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Research Article

Carbon Leakage Concept after Carbon Pricing & Green Deal Policies

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Abstract

As part of the European Green Deal, EU nations are required to decrease their carbon emissions by 55% by 2030 and reach carbon neutrality by 2050. The EU's emissions trading system is the cornerstone of this goal. In theory, rising carbon prices may cause carbon leakage, or the transfer of economic activity and related emissions from high-carbon economies to low-carbon economies. Losing market share to rivals in international rivalry might result in short-term international carbon leakage. In the long term, it can be accomplished by moving domestic businesses abroad. To date, a variety of tools, including offsets and free allowances granted under the ETS, have been used to support the carbon leakage risk of high-risk industries. This paper develops an international technique, the EU Emissions Trading Scheme (ETS) Phase IV consultation, to produce a sector-level risk assessment of carbon leakage in Türkiye. This methodology combines emissions intensity and trading intensity, two important indicators for assessing carbon leakage risk. Although the former is commonly employed as a measure of a company's exposure to carbon costs, the latter indicates its ability to pass on costs to customers without losing market share. According to the carbon risk study carried out in Türkiye for the aluminium, cement, paper, fertilizer, iron-steel, and ceramics sectors, cement has the highest risk, while paper carries the lowest risk. For Türkiye, it is important to consider the risk of carbon leakage, in particular emission intensity and trade intensity, in order to accelerate and facilitate low-carbon development.

Keywords: *European Green Deal, CBAM, Carbon Leakage, Carbon Pricing, ETS, EU ETS*

JEL Classification: *Q54, Q56, E27*

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Karbon Fiyatlandırmasından Sonra Karbon Sızıntısı Kavramı & Yeşil Anlaşma Politikaları

Öz

Avrupa Yeşil Mutabakat kapsamında, AB ülkeleri karbon emisyonlarını 2030 yılına kadar %55 oranında azaltmaları ve 2050 yılına kadar karbon nötrlüğüne ulaşmaları gerekmektedir. AB'nin emisyon ticaret sistemi bu hedefin temel taşıdır. Teorik olarak, artan karbon fiyatları karbon kaçağına veya ekonomik faaliyetlerin ve ilgili emisyonların yüksek karbonlu ekonomilerden düşük karbonlu ekonomilere aktarılmasına neden olabilir. Uluslararası rekabette pazar payının rakiplere kaptırılması, kısa vadede uluslararası karbon kaçağına neden olabilir. Uzun vadede ise bu durum yerli işletmelerin yurtdışına taşınmasıyla gerçekleşebilir. Bugüne kadar, yüksek riskli endüstrilerin karbon kaçağı riskini desteklemek için denkleştirmeler ve ETS kapsamında verilen ücretsiz tahsisatlar da dahil olmak üzere çeşitli araçlar kullanılmıştır. Bu çalışma, Türkiye'de karbon kaçağına ilişkin sektör düzeyinde bir risk değerlendirmesi oluşturmak için uluslararası bir teknik olan AB Emisyon Ticareti Programı (ETS) Faz IV istişaresini geliştirmektedir. Bu metodoloji, karbon kaçağı riskini değerlendirmek için iki önemli gösterge olan emisyon yoğunluğu ve ticaret yoğunluğunu birleştirmektedir. Bunlardan ilki genellikle bir şirketin karbon maliyetlerine maruz kalmasının bir ölçüsü olarak kullanılırken, ikincisi şirketin pazar payını kaybetmeden maliyetleri müşterilere aktarma kabiliyetini göstermektedir. Türkiye'de alüminyum, çimento, kağıt, gübre, demir-çelik ve seramik sektörleri için yapılan karbon kaçağı riski çalışmasına göre, çimento en yüksek riske sahipken, kağıt en düşük riski taşımaktadır. Türkiye için karbon kaçağı riski, özellikle emisyon yoğunluğu ve ticaret yoğunluğu göz önünde bulundurularak hareket edilmelidir, böylece düşük karbonlu kalkınmaya ulaşmak daha hızlı ve kolay olacaktır.

Anahtar Kelimeler: *Avrupa Yeşil Mutabakatı, SKDM, Karbon Kaçağı, Karbon Fiyatlandırması, ETS, AB ETS*

JEL Sınıflandırması: *Q54, Q56, E27*

1. Introduction

In the European Green Deal announced on 11 December 2019, the European Union (EU) set the target of the first climate-neutral continent in 2050. The EU stated that it will adopt a new growth strategy to achieve this goal and reshape all its policies on the axis of climate change (European Commission, 2019). In this regard, the European Commission implemented the "Fit for 55" legislative amendment package, which aims to evaluate the EU's energy, land use, transportation, and taxation policies in order to achieve a 55% decrease in emissions from 1990 levels by 2030. The Carbon Border Adjustment Mechanism (CBAM) is a crucial component of the package that will impact global trade, as it is being applied for the first time ever.

Türkiye has announced that it will decrease its greenhouse gas (GHG) emissions by 41% by 2030 compared to Türkiye's first Nationally Determined Contributions (NDC) Business as Usual (BAU) scenario. In Türkiye's first updated NDC, 2012 is considered the base year (reference year) of the scenario and is economy-wide (Türkiye’s NDC, 2023). Türkiye, which has a long-term goal of peaking its emissions by 2038 at the latest and achieving net-zero emissions by 2053, is evaluating the role of carbon pricing in helping it achieve this goal. However, once Türkiye starts to implement carbon pricing, the country's emission-intensive and trade-exposed sectors may be at risk of carbon leakage if their international competitors do not. The term "carbon leakage" describes the scenario that could occur if companies relocate their manufacturing to another nation with less stringent emission regulations because of the expenses associated with climate legislation. The overall amount of emissions may rise as a result (European Commission, 2021). Carbon pricing mechanisms are defined as a cost-effective market-based policy instrument to reduce greenhouse gas emissions and combat climate change. Different carbon pricing mechanisms provide different frameworks and incentives to reduce emissions. Carbon markets impose a limit on emissions on companies in order to meet emission reduction targets set by governments. There are two widely used carbon pricing mechanisms in the world. These are the emissions trading scheme and the carbon tax (ICAP, 2024). So far, 75 global carbon pricing initiatives—36 emission trading systems and 39 carbon taxes—have been put into place or are planned for deployment (World Bank, 2024).

In the literature, there are many studies on carbon leakage risk and considerable progress has been made in investigating carbon leakage problems, especially in terms of leakage level assessment and prevention measures. More thorough and methodical analyses are needed to accelerate research on this important but difficult issue, as most studies are limited to a few specific areas. This paper presents a comprehensive review of the literature on the subject of carbon leakage in the context of differentiated climate policies in Türkiye. It also performs a detailed carbon leakage risk calculation for a number of key industrial sectors, including aluminium, cement, paper, fertiliser, iron-steel and ceramics, for the year 2021. Finally, it offers a number of recommendations for future research on climate policies. To undertake this review, this paper provided answers to the following queries. (1) What are the causes and reasons behind carbon leakage? (2) How can the danger of sectoral carbon leakage be evaluated? And (3) What should be taken into account in future studies to create and assess climate policies more fairly and efficiently? This is how the rest of the paper is structured. The research framework and methodology are presented in Section 2. The method and contributing causes for carbon leakage are explained in Section 3. The sectoral carbon leakage risk computation and interpretation are summed up in Section 4. Conclusions and recommendations for further study are provided in Section 5.

2. Methodology

A quantitative analysis in the form of an evaluation of the risk of carbon leakage at the sector level was used for the selection process. This analysis is based on modelling results for six sectors according to the EU ETS Phase 4 international methodology, which is appropriate for use in the Turkish context. As seen in Table 1, this methodology is determined using the trade intensity and emission intensity measures.

Although there are many carbon leakage risk assessment methodologies, it was preferred to use this method since the currently accepted method in the EU is EU ETS Phase 4. The EU Commission establishes a list of carbon leakage for each period of the ETS; the list of carbon leakage for the fourth period, covering the years 2021-2030, is calculated according to the benchmarks of each installation in a sector or sub-sector. Furthermore, when analysing the formulation in Table 1 below, it is estimated that this method is the most accurate method to understand the realisation rate of green transformation in production in regard to technological infrastructure and capacity and the large number of trading partners that Türkiye has. The level of economic development, industrial structure, level of urbanisation, government interventions, structure of energy consumption and dependence on foreign trade are some of the factors that determine carbon emission intensity (Sun, 2022).

Table 1: EU ETS Phase 4 (2021-2030) method according to the carbon leakage list

Methodology	Measurement	Contents
EU ETS Phase 4	Emission intensity x Trade intensity > 20%	**Trade intensity**: (import + export)/(import + production) **Emission intensity:** $kgCO_2$/Gross Value Added

Source: (European Commission, 2018)

The study utilises a comprehensive dataset that includes a consistent representation of the identified sectors, as well as production and trade flows for 2021 and detailed calculations of emissions versus gross value added. This mixed dataset is based on data from the Turkish Statistical Institute (TurkStat). The database covers the classification of 6 sectors in Türkiye according to their Scope 1 emissions, and the base year for calculations is 2021.

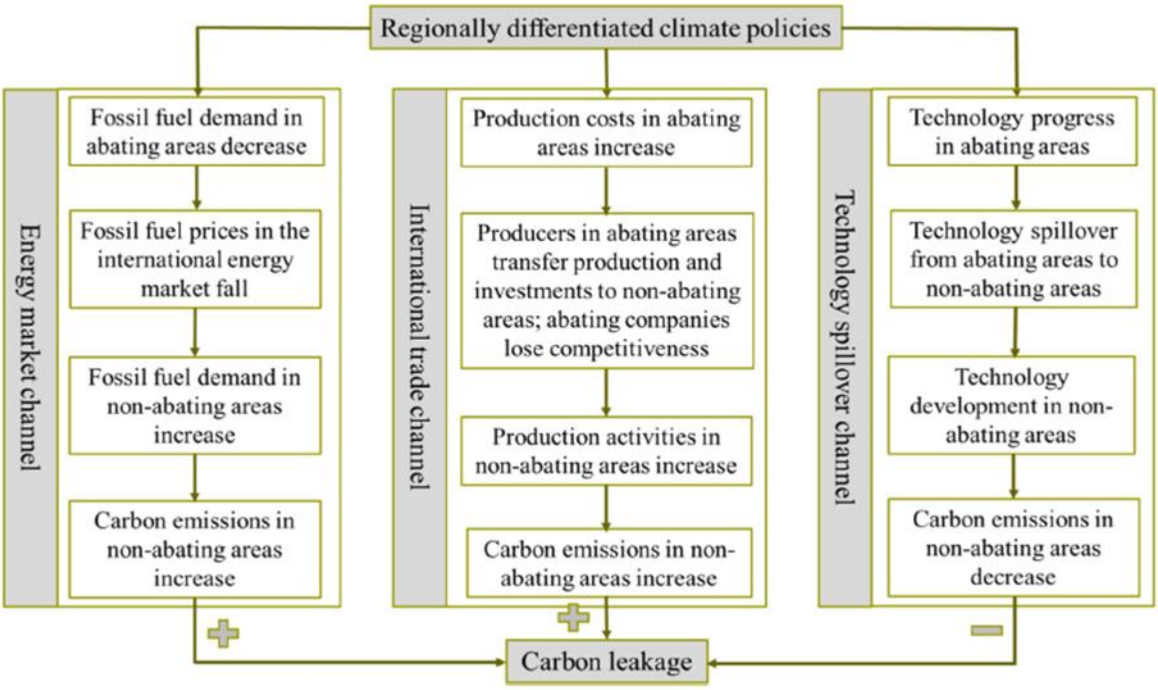
The four-digit NACE Rev. 2, which corresponds to the sector classification employed by the European Commission in its carbon leakage assessment, is linked to the sector classification. Since the NACE classification is a hierarchical system, there is a positive correlation between the number of stages and the level of detail.

3. Causes and Affecting Factors of Carbon Leakage

'Carbon leakage' refers to the possibility that businesses would relocate their carbon-intensive operations to nations with more climate-friendly policies and lower production costs than they would have in their original location. Direct and indirect carbon leakage are the two main forms of carbon leakage that can be identified. Despite extensive research on this topic, it is unclear from empirical data how often carbon leakage occurs (Grebe, 2023).

Carbon leakage is one of the primary barriers to taking climate policies further in support of climate governance (Yu et al. 2021). Before measuring carbon leakage, it is necessary to understand how and why carbon leakage occurs and the main factors affecting it. Then, ways to prevent carbon leakage should be sought. Existing research on carbon leakage includes three channels (Tan et al., 2018). As can be seen from Figure 1, the energy market channel and the international trade channel generally reduce the effectiveness of climate policies by creating carbon leakage (expanding carbon leakage) and hurting the economy and the environment. International technology spillovers, on the other hand, are typically thought to lower the danger of carbon leakage (Yu et al. 2021). Given that the primary cause of greenhouse gas emissions is the burning of fossil fuels, there is little question that the energy market plays a significant role in the implementation of climate policy. According to the international energy market channel, when some regions enact policies aimed at reducing emissions, this will decrease demand for fossil fuels in those regions that have done so. This could also result in a drop in the price of fossil fuels on the global energy market, which would then increase demand for fossil fuels in non-mitigating regions and raise emissions.

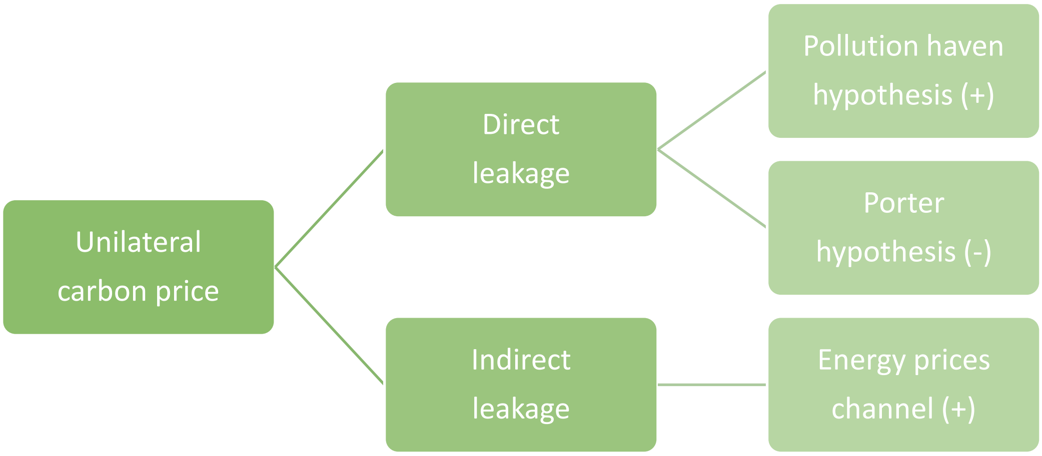
Figure 1: **Mechanism of Carbon Leakage (Yu et al. 2021).**



3.1. How and Why Does Carbon Leakage Happen?

The relocation of manufacturing operations to nations with no or reduced greenhouse gas prices is referred to as "direct carbon leakage". Operational leakage refers to the movement of production shares inside a multinational corporation, while investment leakage refers to the building or acquisition of new production facilities (Zachmann and McWilliams, 2020). Conversely, the phenomenon of "indirect carbon leakage" is triggered by a decline in domestic demand, which occurs as a consequence of initiatives aimed at curbing the utilisation of fossil fuels in order to mitigate the effects of climate change. The price of these fuels on the global market decreases in tandem with a decline in demand. In nations without CO2 pricing, a lower market price increases demand for fossil fuels, preventing the realization of global emission reductions (Grebe, 2023).

Figure 2: Theoretical pathways of carbon leakage (+/- positive or negative leakage rates)



There is concern that more strict or unilateral climate laws may result in (1) market share loss to foreign competitors who emit greater pollution and (2) increasing emissions in other regions due to carbon leakage (Kartensen et al, 2018).

3.2. How to Solve Carbon Leakage?

There are many recommendations and new mechanisms in the literature and policymakers to prevent and reduce carbon leakage. The EU ETS's strategy to prevent carbon leakage is based on the free allocation of more emission allowances to economic sectors that the European Commission deems more likely to experience carbon leakage than not. Additionally, industries that are vulnerable to carbon leaks are compensated for the expenses of CO2 that are borne by them through electricity rates (Grebe, 2023). On the other hand, the CBAM will minimize the risk of carbon leakage by gradually reducing free allowances and eventually eliminating them. Beginning on October 1, 2023, iron and steel, cement, aluminium, fertilizer, power, and hydrogen products will be included in the first stage of the CBAM reporting procedure. As part of the implementation, carbon emissions from the manufacturing of these products that are imported into the EU as well as (indirect) emissions from the generation of power utilized in industrial processes will be recorded during the transition period until January 1, 2026.

Starting from 1 January 2026, in the actual implementation period, carbon fees will start to be paid for the emissions embedded in imported products by the importers authorised in the EU, taking into account the weekly carbon prices in the EU ETS, and indirect emissions in the cement and fertiliser sectors will also be subject to remuneration. Free allowances provided to European producers in the EU ETS within the scope of the CBAM will also be taken into account in a way to reduce the financial obligation. On the one hand, free allowances in the EU ETS will be cancelled within the framework of a certain reduction schedule in the period 2026-2034, while at the same time, the CBAM financial obligations will increase at the same rate (EU CBAM Regulation, 2023).

Output-based rebating funds (OBR) for emission tax payments and output-based free allocation of permits are two other techniques (Böhringer et al., 2017). The key distinction between CBAM and OBR is centered on financial incentives. OBR encourages domestic manufacturing, while CBAM limits the foreign supply of commodities exposed to commerce and high emissions to the controlled nation. This is due to the OBR's implicit production subsidy function (Böhringer and Lange, 2005). Put another way, the OBR reduces the incentives for consumers to move from buying items with high emissions to those with lower emissions. The OBR will continue to encourage the manufacture of items that are exposed to trade and have high emissions, even though CBAM will take some time to be implemented internationally.

Another insight is policy-induced carbon leakage. It refers to companies moving their emission-intensive operations abroad to evade regulations, precluding many of the possibilities for mitigation policies in the case of trade-exposed production with high emissions, given that such investments are likely to shift to regions with weaker climate policies (Grubb et al., 2022).

Supporting the low-carbon manufacturing of goods whose manufacture is associated with high-carbon emissions would be a better course of action. First, bolstering long-term competitiveness in sectors that are already high in carbon is possible through governmental support. Secondly, it might give the globe access to the technology required for significant decarbonization. One way to do this is by paying for production that produces less carbon dioxide (Zachmann and McWilliams, 2020). Policymakers could define emissions criteria for disruptive low-carbon alternatives for steel, cement, pulp and paper, aluminium, and other products.

4. Carbon Leakage Measurement and Sectoral Effects

The EU Commission determines a carbon leakage list for each ETS period. The Carbon Leakage List of the 4th period covering 2021-2030, is calculated based on the benchmarks of each facility of a sector or sub-sector. However, it is important to note that free allocations will be phased out gradually until 2030. This is because free allocations have a significant financial value, which gives the Carbon Leakage List an economic value (European Commission, 2018).

The number of free allocations that each of the following rules has been awarded to a (sub-) installation i in sector s:

$Allocation_{ist}$ = $benchmark_i$ x historic activity $level_i$ x reduction or correction $factor_{it}$ x carbon leakage exposure $factor_{st}$

Based on quantitative criteria, which comprise two factors: trade intensity and carbon intensity, sectors are frequently classified as hazardous with respect to carbon leakage (Ulmer, 2022). Both factors might be interpreted as estimations of the risk that producers in unregulated areas would lose market share if the increased costs resulting from a national ETS are passed on to the customer. While trade intensity estimates the likelihood that the cost increase will be passed on to consumer prices, carbon intensity measures the amount of potential cost increase (Juergens et al. 2013).

Table 2: Products analysed for carbon leakage risk

NACE Code	Description
1712	Manufacture of paper and paperboard
2015	Manufacture of fertilisers and nitrogen compounds
2331	Manufacture of ceramic tiles and flags
2351	Manufacture of cement
2410	Manufacture of basic iron and steel and of ferro-alloys
2442	Aluminium production

According to EU ETS Phase 4, the carbon leakage list is established in two phases. The NACE-4 degree of discrimination was applied in the first quantitative evaluation level. A sector or subsectors shall be deemed at risk of carbon leakage if the carbon leakage indicator is more than 0.2. As per the updated ETS Directive, a second assessment is conducted if specific sectors and sub-sectors fail to meet the primary carbon leakage criterion for inclusion in the carbon leakage list. When sectors and sub-sectors have emission intensities more than 1.5 and the carbon leakage indicator is between 0.15 and 0.2, a new qualitative or quantitative evaluation is conducted at the disaggregated level (PRODCOM-6 or 8 level) (European Commission, 2018).

4.1. Evaluation-Based Carbon Leakage Measurement

The EU Emissions Trading Scheme (ETS) Phase IV consultation is the basis for the sector-level carbon leakage risk assessment in Türkiye that is presented in this paper. To calculate the carbon leakage risk, this methodology combines two essential metrics: trade intensity and emission intensity. In the carbon risk analysis conducted for aluminium, cement, paper, fertiliser, iron-steel, and ceramics sectors in Türkiye, the riskiest sector is cement, while the lowest risk is observed in the paper sector.

Table 3: Comparison of emission and trade intensity of sectors

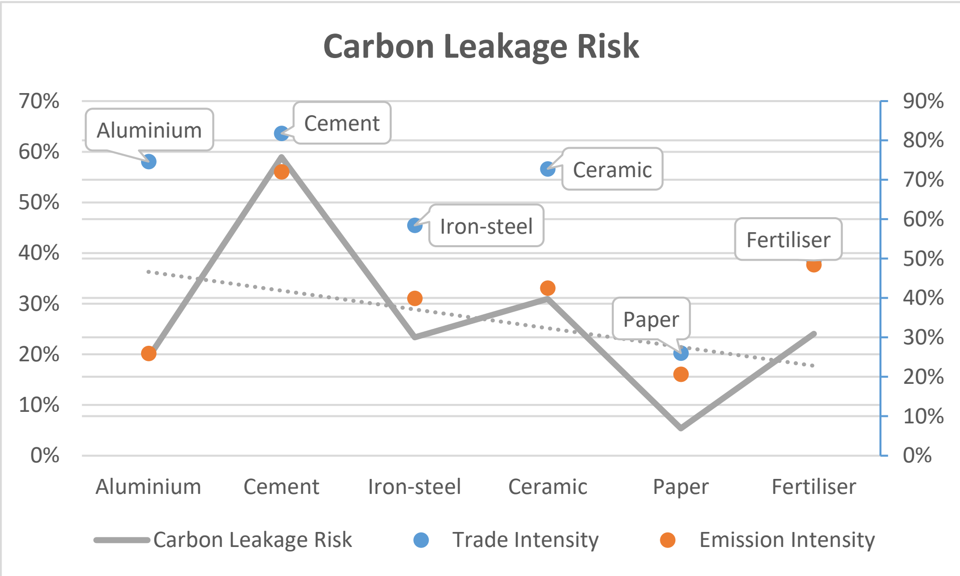
Sectors (2021)	Trade Intensity	Emission Intensity
Aluminium	75%	26%
Cement	82%	72%
Iron-steel	58%	40%
Ceramic	73%	43%
Paper	26%	21%
Fertiliser	50%	49%

When emission intensity and trade intensity are multiplied by each other, if it is more than 20%, it means that the risk of carbon leakage is high. While the risk of carbon leakage is high in the cement, iron-steel, ceramics, and fertiliser sectors, it is anticipated that the paper industry will have a lower risk of carbon leakage.

There are two other main points covered by trade intensity in the assessment of sectoral carbon leakage risk:

The first is the so-called ‘carbon cost effect’, which is the effect of carbon pricing on a certain industry or business. The ability to account for the cost of carbon is the second. The question is whether businesses can pass on the cost of carbon to consumers without losing market share or seeing a decline in profit margins. To measure the carbon cost impact, each production unit can be measured by the volume of emissions arising in revenue, value-added, and profit (PMR Türkiye, 2018). Various factors are important in measuring cost-reflective capacity, including market power, demand elasticities, domestic supply elasticities, and external supply elasticities. A better understanding of the relationship between trade intensity and carbon intensity provides theoretical support for Türkiye to better use its foreign trade activities to achieve low-carbon development (Wang et al., 2021).

Figure 2: **Sectors' Rate of Carbon Leakage Risk**



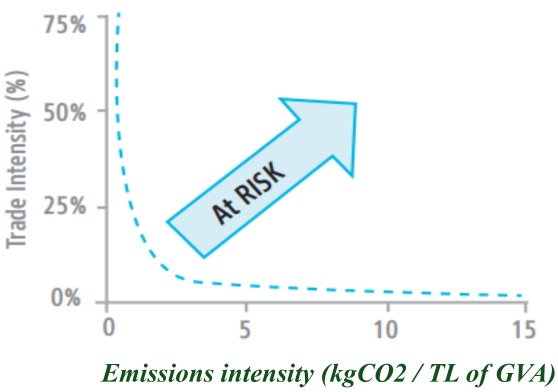
Carbon leakage and investment decisions are influenced by emission intensity details, cost, and emission reduction potential. If a business can reduce its emissions at a low cost, it will be able to reasonably lower the carbon cost it faces and, thus, lower the risk of carbon leakage. This can, however, differ greatly amongst firms.

The risk of carbon leakage, examined sectorally, depends on the emission and trade intensity factors in the country. However, when examined universally, the decisive factor at this point comes from carbon price differences. In contrast, competing countries that implement equivalent carbon pricing policies can reduce the risk of carbon leakage.

Table 4: Risk assessment of sectors

Sectors	Is there a risk of carbon leakage?
Aluminum	Yes
Cement	Yes
Iron-steel	Yes
Ceramic	Yes
Paper	No
Fertilizer	Yes

Figure 3 :Trade intensity and emission intensity together to create leakage risk (PMR Türkiye, 2018)



4.2. Effects of Carbon Leakage Risk on The Sectors

Due to their products' high carbon content and exposure to international markets, sectors that are both carbon-intensive and marketable are more vulnerable to leakage. Increased competition and difficulty for businesses to pass on price increases to customers are two effects of high trade volumes. Cement, iron and steel, and ceramic production are the three main industrial sectors known to be prone to carbon leakage risk. Extensive environmental policies have been noted to raise the costs of environmental and energy regulations and to have minor negative effects on commerce and employment, according to industry consultations and the literature. Furthermore, the necessity for environmental regulations that foster innovation in cleaner technologies has been acknowledged. It is recognised that although green technology investments may be costly in the short term, they will provide positive returns to the sectors in the long term.

The effects of carbon leakage risk on domestic production and net imports for each sector are considered as the 'competitiveness effect'. Customers of commodities like steel and aluminum frequently adjust their consumption to foreign alternatives in response to price fluctuations, but they also take other actions, such as converting to alternative materials that require less energy or consuming less energy (Aldy and Pizer, 2011).

Carbon leakage risk can be evaluated according to sectors as follows:

Paper: Paper is the sector with less emission intensity and the least risk of carbon leakage compared to other sectors. Because the process of making paper produces very little emissions. Most of Türkiye's international competitors in this field apply carbon pricing. At this point, it needs to improve its technology to become more advantageous.

Cement: Cement industry producers have been identified as the most vulnerable sector to the hazard of carbon leakage. However, the sector can benefit from various opportunities for emissions reduction, given its relatively high emissions intensity (PMR Türkiye, 2018). It can also reduce the risk of carbon leakage due to the sector's increased production and current profitability. This shows that the sector is flexible and can quickly adapt to increasing carbon prices.

Ceramics: As a result of quantitative evaluations, it is understood that the sector is at risk. However, the advantage of the ceramics industry is that its trade is largely made to countries that already price industrial emissions or to places where this is implemented at an advanced level. Thus, the sector will have various opportunities to reduce risk.

Iron and steel: The model evaluation suggests a risk to the sector. Nonetheless, many variables lessen the chance of carbon leakage. Electric arc furnaces are widely used, indicating that Türkiye has the potential to become a low-emission steel production hub in the area if the industry moves away from coal and toward on-site production and/or systemic decarbonization. Lastly, nations with sophisticated systems or already charging for industrial emissions represent the sector's principal trading partners. For example, Bektaş (2021) focused on the Europen Green Deal and planned carbon border adjustment mechanism as important developments that will affect trade from the perspective of energy-intensive sectors of Turkey. Possible impacts of implementing the EU's plans and measures that can be taken for the iron-steel industry to be less negatively affected by the EU developments are examined. GDP is found as the most important increasing factor for the differentiation in emissions.

Aluminium: Since aluminium is an energy-storing metal that can be recycled or reused after production without any loss of quality, the emission difference between primary and secondary aluminium is quite high. It is observed that secondary aluminium is preferred in the aluminium trade in Türkiye because it is a form of production that provides lower emissions and higher added value.

5. Conclusions and Future Research

Carbon leakage is unavoidable due to the lack of consistent and resolute international cooperation for the application of diverse climate policies and global climate action. The incidence of carbon leakage underlies how nations divide up the burden of reducing global emissions more equally and has a substantial impact on the environmental efficacy of climate policies as well as the financial costs of attaining emissions reduction targets. At this point, considering the great importance of supporting climate governance, it is observed that detailed studies on carbon leakage are increasing. This article was prepared with the objective of establishing a road map for Türkiye and elucidating the particulars of policy creation. It was written with the intention of offering suggestions for future climate policies by examining the phenomenon of carbon leakage, its evaluation, and the principal factors influencing the evaluation results. This paper demonstrates that the average carbon leakage risk differs between the EU and other countries due to the selection of Scope 1 emissions and the consideration of Türkiye's trade preferences. It is thought that it would be beneficial to further expand the scope and examine it in other studies.

Based on the experiences gained and the findings from the literature research, three main recommendations are put forward for future research. First, it is essential to create consistent policy metrics to compare climate policies that vary by region, second, it should be handled with standardized measures in calculation methodologies and modeling parameters, and finally, different alternative ways to combat carbon leakage need to be highlighted. Examples of these areas to concentrate on include the policy effects of R&D investments and subsidies for technology aimed at reducing emissions, the diffusion of technology across regions, and the supplementary or substitute outcomes of these areas with other policy instruments. It should be taken into consideration that it is not an issue that can be solved only with CBAM or taxes.

It can be argued that emission pricing together with CBAM are the most appropriate instruments to reduce carbon leakage. It is well recognized that CBAM is a more economical approach than an output-based rebate. However, a different approach that could be comparable to CBAM is the combination of an output-based rebate and a consumption tax on commodities that are exposed to trade and have high emissions. This is due to the fact that a consumption tax of this kind would certainly boost welfare and have greater policy terms.

Türkiye should focus on low-carbon development and reduce emissions. Emissions can be reduced through sectoral energy intensity, sectoral energy mix, and emission factor. In addition, the use of new technologies to improve efficiency, the consideration of green hydrogen and carbon-free gas, the improvement of resource efficiency, and the promotion of the use of renewable resources are recommended.

AUTHORS' CONTRIBUTION

All parts were written by three authors.

CONFLICT OF INTEREST DECLARATION

There is no financial conflict of interest with any institution, organization or person, and there is no conflict of interest between the authors.

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