading partner

After the military invasion of Ukraine by Russia, many trading partners have sanctioned Russia, ceasing almost all exports. The Economist (2022) explains that many importers refuse to unload Russian oil freights due to their actions against Ukraine. This situation led to a 2 million barrels per day (BPD) decrease in oil exports from 2.3 million BPD. However, while some countries refuse to accept exports from Russia, others act the opposite. The Economist argues that India increased exports of Russian oil, though not much due to currency problems and simply because importing oil from the United Emirates is cheaper than Russia. However, the long Russian trading partner, China, is willing to increase its imports of Russian oil. "China could opportunistically increase its purchases to 12m BPD" (The Economist, 2022, p.64). Therefore, as with oil exports and other goods such as aluminium, iron and steel and fertiliser, this scenario will speculate on what if Russia re-directs its exports destined for the EU to China.

This scenario will consider Russia re-directing its aluminium, iron and steel and fertiliser, destined to the EU, exports to China. This scenario will not consider exports from the electricity and cement sectors, as Russia exports little cement in total, and China is more self-efficient in electricity generation. In 2020 China was the country with the highest amount of electrical energy generated in the world (Eneradata, 2021). First, this scenario will compare the rate per

[6] The price change 1:3 (1) compares prices aggregate price reduction for the EU importers, including flat carbon tax and decarbonisation of production plants. However, it does not consider that the cost of carbon tax will be added in the production cost. The price (2) 2:3 provides the actual price reduction of the Russian goods for the EU importers, considering only decarbonisation of production plants

tonne of goods between Russia and China obtained from trade data. Secondly, it will speculate on the viability of introducing a domestic carbon tax in Russia if China will design a similar CBAM mechanism domestically to protect its producers and cease the possibility of the carbon leakage problem.

4.3.1 – Chinese ETS

China is the biggest world polluter because of its fast industrialisation and increased economic growth (The Economist, 2021). However, China is one of the countries taking action to mitigate the climate change problem. In 2011 Chinese government selected seven regions to implement and test emission trading system pilots' projects (Da Zhang et al.,2014; Jotzo et al., 2014; Liu et al., 2015). These projects form the world's most extensive emissions trade system. “Chinese ETS” is part of the Chinese strategy to reduce GHG emissions by 60% by 2030 and achieve net-zero emissions by 2060. Therefore, on February 1st, 2021, the world's most extensive cap-and-trade system went live (The Economist, 2021). However, the Chinese ETS differed from the EU ETS.

While EU ETS has an absolute emissions cap, Chinese ETS rates polluters under particular criteria - size, fuel and carbon intensity (IEA, 2020). Moreover, this system does not include the entire energy sector, only 30%, nor the transport and construction industries (The Economist, 2021). "Only China's energy sector is included in trading this year. Other polluting sectors such as steel and cement are expected to be added in future cycles” (Shepherd, 2021, para. 6). Moreover, the characteristics of Chinese ETS point out that though aluminium and iron and steel are yet to be included, the price for these goods will increase due to the increased rate of fossil fuels required for production. Therefore, these are essential considerations accessing the discussion regarding whether China will implement any mechanism to protect their producers from Russian competition, like EU’s CBAM.

4.3.2 – Russian vs Chinses export rates

Table 4.1 - Scenario 3 – China’s exports from aluminium, iron and steel, and fertilisers sector

Sectors	Aluminium	Iron and Steel	Fertilisers
Total Exported (€)	€ 10,446,222,754.27	€ 3,182,384,083.27	€ 859,729,238.80
Total Exported (t)	4,738,423.39	3,900,643.16	3,636,945.87
Average price (€/t)	€ 2,204.58	€ 815.86	€ 236.39
Emissions embodied (tCO2)	26,489,754.30	8,191,350.63	9,688,823.79
Emissions per tonne (CO2/t)	5.590415233	2.1	2.664
the price difference from Russian exports (%)	19.38%	68.35%	10.41%

Source: UN comtrade (2021), Hasanbeigi 2022

For this scenario, I used UN Comdata for China to calculate the average rate for a tonne of Chinese goods from the aluminium, iron and steel, and fertilisers sectors. I divided total exports (in €) by total exports in weight (tonnes) to calculate the average price. In addition, I used a similar approach to calculate average carbon intensity only for the aluminium sector. At the same time, for the iron and steel industry, I used data on average emissions generated from the iron and steel sector in China, provided by Hasanbeigi (2022), to estimate emissions embodied in export from the iron and steel industry. To access the carbon intensity of the fertilisers sector, I used the same source as for Russia, provided by IFS.

Table 4.1 demonstrates estimates for China, while 4.2 demonstrates estimates for Russia. According to estimates, in 2020, China exported a total of €10.4 billion, €3.2 billion, and €859.7 million worth of aluminium, iron and steel, and fertilisers, respectively. The average rate for aluminium was €2,204, iron and steel €815 and fertilisers €236 per tonne. However, the average rate per tonne of goods from Russia was €1,777, €258 and €211 for aluminium, iron and steel, and fertiliser. Hence, the rate for a tonne of goods from the above sectors is lower for goods from Russia than China.

Table 4. 2 -Scenario 3 - Russia's exports from aluminium, iron and steel, and fertilisers sector (only to the EU)

Sectors	Aluminium	Iron and Steel	Fertilisers
Total Exported (€)	€ 2,321,892,429.96	€ 2,745,659,860.90	€1,616,937,903.84
Total Exported (t)	1,306,417.08	10,632,412.16	7,634,751.92
Average price (€/t)	€ 1,777.30	€ 258.23	€ 211.79
Emissions embodied	7,812,570.97	21,796,444.93	21,102,454.30
Emissions per tonne (tCO2/t)	5.98	2.05	2.76

Source: IFS (2019), UN comtrade (2021), Divin et al.

Moreover, the carbon intensity of goods from the aluminium and fertiliser sectors is lower for producers in China than those from Russia. The carbon intensity of the aluminium sector in China is 5.59 tCO2 per tonne of aluminium, 2.1 tCO2 per tonne of iron and steel, and 2.664 tCO2 per tonne of fertilisers produced. At the same time, those are 5.98 tCO2/tonne for aluminium, 2.05 tCO2/tonne for iron and steel, and 2.76 tCO2/tonne for fertilisers' producers from Russia. Hence, the trend demonstrates that although the rate for goods in mentioned above sectors from Russia is lower than those of China, the carbon intensity is higher, except for iron and steel sector. The following section will discuss the findings, comparing the different scenarios.

5 - Discussions

5.1 Scenario 1

The results of some scenarios are up to expectations, and others, however, have revealed some interesting insights. The results of scenario 1 suggest that the "no-action" scenario is the most economically unsustainable for Russian exporters. The introduction of CBAM will increase the price of Russian exports by approximately 39%, due to high CO2 intensity production, and this price increase is expected to significantly affect the competitiveness of Russian goods in the European market. The development of this scenario is consistent with the estimates presented by BCG (2020). According to their calculations, the introduction of CBAM would amount to approximately $4.5 billion in additional import duties. However, their effects evaluation of exports from Russia included sectors that are yet to be covered by CBAM, such as oil and gas fuels. At the same time, in the conducted analysis, the additional price for exports only from sectors covered by CBAM amounted to €4.6 billion, which is significantly higher, considering €80 per tonne of CO2 and accounting only for sectors covered by CBAM.

The implications for each sector covered by CBAM result in significant price increases for EU importers and a loss of competitive advantage for Russian exports. However, if Russia implements domestic climate mitigation mechanisms, like EU ETS, the domestic carbon tax will reduce the price for the EU importers. Simultaneously, revenue collected from purchasing carbon certificates, accounting for emissions direct emissions emitted during the production of exported products, could be collected by the Russian government rather than by the EU. Therefore, scenario 1 points out that CBAM is one of the main reasons the Russian government introduced the "Sakhalin trial". This statement was confirmed during the interview:

"- Do you think CBAM stimulated the development of domestic carbon tax in Russia?

[Interviewee] -Of course, it did. Even the Sakhalin trial may clarify the intentions of the European Union, which plans to introduce carbon border adjustment regulation, which will lead to higher costs for Russian exporters. If the EU recognises the pilot projects, then perhaps Russia will begin to replicate the experiment, and in the future, the Sakhalin system can be linked to foreign counterparts."

Table 5.1 – The average carbon intensity comparison of aluminium, fertilisers, electrical energy and iron and stell sectors among the EU, Russia and China

Sectors	Aluminium (tCO2/t)	Fertilisers (tCO2/t)	Electrical Energy (kgCO2/KWh)	Iron and Steel (tCO2/t)
Russia	5.98	2.76	0.55	2.05
Germany	4.17	2.35	0.33	1.75
Poland	3.76	2.35	0.33	1.75
Sweden	3.75	2.35	0.33	1.75
China	5.59	2.66	0.71	2.1

Source: ATLAS (2021), IFS (2019), UN comtrade (2021), Divin et al., (2011), Hasanbeigi 2022

Note: The data on emissions from fertilisers sectors for Germany, Poland and Sweden is given as the EU average

However, this scenario is proven functional only under the condition that the EU producers from sectors covered by CBAM apply less carbon-intensive techniques than those of Russia. If the opposite proves true, non-EU producers will maintain their completeness compared to the EU producers, weakening the functionality of CBAM and resulting in carbon leakage. To rule out this possibility, using UN Comdata, table 5.1 provides comparative data on direct emissions for the aluminium sector. Data supplied by IFS compares emissions emitted during the production of fertilisers, and the data by Divin et al. (2011), comparing the average emissions generated during the production of electrical energy. Finally, Hasanbeigi (2022) provides a comparative data for iron and steel sector. The estimates in table 5.1 demonstrate that Russia has the highest carbon intensity compared to other countries, while the EU shows the lowest.

5.2 Scenarios 2.1 and 2.2

Both scenarios 2.1 and 2.2 account for the domestic carbon tax effect, assuming the functionality of the Sakhalin trial will expand for the whole country. The recent military action against Ukraine and the imposition of sanctions against Russia might falsely suggest that the Russian government will not continue with the trial since Russia can no longer trade with the EU. However, the opposite was stated.

- *"In light of the current economic situation in Russia (sanctions from the US and EU), do you think the Russian government will proceed with the Sakhalin trial?*

- *[Interviewee] The Sakhalin trial continues, there is no information about its suspension. I am sure that the trial will be completed "*

Assuming further full domestic expansion of the Sakhalin project, scenario 2.1 shows that the introduction of a domestic carbon tax would amount to €1.3 billion, or an increase of 12 per cent in the cost of production for Russian producers. Moreover, these costs would be reduced for EU importers when purchasing carbon certificates. However, Russian exporters would be expected to include these costs in the final export price, while the tax would be levied by the sole beneficiary, the Russian government. In addition, a single carbon tax is expected to affect little the competitiveness of Russian goods on the EU market. The introduction of a domestic carbon tax will increase production costs for Russian exports by the same amount expected to reduce the price of carbon certificates. Thus, the most cost-effective outcome for EU importers is the purchase of EU goods because they are more carbon-efficient than Russian goods, resulting in lower carbon taxation. Scenario 2.2, however, shows a more positive outcome.

Incentivising the modernisation of existing production facilities to reduce their carbon intensity by 20%, combined with the domestic carbon tax, reduces the best CBAM cost for EU importers. These results align with the proposed development by Kanischev et al. (2021). The modernisation by 20% will not reduce the carbon intensity of Russian producers to the level of the EU producers. However, the modernisation of existing plants will increase its competitiveness compared to other non-EU exporters. Finally, scenario 2.2 reduces exports' aggregate cost by 6.7%. Therefore, the analysis demonstrates that scenario 2.2, reducing carbon intensity through modernisation in combination with the domestic carbon tax, is the most beneficial for both Russian producers and the EU importers, demonstrating the soundness of the Sakhalin trial project.

5.3 Scenario 3

While scenarios 1 and 2 address the economic implications of CBAM for Russia, scenario 3 involves some reconfiguration of existing export routes. As per claims by The Economist (2022) and Financial Times (2022), China may accommodate some exports destined for countries which sanctioned Russia due to its military actions against Ukraine. In that case, Chinese producers may suffer losses from the increased competition of Russian goods in the domestic market. The analysis shows that Russian goods from the aluminium, iron and steel and fertilisers sectors are, on average, sold at lower rates than Chinese goods. However, like in scenario 2, export goods from Russia are more carbon-intensive than those from China. Hence, Chinese producers may find new problems for their domestic producers by increasing the inflow of Russian goods into the local market. The possibility of this development was addressed during the interview.

- *"Do you think new trading partners will consider implementing mechanisms like CBAM to not lose a competitive advantage over Russian imports?*

- *[Interviewee] At the moment, most countries, in one way or another, are working on the introduction of mechanisms such as CBAM or similar mechanisms, and, in my opinion, this has little to do with issues of competition with the Russian Federation, but rather with general trends in the international economy."*

Though during the interview, it is stated that the development of climate mitigation mechanisms and systems by other countries has little to do with international competitiveness, the results show the opposite. First, in next future, Chinese ETS will add new sectors to reduce domestic GHG emissions (IEA, 2020; The Economist, 2021). In this case, the price of Chinese goods will increase even further, making competition with Russian producers even stronger, not including full-social costs. Secondly, due to the lower price for Russian goods, the demand for Chinese goods in the domestic market is expected to reduce, reducing the profits of Chinese manufacturers. Finally, both of these factors will create the opportunity for carbon leakage in China, reducing the efficiency of the Chinese ETS and hindering the government's plan to achieve carbon neutrality by 2060. Though it is only speculation, this analysis suggests that China may also consider introducing a carbon border adjustment mechanism to protect its domestic producers from Russian and international competition and reduce the possibility of carbon leakage.

6 - Conclusion

Since COP3, the EU has demonstrated its leadership in mitigating the environmental problem, though their efforts mainly extended to the EU region. The EU was the first to implement a cap-and-trade system – the EU ETS – in 2005. However, Nordhaus (2020) argues that Kyoto Protocol and the 2015 Paris agreement induce free-riding that undermines the efforts of both agreements. Moreover, carbon leakage is another issue that hinders the functionality of climate change mitigating systems, such as EU ETS. Hence, in 2021 the EU, again, demonstrated its leadership in climate change mitigation, introducing CBAM to address carbon leakage and free-riding issues.

CBAM is the first climate change mitigation mechanism that extends globally. Incentivising other countries to green their production and simultaneously reduce their emissions, the functionality of CBAM does not break any WTO rules of fair trade. As demonstrated in scenario 1, the introduction of CBAM would increase prices for Russian exports by 39%. Increasing export rates significantly, CBAM nudges EU's trading partners to consider implementing the domestic carbon tax or systems, like EU ETS. Therefore, in scenario 2, I calculated the effect of CBAM, considering the functionality of the Sakhalin trial diffused for the whole country.

I divided results of the scenario 2 into two parts. While the first part considered only the implications of a flat carbon tax stated in the Sakhalin trail's proposal, part two considered the implication of carbon tax combined with the modernisation of existing production facilities (reducing carbon intensity by 20%). The results demonstrated that a combination of flat carbon tax with the modernisation of existing production facilities would reduce the impact of CBAM on final export price by 6.7%, compared to scenario 1 (no-action) and scenario 2.1 (only flat carbon tax). These results lead to a conclusion showing that while sole carbon tax benefits only the Russian government, considering only economic benefits, the modernisation of production facilities also benefits Russian producers and the EU importers, reducing the overall cost of production and increasing the competitiveness of Russian goods on the global market. Hence, though it is difficult to achieve, only the combination of both will benefit both export and import parties.

All estimates in scenario 1 and scenario 2 are calculated assuming that EU producers will use more environmentally friendly and less carbon-intensive inputs to produce the same products exported from Russia. This assumption is crucial for the CBAM mechanism because, when free allowances are phased out, the EU ETS would also obligate EU producers to pay the same amount per tonne of carbon used in the production process as CBAM would require non-EU producers. If it turns out otherwise, the EU efforts to reduce carbon leakage will be ineffective, as export prices from non-EU countries will be lower than those from the EU.

Finally, in scenario 3 if Russia redirects its exports destined for the EU countries to China,
I speculate that China might consider introducing a mechanism like CBAM. This reasoning is based on results stating that Russian exports are priced lower than Chinese, though more carbon-intensive. This difference between Russian and Chinese goods may reduce the competitiveness of Chinese producers. Though the opposite was stated during the interview, the data confirms the speculation. Moreover, the same might apply if countries like Russia decide to redirect their exports to other trading partners, they might consider implementing mechanisms like CBAM to address competition. Hence, the introduction of CBAM may be a desirable measure to reduce the risk of carbon leakage and equate the competitiveness of Russian producers in China.

This paper is in line with expectations – no action scenario will be the most unfavourable for Russia, while introducing a domestic carbon tax and reducing overall carbon intensity is the most beneficial. However, many other factors have to be accounted for while analysing the impacts of CBAM. If production cost combined with the price for carbon certificates in some countries will be lower than production in the EU, this result will undermine the CBAM functionality. Therefore, further research is required to analyse the possibility of such a scenario, as well as a more detailed input/output analysis of the industries covered by CBAM.

7- References:

Aylor, B., Gilbert, M., Kosach, A., Lang, N., Macadu, M., Oberg, J., Parapechk, S., Piper, C., Polunin, K., Sudmeijer, B., Voigt, N., 2020. How an EU Carbon Border Tax Could Jolt World Trade. BCG, [Online]. 24. Available at: [Accessed 1 December 2021].

Balashov M.M. (2020). The impact of carbon regulation mechanisms on the development of industry in the Russian Federation. Strate-
gic Decision and Risk Management, 11(4), 354-365. DOI: 10.17747/2618-947X-2020-4-354-365.

Baumert, N., Kander, A., Jiborn, M., Kulionis, V. and Nielsen, T., 2019. Global outsourcing of carbon emissions 1995–2009: A reassessment. *Environmental science & policy*, *92*, pp.228-236.

Berahab, R., 2022. Is the EU's Carbon Border Adjustment Mechanism a Threat for Developing Countries? *Policy Center for the New South*, [Online]. Available at: https://www.policycenter.ma/opinion/eus-carbon-border-adjustment-mechanism-threat-developing-countries [Accessed 3 May 2022].

Bravo Gallegos, M., van Asselt, H. and Suljada, T. (2022). *Swedish policy positions and perspectives on CBAM*. SEI discussion brief. https://doi.org/10.51414/sei2022.004

BP (2021). Statistical Review of World Energy [Database], [Accessed 21 February 2022]. Available from: https://www.bp.com/en/global/corporate/energy-economics/statisticalreview-of-world-energy.html

Buchanan, J.M., 1965. An economic theory of clubs. Economica, 32(125), pp.1-14.

CARB, 2014. Assembly Bill 32 overview. California Air Resources Board [Available]:
Carbon Border Adjustment Mechanism: Questions and Answers. 2021. European Comission. [ONLINE] Available at: https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661. [Accessed 3 May 2022].

Chatham House (2021), '*resourcetrade.earth*' [DATA], https://resourcetrade.earth/
Eckert, E. and Kovalevska, O., 2021. Sustainability in the European Union: analyzing the discourse of the European green deal. *Journal of Risk and Financial Management*, *14*(2), p.80.

EIA. 2021. How much carbon dioxide is produced per kilowatthour of U.S. electricity generation? [ONLINE] Available at: https://www.eia.gov/tools/faqs/faq.php?id=74. [Accessed 4 May 2022].

Elektroenergetika 2020: neodnoznachnye rezultaty neprostogo goda [Electricity 2020: ambiguous results of a challenging year]. 2021. Ria Rating. [ONLINE] Available at: https://riarating.ru/macroeconomics/20210310/630196308.html. [Accessed 4 May 2022].

Elkerbout, M., Egenhofer, C., Núñez Ferrer, J., Catuti, M., Kustova, I. and Rizos, V., 2020. The European Green Deal After Corona: Implications for EU Climate Policy. *CEPS Policy Insights, 6*.

EMBER. 2022. Carbon pricing. [ONLINE] Available at: https://ember-climate.org/data/data-tools/carbon-price-viewer/. [Accessed 4 May 2022].

Enerdata. 2021. World Energy & Climate Statistics – Yearbook 2021. [ONLINE] Available at: https://yearbook.enerdata.net/. [Accessed 4 May 2022].

EU Comission. 2022. Russia, EU trade relations with Russia. Facts, figures and latest developments.. [ONLINE] Available at: https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/russia_en. [Accessed 1 May 2022].

European Council. 2022. Council agrees on the Carbon Border Adjustment Mechanism (CBAM) – press release. [ONLINE] Available at: https://www.consilium.europa.eu/en/press/press-releases/2022/03/15/carbon-border-adjustment-mechanism-cbam-council-agrees-its-negotiating-mandate/. [Accessed 5 May 2022].

EU ETS Handbook. 2015. EU Comissions. [ONLINE] Available at: https://www.sallan.org/pdf-docs/ets_handbook_en.pdf. [Accessed 3 May 2022].

European Commission (2021) Regulation of The European Parliament And Of The Council (2021/0214 (COD)) Brussels, 14.7.2021. [Online]. Available at: https://ec.europa.eu/info/sites/default/files/carbon_border_adjustment_mechanism_0.pdf [Accessed 1 January 2022].

European Commission, 2021.Carbon Border Adjustment Mechanism: Questions and Answers, [Online]. Available at: https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661 [Accessed 1 January 2022].

European Commission, Directorate-General for Climate Action, Review of the EU ETS market stability reserve: *Final Report*, 2021, https://data.europa.eu/doi/10.2834/046513 [Accessed 3 May 2022].

Federalniii zakon "O provedenii eksperementa po ustanovleniju specialnogo regulirovaniya vybrosov i poglosheniya parnikovyx gazov v Sahalinskoj oblasti" [FEDERAL LAW On an experiment to establish special regulation of greenhouse gas emissions and removals in Sakhalin Oblast] Avalibale at: https://ecology.sakhalin.gov.ru/climate-project/about-climate-project/35-proekt-federalnogo-zakona-o-provedenii-jeksperimenta-po-ustanovleniju-specialnogo-regulirovanija-vybrosov-i-pogloschenija-parnikovyh-gazov-v-sahalinskoj-oblasti.html [Last accessed 1 April, 2022]

Federalniii zakon ot 02.07.2021 № 296-ФЗ "Ob ogranichenii vybrosov parnikovyh gazov" [Federal Law of 02.07.2021 No. 296-FZ On limiting greenhouse gas emissions] [online] Avalibale at: http://publication.pravo.gov.ru/Document/View/0001202107020031 [Last accessed 1 May, 2022]

Fernández-Delgado, M., del Amo-Mateos, E., Lucas, S., García-Cubero, M.T. and Coca, M., 2020. Recovery of organic carbon from municipal mixed waste compost for the production of fertilizers. *Journal of Cleaner Production*, *265*, p.121805.

Federation Council of The Federal Assembly of The Russian Federation. 2022. Sakhalin Region. [ONLINE] Available at: http://council.gov.ru/en/structure/regions/SAK/ . [Accessed 2 May 2022].

Golyashev, A., Skryabina, V., Kudrin, A., Kolomiec, A. and Fedorenko, D., 2021. Transgranichnoe uglerodnoe regulirovanie: vyzovy i vozmozhnosti [Cross-border carbon regulation: challenges and opportunities]. *Analytical Center for the Government of the Russian Federation*, [Online]. n98, 23.

Grikevich, D. and Melkin, V., 2021. V pravitelstve gotovyat rosiskii variant uglerodnogo sbora ES [The government is preparing a Russian version of the EU carbon levy]. *Vedomosti*, [Online]. Available at: https://www.vedomosti.ru/economics/articles/2021/09/22/887822-vlasti-uglerodnogo-naloga [Accessed 1 May 2022].

Hasanbeigi, A., Price, L., Chunxia, Z., Aden, N., Xiuping, L. and Fangqin, S., 2014. Comparison of iron and steel production energy use and energy intensity in China and the US. *Journal of Cleaner Production*, *65*, pp.108-119.

Hasanbeigi, A., 2020. Part 1: Cleanest and Dirtiest Countries for Primary Steel Production. *Global Efficiency Inteligence*, [Online]. 1, 1. Available at: https://www.globalefficiencyintel.com/new-blog/2020/cleanest-dirtiest-countries-primary-steel-production-energy-co2-benchmarking [Accessed 10 May 2022].

Heitzig, J., Lessmann, K. and Zou, Y., 2011. Self-enforcing strategies to deter free-riding in the climate change mitigation game and other repeated public good games. Proceedings of the National Academy of Sciences, 108(38), pp.15739-15744

Hovi, J., Sprinz, D.F., Sælen, H. and Underdal, A., 2016. Climate change mitigation: a role for climate clubs?. Palgrave Communications, 2(1), pp.1-9.

Hoxha, A. and Christensen, B., (2019). 'The Carbon Footprint of Fertiliser Production: Regional Reference Values', *International Fertiliser Society at a Conference in Prague, Czech Republic*. Prague, Czech Republic, 8th May 2018. ISBN 978-0-85310-442-1: International Fertiliser Society, pp.4-20.

IEA (2020), China's Emissions Trading Scheme, IEA, Paris https://www.iea.org/reports/chinas-emissions-trading-scheme

IEA (2020), *Iron and Steel Technology Roadmap*, IEA, Paris https://www.iea.org/reports/iron-and-steel-technology-roadmap

IEA (2020), Renewables 2020, *IEA*, Paris https://www.iea.org/reports/renewables-2020
Jakob, M., 2021. Why carbon leakage matters and what can be done against it. One Earth, 4(5), pp.609-614.

Jotzo, F. and Löschel, A., 2014. Emissions trading in China: Emerging experiences and international lessons. *Energy Policy*, *75*, pp.3-8.

Kander, A, Malanima, P & Warde, P 2013, Power to the People - Energy in Europe over the last five Centuries. Mokyr (ed.) Princeton Economic History of the Western World, Princeton University Press. (p. 286; 330)

Kanischev, M., 2021. Princypy i podhody k ustanovleniu stavki karbonovogo naloga i reaizacii proektov po karbonovoj efektivnosti v Rosiiskoj Federacii [Principles and approaches for setting the carbon tax rate and implementing carbon efficiency projects in the Russian Federation]. *ANSELM*.

Korsunskaya, D., Marrow, A., 2021. Russia considering own carbon tax as EU prepares one - Vedomosti, J. Neely, ed. Nasdaq. Available at: https://www.nasdaq.com/articles/russia-considering-own-carbon-tax-as-eu-prepares-one-vedomosti-2021-09-23 [Accessed January 6, 2022].

Lee, B. and Baron, R., 2021. Why the EU's proposed CBAM must not be used to launch a carbon club. *World Economic Forum*, [Online]. Available at: https://www.weforum.org/agenda/2021/06/eu-carbon-border-clubs-climate-cbam/ [Accessed 4 May 2022].

Liu, L., Chen, C., Zhao, Y. and Zhao, E., 2015. China′ s carbon-emissions trading: Overview, challenges and future. *Renewable and Sustainable Energy Reviews*, *49*, pp.254-266.

Mathieu, C., Barichella, A., de Perthuis, C. and Nagashima, M., 2021. Can the Biggest Emitters Set Up a Climate Club? A Review of International Carbon Pricing Debates. *Études de l'Ifri*, [Online]. Available at: https://www.ifri.org/en/publications/etudes-de-lifri/can-biggest-emitters-set-climate-club-review-international-carbon [Accessed 4 May 2022].

Mazzucato, M., 2019. Europe's Green Deal could be the most important in a generation. *Financial Times*, [Online]. Available at: https://www.ft.com/content/2f5bbdf6-1aab-11ea-81f0-0c253907d3e0 [Accessed 1 May 2022].

Mechanisms under the Kyoto Protoco. 2022. UNFCCC. [ONLINE] Available at: https://unfccc.int/process/the-kyoto-protocol/mechanisms. [Accessed 3 May 2022].

Mitsui & Co. Global Strategic Studies Institute (MGSSI). 2021. Russia's Climate Change Measures Entering a Transitional Period — Analysis In Terms Of Increase And Decrease. [ONLINE] Available at: https://www.mitsui.com/mgssi/en/report/detail/__icsFiles/afieldfile/2021/12/08/2111e_kitade_e.pdf. [Accessed 1 May 2022].

National oil and gas service association. 2022. VRP Sakhalinskoy oblasti v 2021g mozhet sokratitsya na 6.9% iz-za padeniya dobuchi nefti [Sakhalin Oblast GRP may shrink by 6.9% in 2021 due to decline in oil production]. [ONLINE] Available at: https://nangs.org/news/economics/vrp-sakhalinskoj-oblasti-v-2021g-mozhet-sokratitsya-na-6-9-iz-za-padeniya-dobychi-nefti. [Accessed 2 May 2022].

Nielsen, T., Baumert, N., Kander, A. *et al.* The risk of carbon leakage in global climate agreements. *Int Environ Agreements* **21,** 147–163 (2021). https://doi.org/10.1007/s10784-020-09507-2

Nogrady, B., 2021. China launches world's largest carbon market: but is it ambitious enough?. *Nature*, [Online]. Available at: https://www.nature.com/articles/d41586-021-01989-7%20 [Accessed 1 May 2022].

Nordhaus, W., 2015. Climate clubs: Overcoming free-riding in international climate policy. American Economic Review, 105(4), pp.1339-70.

Nordhaus, W., 2020. The climate club: how to fix a failing global effort. Foreign Aff., 99, p.10.

Pamuk, H. and Landay, J., 2022. U.N. General Assembly in historic vote denounces Russia over Ukraine invasion. *Reuters*, [Online]. Available at: https://www.reuters.com/world/un-general-assembly-set-censure-russia-over-ukraine-invasion-2022-03-02/ [Accessed 1 May 2022].

Potoski, M. and Prakash, A., 2005. Green clubs and voluntary governance: ISO 14001 and firms' regulatory compliance. American journal of political science, 49(2), pp.235-248.

Prakash, A. and Potoski, M., 2007. Collective action through voluntary environmental programs: A club theory perspective. Policy Studies Journal, 35(4), pp.773-792.

Principles of the trading system. nd. WTO. [ONLINE] Available at: https://www.wto.org/english/thewto_e/whatis_e/tif_e/fact2_e.htm. [Accessed 3 May 2022].

PWC. 2021. Carbon Border Adjustment Mechanism. [ONLINE] Available at: https://www.pwc.nl/en/services/tax/managing-tax-and-energy-transition/fit-for-55/carbon-border-adjustment-mechanism.html. [Accessed 5 May 2022].

Shepherd, C., 2021. China's carbon market scheme too limited, say analysts. *Financial Times*, [Online]. Available at: https://www.ft.com/content/3bcc2380-8544-4146-ba71-83944caff48d [Accessed 4 May 2022].

Shul'ga, J., 2021. Ustoichevoee razvitie i ekologiya v metalurgii: obzor deyatelnosti rossijskih kompanij [Sustainability and the environment in the metals industry: a review of Russian companies]. *Forbes Russia*, [Online]. 1, 1. Available at: https://www.forbes.ru/obshchestvo/432897-ustoychivoe-razvitie-i-ekologiya-v-metallurgii-obzor-deyatelnosti-rossiyskih [Accessed 1 May 2022].

Tagliapietra, S. and Wolff, G.B., 2021. *Form a climate club: United States, European Union and China.*

Tagliapietra, S. and Zachmann, G., 2020. Europe's Green Deal must reach beyond its borders. *Financial Times*, [Online]. Available at: https://www.ft.com/content/5119df68-727a-4c4f-8325-fa337c6f8762 [Accessed 1 May 2022].

The Economist. 2021. Can China's new carbon market take off?. [ONLINE] Available at: https://www.economist.com/finance-and-economics/what-can-russia-do-to-sell-its-unwanted-oil/21808447. [Accessed 4 May 2022].

The Economist. 2021. The EU proposes a carbon tariff on some imports. [ONLINE] Available at: https://www.economist.com/finance-and-economics/2021/07/15/the-eu-proposes-a-carbon-tariff-on-some-imports. [Accessed 3 May 2022].

The Economist. 2021. What is the European Green Deal?. [ONLINE] Available at: https://www.economist.com/the-economist-explains/2021/06/01/what-is-the-european-green-deal. [Accessed 1 May 2022].

The Economist. 2022. What can Russia do to sell its unwanted oil?. [ONLINE] Available at: https://www.economist.com/finance-and-economics/what-can-russia-do-to-sell-its-unwanted-oil/21808447. [Accessed 4 May 2022].

The Growth Lab at Harvard University. (2019). "Growth Projections and Complexity Rankings, V2" [Data set]. https://doi.org/10.7910/dvn/xtaqmc

Tihonov, S., 2021. Seti so zdorovym pitaniem [Networks with healthy consumption]. *Rosijskaya gazeta*, [Online]. 1, 1. Available at: https://rg.ru/2021/03/28/kak-ustroen-rossijskij-energeticheskij-balans.html [Accessed 4 May 2022].

Trading Economics. 2022. EU Carbon Permits. [ONLINE] Available at: https://tradingeconomics.com/commodity/carbon. [Accessed 6 May 2022].

UNFCCC (2008) Kyoto Protocol Reference Manual on Accounting of Emissions And Assigned Amount. ISBN: 92-9219-055-5.

Protocol, K., 1997. Kyoto protocol. *UNFCCC Website. Available online: http://unfccc. int/kyoto_protocol/items/2830. php (accessed on 1 January 2011)*.

Unger, C., Thielges, S. Preparing the playing field: climate club governance of the G20, Climate and Clean Air Coalition, and Under2 Coalition. *Climatic Change* **167,** 41 (2021). https://doi.org/10.1007/s10584-021-03189-8

Van Renssen, S., 2020. The hydrogen solution?. *Nature Climate Change*, 10(9), pp.799-801.
Victor, D.G., 2011. Global warming gridlock: creating more effective strategies for protecting the planet. Cambridge University Press.

Vygon Consulting. 2022. V strategii nizkoulrednogo razvitiiya slishkom malo govoritsya o tehnologiyax ulavlivaniya i ispolzovani CO2 [The Low Carbon Development Strategy says too little about CO2 capture and use technologies]. [ONLINE] Available at: https://vygon.consulting/pressroom/our-publications/1945/. [Accessed 1 May 2022]. www.arb.ca.gov/cc/ab32/ab32.html.

Wikipedia (2015) *Map of Russia - Sakhalin Oblast*. [ONLINE]. Available at: https://en.wikipedia.org/wiki/File:Map_of_Russia_-_Sakhalin_Oblast.svg [Accessed 10 May 2022].

Xu, Q. and Hobbs, B.F., 2021. Economic efficiency of alternative border carbon adjustment schemes: A case study of California Carbon Pricing and the Western North American power market. Energy Policy, 156, p.112463.

Zhang, D., Karplus, V.J., Cassisa, C. and Zhang, X., 2014. Emissions trading in China: Progress and prospects. *Energy policy*, *75*, pp.9-16. ETS CHINA

7 - Appendix – The interview

[1]

- *How much do you know about the Sakhalin trial? What is the main objective of the Sakhalin trial?*

- *[Interviewee] The aim of the experiment is to achieve carbon neutrality in the territory of the subject of the Russian Federation.*

- *[…] Among the tasks of the experiment are named: stimulation of implementation of technologies to reduce greenhouse gas emissions and increase their absorption; formation of a system of independent verification; creation of a system of circulation of carbon units and units of fulfilment of the quota."*

[2]

- *"What were the influences (motivation) behind the carbon tax design?*

- *[Interviewee] The quote and trading system is the most effective mechanism for achieving carbon neutrality, which has proven effective in international markets."*

- *[…] Achieving carbon neutrality in Sakhalin is much easier than in other areas of the country. Total greenhouse gas emissions for 2019 were 12 million 333 thousand tons and removals were 11 million 068 thousand tons. The difference was 1 million 265 thousand tons".*

[3]

- *"Is the carbon tax used for the Sakhalin trial a flat tax for emissions above the quote, or a cap-and-trade system, like EU ETS?*

- *[Interviewee] The experiment introduces quotas (caps) for greenhouse gas emissions and obliges regional regulated organisations to comply with the established quota (cap)."*

[4]

- *"What is the firms' selection process subject to carbon taxation under the Sakhalin trial? (How do they select firms?)"*

- *[Interviewee] "The criterion for qualification as a regulated entity will be the performance by a legal entity or individual entrepreneur of economic and (or) other activities accompanied by GHG emissions, the mass of which in total is equivalent to 150 thousand tons of carbon dioxide per year or more (for 2022-2023)."*

[5]

- *"What were the influences (motivation) behind the carbon tax design?*

- *[Interviewee] The quote and trading system is the most effective mechanism for achieving carbon neutrality, which has proven effective in international markets."*

- *[…] Achieving carbon neutrality in Sakhalin is much easier than in other areas of the country. Total greenhouse gas emissions for 2019 were 12 million 333 thousand tons and removals were 11 million 068 thousand tons. The difference was 1 million 265 thousand tons"*.