N°2025 – 19 • NOVEMBER 2025

WORKING PAPER

The "Brussels Effect" in carbon markets: Evidence from the European Union Emissions Trading Scheme

Marc BAUDRY [1, 2*,3*], Romile Ronalde Gaylor RAVELONJANAHARY [2*,]*

This paper investigates the international diffusion of carbon markets driven by the European Union Emissions Trading System (EU-ETS), the world's first large-scale greenhouse gases emissions trading scheme. Using cross-sectional data from 161 countries and a spatial autoregressive Probit model with trade-based interdependencies, the paper examines whether EU trade partners are more likely to adopt domestic ETSs. Results indicate a positive and significant diffusion effect, consistent with a "Brussels Effect" based on experience feedback in carbon market governance. However, quantifying the effect reveals that it remains limited in magnitude. The implementation of the Carbon Border Adjustment Mechanism, which relies more on a *de jure* effect than a *de facto* effect, could change the situation.

JEL CODES : Q58 ; F18 ; C21.

1* Paris-Nanterre University (EconomiX)
2* Climate Economics Chair (Institut Europlace de Finance – Paris Dauphine-PSL University)
3* College of Europe

† email marc.baudry@parisnanterre.fr

KEYWORDS

European Union Emissions Trading System

Brussels Effect

Spillovers

Climate Policy

Spatial Autoregressive Probit

Executive summary

This paper examines the international diffusion of carbon emissions trading systems (ETS), focusing on whether the European Union Emissions Trading System (EU-ETS) has influenced ETS adoption among the EU's global trade partners. As the first large-scale CO_2 market, launched in 2005, the EU-ETS serves as a model of cap-and-trade regulation, a source of experience feedback, and a key instrument in the EU's climate diplomacy. The analysis builds on a cross-sectional dataset of 161 countries and relies on a spatial autoregressive Probit model, estimated within a Bayesian MCMC framework, to test whether ETS adoption is subject to positive spillovers. Trade-based spatial weight matrices, derived from the BACI database, replace geographic proximity to capture policy spillovers through commercial linkages. Results from the econometric model are used to quantify a "Brussels Effect" of the EU-ETS as the increase in the probability of ETS adoption by EU's trade partners induced by the pre-existence of the EU-ETS.

Key findings

The study reveals clear but moderate evidence of policy diffusion driven by the EU-ETS:

- **Empirical validation of the "Brussels Effect":** countries with strong trade ties to the EU are significantly more likely to adopt a domestic ETS.
- **Magnitude of influence:** adoption spillovers are of limited magnitude, the probability of ETS adoption rises by **up to seven percentage points** for high-income countries having important trade links with the EU (e.g., Norway, Switzerland, the United Kingdom).
- **Instrument-specific diffusion:** the effect disappears when carbon taxes are included, suggesting that policy learning and emulation are specific to **emissions trading** rather than general carbon pricing.

Policy implications

The findings have several strategic implications for EU and global climate governance:

- **Reinforcing EU leadership:** the EU-ETS strengthens the EU's position as a global standard-setter for market-based climate policies.
- **Balancing competitiveness and ambition:** although spillovers in international ETS adoption exit, they are too limited in magnitude to mitigate risks of **carbon leakage** and **competitiveness loss** associated with the EU's decarbonization efforts.
- **Complementary instruments:** policies such as the **Carbon Border Adjustment Mechanism (CBAM)** could amplify external spillover effects by incentivizing trading partners to implement compatible carbon pricing systems.
- **Sustained capacity-building:** strengthening technical and institutional support for emerging economies remains essential to scale the global carbon market.

1 Introduction

Under the Kyoto Protocol, European Union (EU) member states committed to an 8% reduction in emissions relative to 1990 levels for 2008–2012 (UNFCCC, 2008). This goal was largely achieved through the launch of the European Union Emissions Trading System (EU-ETS) in 2005, the world's first CO_2 market[1]. Covering roughly 11 500 industrial installations responsible for about 45% of EU CO_2-equivalent emissions, the EU ETS operates as a classical cap-and-trade system, setting a maximum cumulative Greenhouse Gas (GhG) emissions cap and distributing tradable allowances among regulated firms (Ellerman & Buchner, 2007; Abrell, Ndoye Faye & Zachmann, 2011).

Soon after its launch, the EU-ETS was presented as a leading instrument for international carbon pricing. In a communication to the Council on the 13rd of November 2006, the European Commission (EC) noted that "*The EU emissions trading scheme is already a key driver of international carbon trading and provides a solid foundation for a global carbon market*" (European Commission, 2006). More recently, at the United Nations General Assembly high-level carbon pricing event held on the 27th of September 2024, EC President Ursula von der Leyen emphasized that European authorities "*are assisting countries who want to develop carbon pricing*"[2]. In line with this vision, the EU actively engages in multilateral initiatives, including the International Carbon Action Partnership (ICAP), of which it is a founding member, and the Partnership for Market Readiness (PMR). Complementing these efforts, the Commission established the Task Force for International Carbon Pricing and Markets Diplomacy, officially stressing that "*Building on the EU's successful experience, the Task Force primarily aims to share the EU's lessons learned and support other jurisdictions in designing and implementing effective domestic compliance carbon pricing and carbon market instruments (such as carbon taxes or emissions trading systems)*"[3]. Bilateral cooperation further illustrates this commitment. The Platform for Policy Dialogue and Cooperation between EU and China on Emissions Trading seeks to "*provide capacity building and training to support Chinese authorities (...) in their efforts to implement and further develop the Chinese nationwide emissions trading system*", while a technical assistance project with Korea focuses on "*building the necessary capacity to implement the Korean ETS*"[4].

Since the EU-ETS inception, numerous non-European countries have also adopted Emissions Trading Systems (ETS) to reduce carbon emissions. By 2025, 38 ETSs are operational worldwide, with 20 more either under development (11) or under consideration (9), highlighting growing recognition of emissions trading as an effective climate mitigation strategy[5]. This paper examines whether the EU-ETS, as the first operational ETS globally, played a leading role in encouraging adoption among the EU's trade partners. It helps clarifying ongoing policy debates on the effectiveness of the EU-ETS, particularly whether

[1]Although the U.S. Acid Rain Program implemented in the 1990's was the first cap-and-trade system, it was dedicated to sulfur dioxide emissions which is not considered a direct Greenhouse Gas (Calel, 2013).
[2] *Opening speech by President von der Leyen with Canadian Prime Minister Trudeau on carbon pricing*. Available at: https://ec.europa.eu/commission/presscorner/api/files/document/print/en/speech_24_4845/SPEECH_24_4845_EN.pdf
[3] See the European Commission website on "*International carbon pricing and markets diplomacy*" (https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/international-carbon-pricing-and-markets-diplomacy_en).
[4] See the European Commission website on "*International Carbon Market*" (https://climate.ec.europa.eu/eu-action/carbon-markets/eu-emissions-trading-system-eu-ets/international-carbon-market_en).
[5] See ICAP website, more specifically its interactive map on ETS worldwide (https://icapcarbonaction.com/en/ets).

the risk of carbon leakage and competitiveness loss (Fournier Gabela & Freund, 2023; Verde, 2020) can be counterbalanced by international adoption spillover effects generated by the EU-ETS put forward by the European Commission (Verde & Borghesi, 2022), potentially reinforced by the Carbon Border Adjustment Mechanism[6]. As the first operational ETS, the EU-ETS may have served as a cornerstone of the international development of carbon markets and a model for other jurisdictions. This influence underpins the EU's ambition to assert global leadership on climate action. The EU's capacity to shape international regulatory frameworks is both theoretically and empirically supported (Vogel, 1997; Christen et al., 2022; Ylönen, 2025) and is commonly referred to as the "Brussels Effect", a concept coined by Anu Bradford in 2012 and further developed in her 2020 book (Bradford, 2012, 2020)[7].

The empirical analysis draws on a cross-sectional dataset of 161 countries, with the dependent variable indicating whether a national ETS was adopted by 2024. To assess potential diffusion effects of the EU-ETS, we employ spatial econometric techniques, constructing a spatial weight matrix based on bilateral trade intensity from the BACI database. This captures trade-based interdependencies as a key driver of ETS adoption, replacing conventional distance-based matrices. Estimation is performed using a spatial autoregressive Probit model within a Bayesian Markov Chain Monte Carlo (MCMC) framework. Results reveal a positive and significant spatial autoregressive coefficient, indicating that ETS adoption in one country is influenced by trade-connected partners having their own ETS, consistent with international spillover effects. Notably, this effect disappears when all carbon pricing mechanisms, including carbon taxes, are considered, suggesting that spillovers are specific to ETS adoption and aligned with a "Brussels Effect" based on experience feedback. The magnitude of the effect is nevertheless moderate: in the baseline model, the "Brussels Effect", defined as the increase in probability that a non-EU partner adopts a domestic ETS due to the EU-ETS existence, reaches at most about 7 percentage points for high-income countries strongly linked to the EU, such as the UK, Norway, and Switzerland. These findings highlight both the selective and measurable influence of the EU ETS on global carbon market diffusion.

The remainder of the paper is organized as follows. Section 2 provides a global overview of carbon emissions trading systems. Section 3 explores the external role of the European Union in promoting the diffusion of climate policies. Section 4 details the research design and methodology, while Section 5 presents and discusses the empirical findings. Finally, Section 6 concludes the study and highlights its policy implications.

2 Carbon emission trading systems across the world

2.1 Theoretical foundations and operational mechanisms of Emissions Trading Systems

Building on Coase's theoretical framework (Coase, 1960), scholars such as Crocker (1968), Dales (1968), and Montgomery (1972) provided a more concrete vision of emissions trading as a policy tool. They all make the case that setting an emissions cap, allocating quotas to emitters so that the total does not exceed this cap, and allowing a market price to emerge

[6] See the European Commission website on "*Carbon Border Adjustment Mechanism*" (https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en)

[7] In this respect, the willingness of the American administration under D. Trump's second term to challenge European regulations concerning the digital and data economy, or regarding environmental and social reporting requirements, can be seen as an implicit acknowledgment of the effectiveness of a "Brussels effect", but also as an indication of its fragility.

through trading would automatically allocate abatement to those market participants who could abate at least cost (Ellerman, Convery et de Perthuis, 2010).

2.1.1 What is an ETS?

An emission trading system (ETS) is thus a market-based policy tool designed to address pollution by making emitters internalize the social cost of emissions. This creates incentives for reducing emissions through changes in production processes, output levels, and investment in cleaner technologies (Long and Goulder, 2023). For CO_2 emissions, ETSs serve as a common alternative to carbon taxes. While taxes fix the price of emissions and let quantities adjust, an ETS fixes the quantity of allowances and lets the market determine the price. Compliance requires participants to surrender allowances matching their annual CO_2-equivalent emissions. Non-compliance results in penalties and additional surrender obligations, ensuring system integrity and emission reductions.

An ETS comprises two interrelated markets: the primary market, involving transactions between governments and regulated entities, and the secondary market, where companies trade among themselves. Under the emissions cap set by the regulator, a limited number of allowances are distributed to firms, either freely or through auctions. Once allocated, these allowances become tradable assets in the secondary market. Companies with surplus allowances—often due to greater energy efficiency or successful emissions reduction—can sell their excess to firms facing higher abatement costs, promoting cost-effective emissions reduction and overall market efficiency within the system.

There are two types of free allocation (Long and Goulder, 2023). Exogenous allocation follows the grandfathering approach, where firms receive a fixed number of allowances based on their historical emissions, regardless of current output. Endogenous allocation instead relies on benchmarking or output-based updating, where allowances are distributed according to emissions intensity, meaning emissions per unit of output. The number of allowances granted to a firm equals the product of the benchmark and the facility's output level. Alternatively, the government can supply allowances through auctions, in which covered facilities obtain them via competitive bidding. Many countries and regions using cap-and-trade systems combine free allocation with auctioning to distribute allowances.

2.1.2 Benefits of cap-and-trade systems

The literature identifies two policy instruments for achieving emissions reduction at the lowest cost: the carbon tax, a price-based tool, and the emissions trading system (ETS), a quantity-based one (Stavins, 2022; Parry, 2022; Pan *et al.*, 2024). While carbon taxation is efficient, it does not ensure that greenhouse gas reduction targets will be met, and in international systems, countries must agree on a common tax rate. Determining the appropriate tax rate to achieve the desired cuts without over or undercharging firms is also difficult. Bai and Ru (2024) find that ETS adoption reduced CO_2 emissions by 12.1% and overall greenhouse gases by 18.1%, mainly by cutting coal use and increasing renewables. They also note that carbon taxes were less effective, though higher rates and broader coverage could improve results.

Many countries, following the example of the European Union, have increasingly prioritized the development of ETSs[8]. ETSs provide certainty over the total quantity of greenhouse gas emissions by setting binding caps aligned with environmental objectives; they allow initially separate cap-and-trade systems to be linked; they promote cost-effectiveness by allowing firms to trade allowances, ensuring emissions are reduced where it is cheapest; they generate public revenue when allowances are auctioned, enabling reinvestment in climate and social initiatives or a double dividend similar that generated with a carbon tax (Pearce, 1991); and they mitigate budgetary risks by securing a predictable pathway to meet reduction targets, reducing reliance on costly alternative measures (European Commission, 2017).

2.2 The European Union Emissions Trading System

In 1997, the Kyoto Protocol set binding GHG reduction targets for 37 industrialized countries, creating demand for effective compliance tools. In response, the European Commission released a Green Paper proposing an EU-wide ETS, initiating broad stakeholder consultations (European Commission, 2000). These led to the adoption of the EU ETS Directive in 2003 and the launch of the EU Emissions Trading System in 2005. Since then, the system has undergone several changes and has been divided up into distinct trading periods over time, known as phases. The EU ETS is currently in its fourth trading phase (2021-2030). It caps the total volume of GHG emissions from fixed installations, aircraft operators, and large ships entering EU ports responsible for around 50% of EU GHG emissions and remains a cornerstone instrument of the EU's policy framework to combat climate change and reduce GHG emissions cost-effectively.

The EU ETS covers the 27 EU member states, plus Liechtenstein, Norway, and Iceland which delegate ETS decision-making to the EU for economic efficiency. In addition, the system has been formally linked to the Swiss ETS since 2020, enabling mutual recognition and trading of allowances between the two markets. By contrast, the UK created a separate UK ETS after Brexit. However, the EU and UK are now negotiating a formal market link. For year 2024, the EU-ETS absolute cap was set at 1,386 $MtCO_2e$ for sectors such as electricity and heat generation, industrial manufacturing, and maritime transport, and 27.6 $MtCO_2e$ for aviation. The average auction price in 2024 was EUR 64.74, while the average secondary market price reached EUR 65.23. These transactions generated approximately EUR 38.8 billion in revenue for that year alone. Since its launch, the EU ETS has generated a cumulative total of around EUR 184 billion in revenues[9].

2.3 Emissions Trading Systems outside the EU

The number of ETSs in operation around the world continues has reached 38 in 2025, with a further 20 systems in various stages of development or consideration[10]. These systems cover over 12 $GtCO_2e$, representing approximately 23% of global GHG emissions, and span jurisdictions gathering one-third of the global population and 58% of global GDP.

[8] The EU's adoption of an ETS was driven less by its economic advantages over a carbon tax than by legal constraints (the EU lacks fiscal authority) and the desire to align with the United States during the Kyoto negotiations, particularly in anticipation of a global ETS that ultimately never materialized (Convery, 2009).
[9] See the European Commission website on "*EU ETS emissions cap*" (https://climate.ec.europa.eu/eu-action/carbon-markets/eu-emissions-trading-system-eu-ets/eu-ets-emissions-cap_en)
[10] See ICAP website (https://icapcarbonaction.com/en/ets).

While ETSs have historically operated in developed countries, according to the ICAP Emissions Trading Worldwide Status Report (ICAP, 2025), momentum around ETSs is accelerating, particularly in emerging economies such as Brazil, India, Indonesia, Türkiye, and Vietnam, where innovative design approaches are being implemented. At the same time, existing systems are undergoing refinement and expansion.

ETS developments are advancing rapidly across the Asia-Pacific region. India has introduced regulations to create an intensity-based baseline-and-credit system for energy-intensive industries, supported by a carbon crediting mechanism. China, alongside its eight official ETS pilot programs, is expanding its national ETS launched in 2021 beyond the power sector to key industrial sectors, while considering a shift to an absolute emissions cap. Indonesia's intensity-based ETS for the power sector has operated for two years, with plans for a hybrid "cap-tax-and-trade" model next year. Türkiye and Vietnam are developing regulatory frameworks for pilot ETS programs, while Malaysia, the Philippines, and Thailand are exploring emissions trading as part of broader climate policy strategies, reflecting growing regional momentum.

In Latin America, Brazil has established the legal foundation for a federal ETS and has entered the initial phase of implementation, focusing on regulatory development. Chile is in the process of establishing sector-specific emissions limits and preparing a pilot ETS for the energy sector. Meanwhile, Colombia has initiated a public consultation on ETS regulations, representing a significant step toward the phased implementation of its system. Mexico is currently transitioning its pilot ETS to full implementation.

Developed economies are also advancing their ETSs. Outside the European Union, Canada has issued draft regulations for a federal cap-and-trade system targeting upstream oil, gas, and LNG emissions, while Quebec remains the only province with an explicit ETS. In the United States, following California's Cap-and-Trade Program and the Regional Greenhouse Gas Initiative, Oregon reinstated its ETS after its 2023 invalidation, and Colorado launched a system in 2024 for large in-state manufacturers, with expansion planned for 2028. New York State is developing rules for an economy-wide ETS, and Maryland is exploring the creation of a similar system, reflecting growing interest in market-based emission controls.

2.4 Limitations and controversies surrounding market-based instruments

Today, over 70 carbon pricing schemes exist worldwide, yet their effectiveness in reducing emissions remains debated (Döbbeling-Hildebrandt et al., 2024). The literature identifies three main limitations, often discussed in the context of ETSs, particularly the EU ETS, given its global prominence, though many issues also apply to carbon taxes.

The first limitation is carbon leakage, defined as an increase in foreign emissions caused by domestic emission reductions under stringent regulations (Cameron and Baudry, 2023; Misch and Wingender, 2024). Empirical evidence shows that jurisdictions with strict environmental measures often reduce territorial emissions while increasing consumption-based emissions. This occurs as emissions-intensive and trade-exposed industries relocate to regions with weaker standards, a phenomenon documented by the IPCC (2007).

Closely related is the competitiveness concern. In cap-and-trade systems, compliance obligations can restrict output and place regulated sectors at a disadvantage relative to firms in less regulated jurisdictions. Carbon pricing raises production costs, exacerbating competitiveness gaps, particularly for companies reliant on carbon-intensive inputs produced domestically rather than imported from non-ETS regions. This disadvantage grows with higher carbon prices and affects multinational subsidiaries more severely (Wang *et al.*, 2018; Böning *et al.*, 2023).

The third limitation involves the implementation gap between the Global North and South. Northern countries have advanced carbon pricing, while many Southern economies lack comparable systems due to lower development levels and ETS complexity[11]. According to Copeland and Taylor's (1994) pollution haven hypothesis, stricter Northern regulations may shift carbon-intensive production to weaker-regulation jurisdictions, reinforcing carbon leakage and global competitiveness asymmetries. Recent modelling by Hong et al. (2023) indicates that unilateral Northern ETS policies can alter trade flows, negatively impacting Southern exporters, particularly in energy-intensive sectors.

These three limitations highlight the challenges in designing ETSs that achieve global emissions reductions without unintended economic consequences. Carbon leakage undermines territorial gains by shifting emissions abroad, competitiveness concerns can hinder industrial output and investment, and North–South disparities create inequities in the global transition. Addressing these issues requires complementary policies, such as border carbon adjustments, international coordination, and capacity building in developing economies, to ensure that carbon pricing is both environmentally effective and economically balanced.

3 The EU's External Role in Climate Policy Diffusion

3.1 The "Brussels Effect": The EU as global exporter of regulatory norms

The concept of the *"Brussels Effect"* was first introduced by Anu Bradford (2012 and 2015) and further elaborated in her 2020 book. Bradford's theory draws on earlier analyses of the diffusion of California's environmental regulations within the US, known as the *"California Effect"* (Vogel, 1997), which describes how strict regional standards can influence wider regulatory practices. According to Bradford, five conditions underpin the emergence of the Brussels Effect. The first is market power. The European Union, as one of the world's largest economies, exerts significant influence, encouraging non-EU firms to comply with its regulations rather than lose access to its market. The second condition is the European Union's strong regulatory capacity, while the third is its preference for stringent standards. The fourth condition is the low elasticity of the targets of regulation. The key idea put forward by Bradford (2012, 2015 and 2020) is that the less mobile the target is internationally, the more likely the Brussels effect is to occur, and vice versa. Finally, the fifth and final condition is the non-divisibility induced by the regulation, sometimes referred to as companies' preference for uniform regulation (Bradford, Herrera et Rotaru, 2021. A regulation induces non-divisibility when complying with it leads to changes in the whole production process and the renewal of facilities.

The "Brussels Effect" is traditionally understood in two dimensions: the *de facto* effect and the *de jure* effect (Ylönen, 2025). The General Data Protection Regulation (GDPR) is frequently cited as a prominent example of both aspects, having become a global benchmark

[11] Moreover, unlike many Northern countries that adopt absolute caps, Southern countries such as Indonesia, India, and China tend to favour relative caps, which, for some, serve as a means of reconciling climate policy with economic development.

in data protection for numerous jurisdictions and multinational corporations (Gunst and Ville, 2021; Bradford, 2023). The *de facto* “Brussels Effect” refers to the EU’s unilateral capacity to shape global markets by setting regulatory standards in areas such as competition policy, environmental protection, food safety, data privacy, or the regulation of hate speech in social media. Crucially, this influence is not enforced by law but arises organically through market mechanisms. The *de facto* “Brussels Effect” is reinforced by a *de jure* “Brussels Effect”, namely the adoption of EU-style regulations by foreign governments. While this may be driven in part by lobbying from non-EU firms already aligned with EU standards, a broader range of transmission mechanisms is at play. EU rules often serve as attractive regulatory templates, supported by the Union’s political influence, negotiation leverage, and its demonstrated capacity to provide technical assistance and foster institutional development[12]. In this way, the “Brussels Effect” offers foreign governments an opportunity to externalize parts of their regulatory development to a more experienced and well-resourced framework (Bradford, Herrera et Rotaru, 2021).

3.2 From climate leadership to global policy diffusion

Among the principal international actors addressing the climate crisis, the European Union distinguishes itself through the proactive development of trade, forestry, and climate sustainability policies. As the first operational emissions trading system (ETS) worldwide, the EU ETS has become a central pillar of the global carbon market and a reference model for other jurisdictions adopting similar mechanisms. Through these initiatives, the EU asserts its role as a global leader in promoting the Sustainable Development Goals (SDGs), as reflected in its official communications and strategic frameworks (Trevizan, 2024). According to Verde *et al.* (2022), the EU ETS’s global significance will likely expand as the Union’s declining emissions share contrasts with its sustained climate leadership and increasingly ambitious reduction targets for 2030 and 2050.

The channels through which the EU-ETS is likely to generate a "Brussels Effect" potentially differ from the aforementioned conditions highlighted by Bradford (2012, 2015, and 2020). The main reason is that the EU-ETS is not a standard that foreign firms must comply with to sell their products in Europe. The price signal sent by the EU-ETS, on the contrary, only applies to products manufactured within the EU. Nevertheless, at least three channels can be identified through which the EU-ETS can generate a "Brussels Effect":

- Demonstrated effectiveness of the EU ETS: the future diffusion of ETSs will be shaped by how convincingly existing models prove their practical, economic, and political credibility. The EU ETS, often described as a "grand policy experiment", has served as a key reference point in climate policy, offering valuable lessons from both its achievements and shortcomings. Today, the EU ETS continues to be a pioneer in a new era of climate policy characterised by net-zero emission targets to be reached within three decades or so (Fankhauser *et al.*, 2022). One key factor supporting the system’s credibility is its proven capacity to deliver actual emission reductions while maintaining market-based flexibility.
- Bilateral linkages represent another channel through which the European Union promotes the global diffusion of emissions trading systems. These linkages connect the EU ETS with schemes operating under different jurisdictions. A notable example is

[12] For instance, the EU has developed the Twinning instrument to support the transposition, implementation and enforcement of the EU body of legislation, with a special focus on supporting the EU accession process and preparing candidate countries for EU Membership (see https://enlargement.ec.europa.eu/funding-technical-assistance/twinning_en).

the connection between the EU ETS and the Swiss ETS, effective since 2020. This arrangement allows regulated entities to transfer allowances between accounts and to use allowances issued in one system for compliance in the other. Such cooperation strengthens the appeal of ETS adoption by enabling cross-border allowance trading among regulated actors. Furthermore, the participation of non-EU countries such as Norway, Iceland, and Liechtenstein demonstrates the Union's regulatory influence beyond its borders.

- Implementation of the Carbon Border Adjustment Mechanism (CBAM): The European Union's CBAM addresses carbon leakage and competitiveness concerns associated with emissions trading systems. Although studies suggest that the EU ETS has had so far limited statistically significant impacts on regulated firms (Dechezlepretre *et al.*, 2023), these challenges remain important barriers to ETS adoption globally. In response, the CBAM, entering full operation on January 1, 2026, assigns the same price than the EU-ETS price to the carbon embedded in imported carbon-intensive goods. It applies to key sectors, including iron and steel, aluminium, cement, fertilisers, electricity, and hydrogen. Beyond reducing carbon leakage, CBAM incentivizes emission reductions in exporting countries (Verde et Borghesi, 2022). Unlike prior measures that produce a *de facto* "Brussels Effect", CBAM represents a *de jure* effect: EU carbon-accounting rules set the standard for calculating embedded emissions in imports. Importers wishing to diverge from the benchmark must justify superior performance, effectively exporting EU methodologies and promoting global adoption of EU-aligned carbon-accounting practices[13].

4 Research design

4.1 Data

The empirical analysis relies on a cross-sectional dataset covering 161 countries, with 2004 as the reference year for all control variables, in particular bilateral trade flows used to construct the spatial weights. This pre–EU ETS inception (2005) date limits endogeneity from adoption to macroeconomic and trade outcomes[14], allowing us to isolate how pre-existing governance and economic structures shape ETS adoption. Data are drawn from multiple sources: ICAP[15] for national ETS information around the world; BACI[16] for bilateral trade flows; the World Bank[17] for macroeconomic indicators; and the Quality of Government Institute[18] for institutional quality and democracy data.

The dependent variable is a binary indicator coded as one if a country had a national cap-and-trade emissions trading system in force in 2024 and zero otherwise. Regional systems are coded as zero, including cases where an ETS exists only at the regional level, as in Japan, Canada, or the United States. The key explanatory variable captures potential spatial spillover effects in ETS adoption through trade links. It is measured as a spatial lag derived from a trade-weighted matrix based on bilateral trade intensity, such that stronger trade relationships

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[13] For more details on CBAM, see the dedicated website of the European Commission (https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en)
[14] For example Kramer *et al* (2023) show that California's ETS has had a net positive short-term impact on aggregate economic outcomes.
[15] Ibid.
[16] See https://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=37
[17] See https://databank.worldbank.org/source/world-development-indicators.
[18] See https://www.gu.se/en/quality-government/qog-data/data-downloads.

indicate greater proximity in the spatial structure. This method replaces conventional approaches using geographic distance matrices. Several studies, including Aten (1996), Qu *et al.* (2021), Balvir (2022) and Saputra (2022), construct spatial weighting matrices based on neighborhood structures defined by bilateral trade connections.

The control variables used are presented in Table 1 along with their mean, standard deviation, minimum and maximum values. As explained in the QoG Basic Dataset documentation (2025), the democracy status variable is measured based on five criteria: state-ness, political participation, rule of law, stability of democratic institutions, and political and social integration. The quality of governance variable corresponds to the average value of three ICRG indicators: Corruption, Law and Order, and Bureaucracy Quality. All control variables, except inflation, are log-transformed to aid coefficient interpretation. The GDP–Gini interaction captures how income effects on ETS adoption vary with inequality. EU Member States are aggregated as a single entity to reflect the "Brussels Effect". The dataset comprises 161 countries, including 12 with ETSs in 2024. Bilateral trade data are limited to industrial goods, corresponding to sectors typically covered by emissions trading systems. The Environmental Performance Index was excluded due to missing values in 2004 and 2006, which would have reduced the sample size in the SAR-Probit model. To maintain broad coverage, carbon intensity is used as the environmental control instead.

Table 1: Summary Statistics

Variables	Mean	Std. Dev.	Min	Max
Democracy	1.6346	0.3560	0.4595	2.2925
Quality of governance	-0.8497	0.3629	-2.1972	-0.0281
Inflation	6.1600	7.1987	-5.3554	51.4608
Export intensity	-0.9258	1.0611	-4.7594	1.7331
Carbon intensity	-0.9610	1.8857	-21.6932	1.7628
Education	4.0673	0.6028	1.8045	4.7601
Unemployment rate	1.8279	0.7990	-0.0597	3.6152
GDP per capita	8.0986	1.3938	5.5844	11.2214
GDP*Gini index	29.9860	5.2785	19.1109	43.5346
Trade openness	-1.5364	0.8655	-3.1384	3.1260
Quality of traded goods	0.5789	0.8531	-1.5032	2.6179

4.2 Methodology

A key contribution of this paper is the application of spatial econometric methods to test for the "Brussels Effect" in emissions trading. The analysis focuses on countries with strong trade ties to the European Union, which are likely to adopt its regulatory framework through unilateral policy imitation driven by market interdependence rather than coercion or negotiation.

To account for potential spatial diffusion, a spatial econometric model is employed. Tobler's first law of geography, stating that "*everything is related to everything else, but near things are more related than distant things*" underpins spatial statistics in analyzing spatial dependence. Ignoring spatial relations in cross-sectional models can produce inconsistent or biased estimators (Holloway, Shankar et Rahmanb, 2002). Observing spatial linkages requires constructing a spatial weighting matrix, conducting spatial tests, and selecting the most appropriate spatial model (Anselin, 1988).

Calabrese and Elkink (2014) show that standard probit and logit models yield inconsistent and inefficient results when spatial dependence is present. Between spatial probit and spatial logit specifications, the spatial probit is preferred because the spatial logit error term is intractable, as stressed by Anselin (2002). Consequently, spatial probit models are widely used in the literature (see, among others, McMillen, 1992; Pinkse et Slade, 1998; Smith et LeSage, 2004). Three primary methods have been developed to estimate spatial models with a binary dependent variable: maximum likelihood, instrumental variables or generalized method of moments, and Bayesian Markov Chain Monte Carlo. This study adopts the Bayesian MCMC approach, as proposed by LeSage and Pace (2009), while preliminary maximum likelihood estimation is used to obtain parameter values for the priors. Non-linear relationships among parameters can then be validly inferred using combinations of MCMC draws as shown by Gelfand *et al.* (1990).

The empirical model employed in this study is a Spatial Autoregressive Probit model (SAR Probit), which incorporates a spatial lag structure suitable for binary dependent variables. The structural form of the model is represented as:

$$\boldsymbol{y}^{*} = \boldsymbol{\rho}\mathbf{W}\boldsymbol{y}^{*} + \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon},\ \ \varepsilon \sim N\ (0, \sigma_{\varepsilon}^{2} I_{n}) \tag{1}$$

where $\mathbf{y}^{*}$ is an n-dimensional vector reflecting the latent unobservable net benefits-costs associated with the observed ETS adoption outcomes in 2024; $\boldsymbol{\rho}$ is the spatial autoregressive coefficient capturing how a country's net benefit of adopting an ETS responds to adoption among its main trade partners. A value of zero implies no dependence; $\boldsymbol{\rho} < \mathbf{0}$ is consistent with a pollution-haven mechanism (partners' adoption reduces the incentive to adopt), whereas $\boldsymbol{\rho} > \mathbf{0}$ indicates a spillover or mimetic effect, where partners' adoption mitigates competitiveness concerns and makes adoption more likely; $\mathbf{W}$ is a spatial lag weights matrix, typically row-normalized such that all rows sum to one and the diagonal elements are zero; $\mathbf{X}$ represents an $\mathbf{n} \times \mathbf{k}$ matrix of control variables with related coefficient vector $\boldsymbol{\beta}$; and $\boldsymbol{\varepsilon}$ is an $\mathbf{n} \times \mathbf{1}$ column vector of independently and identically distributed normal errors.

The model can be written in reduced form as:

$$\boldsymbol{y}^{*} = (\mathbf{I} - \boldsymbol{\rho}\mathbf{W})^{(-1)}\mathbf{X}\boldsymbol{\beta} + \mathbf{u}, \quad \text{with } \mathbf{u} = (\mathbf{I} - \boldsymbol{\rho}\mathbf{W})^{(-1)}\boldsymbol{\varepsilon} \tag{2}$$

In this model, the latent variable $\mathbf{y}_{\mathbf{i}}^{*}$ cannot be observed. Instead, the observed outcome is the binary indicator $\mathbf{y}_{\mathbf{i}}$, defined as:

$$\boldsymbol{y}_{\mathrm{i}} = \begin{cases} \mathbf{1}, & \textbf{if} \quad \mathbf{y}_{\mathbf{i}}^{*} > \mathbf{0} \\ \mathbf{0}, & \textbf{otherwise} \end{cases} \tag{3}$$

This latent variable structure makes the overall model nonlinear in parameters. In such nonlinear settings, the standard deviation $\boldsymbol{\sigma}_{\boldsymbol{\varepsilon}}^{\mathbf{2}}$ of error terms is usually set to 1 for identification.

In Bayesian hypothesis testing and model selection, prior distributions of the model's coefficients must be chosen carefully. In this regard, diffuse priors are a commonly used and valuable option. These "non-informative" or "flat" priors reflect the notion of "letting the data speak for themselves" (Wang et Kockelman, 2009). However, this study adopts a more informative approach by estimating prior hyperparameters through a preliminary maximum likelihood procedure. This strategy allows us to incorporate data-driven prior information while retaining the flexibility of the Bayesian framework. As highlighted by Peña *et al.* (2020), and Krishnan *et al.* (2020), such ML-based priors can enhance inference efficiency and objectivity, especially in moderate samples, they provide a robust alternative to non-informative priors.

5 Empirical results

5.1 Model estimates

Parameter estimates were derived using a Bayesian MCMC procedure with 5 000 posterior draws. The first 500 draws served as burn-in, allowing the chains to converge. The final 4 500 draws were used to calculate point estimates, with standard errors derived from these draws. Results are presented in Table 2.

In spatial Probit models, the estimated coefficients do not directly reflect the effect of explanatory variables on the observed outcome $\boldsymbol{y}$, but rather on the latent variable $\boldsymbol{y}^{*}$. As already noted in equation (3), the observed binary outcome $\boldsymbol{y}$ results from a threshold-crossing rule, such that $\boldsymbol{y} = \mathbf{1}$ if $\boldsymbol{y}^{*} > \mathbf{0}$, and $\boldsymbol{y} = \mathbf{0}$ otherwise. LeSage and Lacombe (2018) argue that estimated coefficients should not be interpreted as direct marginal effects. To assess how changes in explanatory variables influence the likelihood of ETS adoption, posterior median estimates of marginal effects are computed. The results are presented graphically in Figure 1. Prior commenting on marginal effects, the focus of the regression results is on the coefficient $\boldsymbol{\rho}$, associated with the spatial lag of the dependent variable $\boldsymbol{W}\boldsymbol{y}^{*}$. The estimated coefficient $\boldsymbol{\rho}$ in the baseline specification is 0.2679, with a posterior standard deviation of 0.1291, statistically significant at the 5% level. This indicates positive spatial dependence in ETS adoption, suggesting that a country's decision to implement an ETS is influenced by the adoption decisions of its trade-connected partners (Table 2, first column). Spatial dependence disappears when carbon pricing, including both ETS and carbon taxes, is considered. As shown in the second column of Table 2, the coefficient $\boldsymbol{\rho}$ becomes statistically insignificant. This suggests that the diffusion effect is specific to ETS adoption and does not extend to broader carbon pricing policies.

Table 2: SAR Probit Model Estimates

	(Only ETS) Bayesian MCMC	(ETS & Carbon tax) Bayesian MCMC
Democracy	0.0867 (0.4142)	0.5776 (0.3774)
Quality of governance	1.7169*** (0.5315)	1.4673*** (0.4564)
Inflation	-0.0163 (0.0227)	-0.0125 (0.0199)
Export intensity	0.3222* (0.1718)	0.2681* (0.1459)
Carbon intensity	-0.0732 (0.0595)	-0.0585 (0.0737)
Education	-0.0821 (0.3246)	-0.0890 (0.2672)
Unemployment rate	-0.2410 (0.1799)	0.0191 (0.1507)
GDP*Gini index	-0.1495** (0.0724)	-0.1113* (0.0639)
GDP per capita	0.5945** (0.2789)	0.3841 (0.2495)
Trade openness	0.0295 (0.1862)	-0.0114 (0.1531)
Quality of traded goods	-0.0535 (0.1666)	-0.0639 (0.1337)
Rho	0.2679** (0.1291)	-0.0309 (0.2176)
N observations	161	161
Diffuse priors	No	No
N- draws	5000	1000
N omit (burn-in)	500	100
Log Likelihood	-24.2338	-43.6757

Notes: ***p<0.01, **p<0.05, *p<0.1. Standard errors in parentheses.

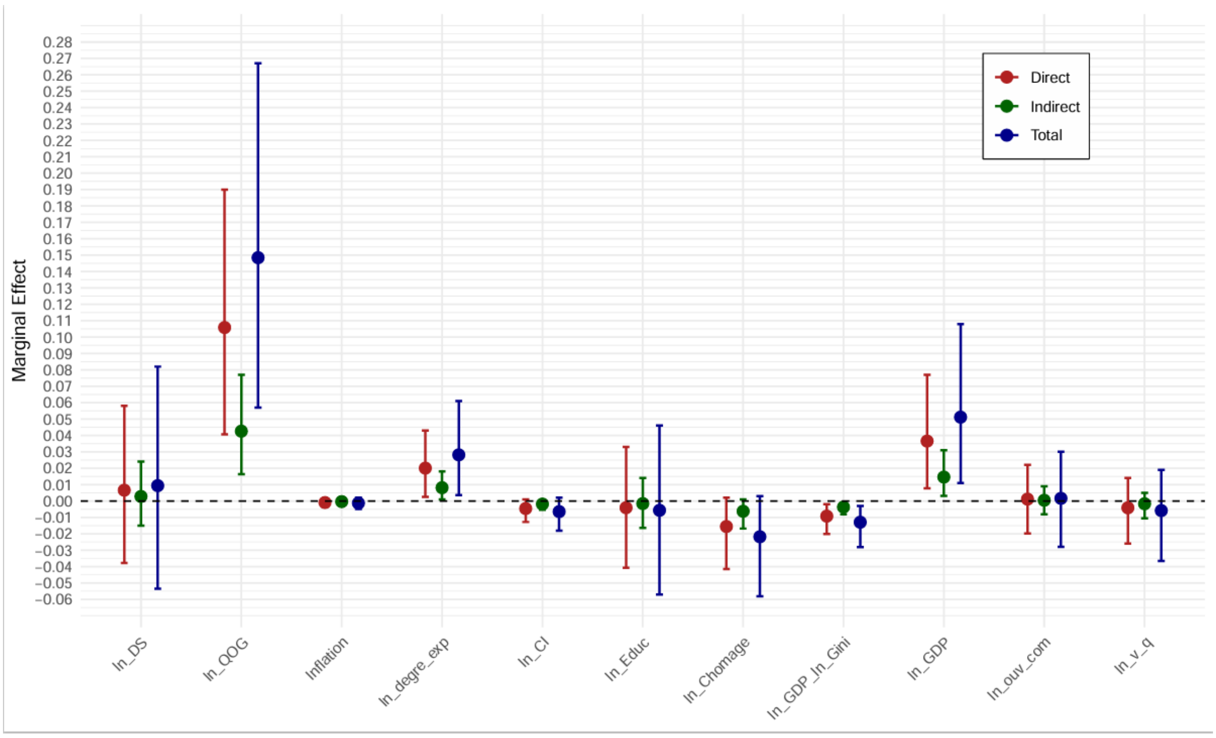
5.2 Posterior Marginal Effects

To evaluate how changes in explanatory variables influence the probability that a country adopts an emissions trading system (ETS), posterior median estimates of marginal effects are computed within a spatial autoregressive probit framework. LeSage and Pace (2009) distinguish among direct, indirect, and total effects in such models. Incorporating spatial dependence implies that a change in an explanatory variable in one country, such as GDP in country *i*, affects not only its own likelihood of ETS adoption but also that of its economically or geographically connected partners. This interdependence arises because outcomes in one country are partly determined by outcomes elsewhere (Lacombe et LeSage, 2018).

In this framework, the direct effect measures how a one percent change in a variable within country $i \in \{1, \cdots, n\}$, influences its own adoption probability, while the indirect effect captures how this change affects the probability of ETS adoption in all other countries. The total effect, the sum of both, represents the cumulative impact of a variable across the entire sample. Each observation produces a set of interdependent responses, generating a $n \times n$ matrix of partial derivatives. For instance, a one percent rise in GDP per capita increases the combined probability of ETS adoption, both domestically and among trade partners, by roughly 0.05 percent on average.

While the coefficients β in the spatial autoregressive probit model are often interpreted as global estimates, proper inference requires accounting for both own and cross-partial derivatives. This distinction highlights that impacts vary across countries depending on their integration in global trade networks. Understanding this spatial heterogeneity is crucial for analysing the "Brussels Effect", as discussed in subsection 5.3, where the influence of the European Union on neighbouring countries is empirically examined. Marginal effects are presented graphically in Figure 1. Of the eleven explanatory variables included, four exhibit 90 percent confidence intervals that exclude zero across direct, indirect, and total effect estimates[19]. These variables, namely governance quality, export intensity, the GDP–Gini interaction term, and GDP per capita, display a statistically significant impact on ETS adoption. The direction of the estimated direct effects aligns with theoretical expectations, indicating that higher income, stronger governance, greater export integration, and lower inequality significantly increase the likelihood of adopting a national ETS. Overall, the findings underscore the importance of institutional capacity and macroeconomic wellbeing in explaining the global diffusion of carbon market mechanisms.

Figure 1: Marginal Effects with 90% Confidence Intervals



[19] The dot represents the median of each effect, and the bar indicates the 90% confidence interval.

The only variable exhibiting a significant negative direct effect is the GDP–Gini interaction term. The estimated coefficient indicates that a one percent increase in this interaction reduces the probability of ETS adoption by approximately 0.01 percent. This finding aligns with evidence that even in high-income countries, social inequality constrains public and political support for climate action (Zahnow *et al.,* 2025). It underscores the need for climate policy design to address distributive concerns and inequality aversion, as emphasized by Berger *et al.* (2025). By contrast, governance quality, export intensity, and GDP per capita display positive and statistically significant direct effects. A one percent increase in governance quality raises the likelihood of ETS adoption by about 0.1 percent. This result suggests that countries with stronger institutional capacity, well-functioning legal systems, efficient bureaucracies, and low corruption levels are better equipped to implement complex policy instruments such as ETSs. Consistent with this interpretation, Creutzig *et al.* (2023) identify impartial governance and social trust as enabling conditions for effective climate policy and technological transition. The positive relationship between GDP per capita and ETS adoption supports the Environmental Kuznets Curve hypothesis, which posits that beyond a certain income threshold, economic growth coincides with environmental improvement (Grossman et Krueger, 1991; Harbaugh, Levinson et Wilson, 2002; Satici et Cakir, 2021). The export intensity variable captures the influence of trade orientation on policy adoption. Its positive effect indicates that export-dependent countries are more likely to adopt ETS mechanisms, reflecting their exposure to international regulatory pressures, border adjustment policies, and reputational expectations in global markets (Bernauer et Böhmelt, 2013. Such exposure generates incentives to establish domestic carbon markets that align with international environmental norms.

The indirect effects exhibit a pattern similar to that of the direct effects, with 90% confidence intervals indicating that four explanatory variables have posterior distributions sufficiently distant from zero to confirm the presence of meaningful spatial spillovers. These indirect effects are consistently smaller in magnitude than their corresponding direct effects, reflecting their status as secondary, or "second-order," influences. The negative indirect effect of the GDP–Gini interaction indicates that higher inequality in a country, relative to its GDP, reduces the likelihood that its trading partners adopt an emissions trading system, representing a negative spatial spillover. Conversely, the positive indirect effects of governance quality and GDP per capita suggest the presence of peer effects: when a country with strong institutions and higher income implements ambitious climate policies, such as an ETS, it increases the probability of adoption among its trading partners. This dynamic fosters clusters of countries with similar governance and economic profiles, promoting convergence in ETS adoption. Quantitatively, a 1% increase in governance quality and GDP per capita in a country raises the probability of ETS adoption among trading partners by 0.04% and 0.014%, respectively. The indirect effect of export intensity is also positive, with a 1% increase in a country's export intensity raising the probability of adoption among its trading partners by 0.01%.

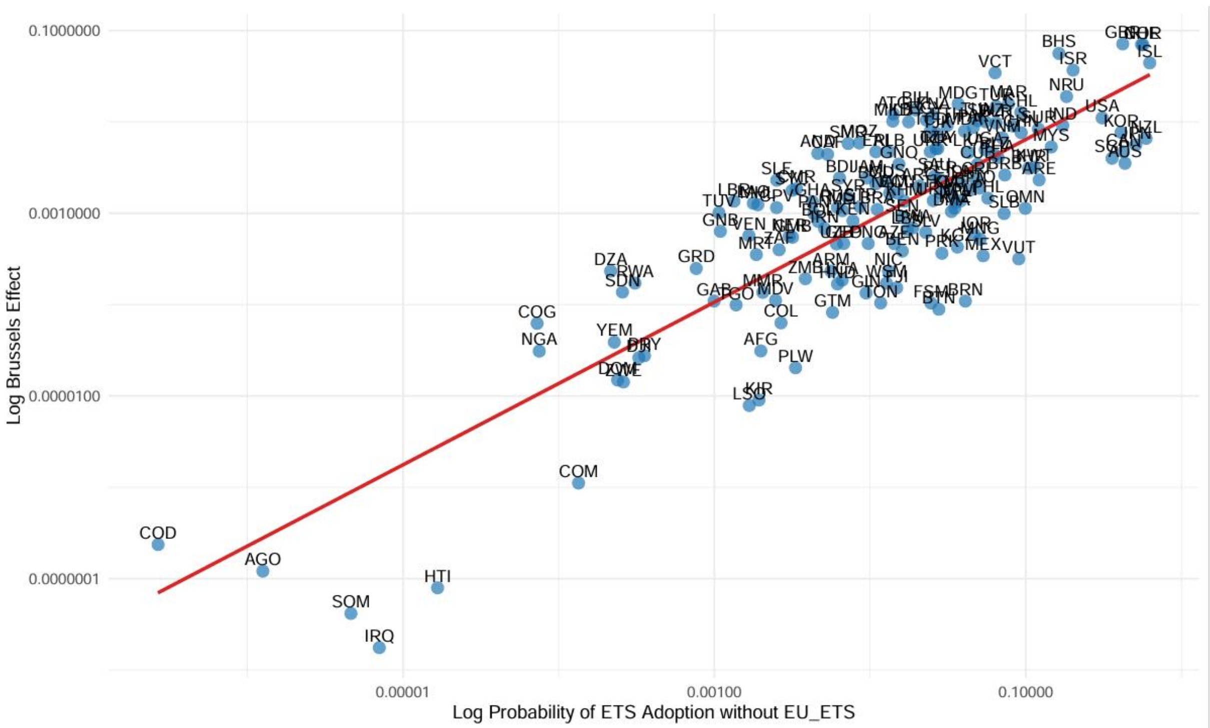
5.3 Estimating the "Brussels Effect"

The SAR Probit regression, with a positive and significant $\boldsymbol{\rho}$ coefficient, confirms the existence of diffusion effects between countries. In this section, we aim to estimate more precisely the magnitude of the "Brussels Effect", understood as the specific contribution of the European Union's ETS to global ETS adoption dynamics. The underlying hypothesis is that, as the world's first operational ETS, the EU ETS should exert a measurable influence on other countries, particularly its commercial partners, through international policy spillovers. To isolate this effect, we proceed in two steps:

- Baseline probability: For each country i, we compute the probability of ETS adoption with the EU ETS coded as 1, meaning we account for its presence in the spatial network.
- Counterfactual probability: We simulate the absence of the EU ETS by setting its value to 0 in the outcome variable and re-compute the probability of ETS adoption for the same countries under this scenario.

The "Brussels Effect" for each country is thus measured as the difference between these two probabilities[20]. This difference captures how the presence of the EU ETS alters the likelihood that a given EU trading partner adopts its own national ETS.

Figure 2: The "Brussels Effect" on ETS Adoption



The positive slope of the red line fitting the set of points shown in Figure 2 suggests that the more a country is likely to adopt an ETS independently of the EU-ETS, the larger the "Brussels Effect" and vice versa. For example, in the case of Norway the probability of adopting an ETS independently of the EU-ETS is 56%, which increases to 64% when the influence of the EU ETS is considered, representing a "Brussels Effect" of about 8%. For Switzerland, the probability rises from 55% to 62%, also indicating a "Brussels Effect" of roughly 7%. In Turkey, the probability increases from 6.5% to 8%, corresponding to a "Brussels effect" of approximately 1.5%. The case of the United Kingdom is unique. Since the EU-ETS was established before Brexit, the country was effectively covered by the EU-ETS before withdrawing from it to form the UK-ETS. By contrast, countries such as Iraq, the Democratic Republic of Congo, Comoros, Angola, Somalia, and Haiti, clustered near the

[20] The initial estimations of the "Brussels Effect" were expressed in probabilities, but in Figures 2 and 3 the values were log-transformed for graphical representation.

origin at the lower end of the line, exhibit both extremely low baseline probabilities of ETS adoption and negligible changes when the influence of the EU ETS is removed. This suggests that the "Brussels Effect" is virtually absent in contexts where the structural conditions for ETS implementation are not present. It is also worth noting that the countries for which the "Brussels Effect" is most pronounced are generally high-income economies with substantial trade ties to the European Union. This highlights the role of economic connectivity in the capacity of the EU to shape its partners climate policy.

Figure 3: "Brussels Effect" estimates and confidence interval

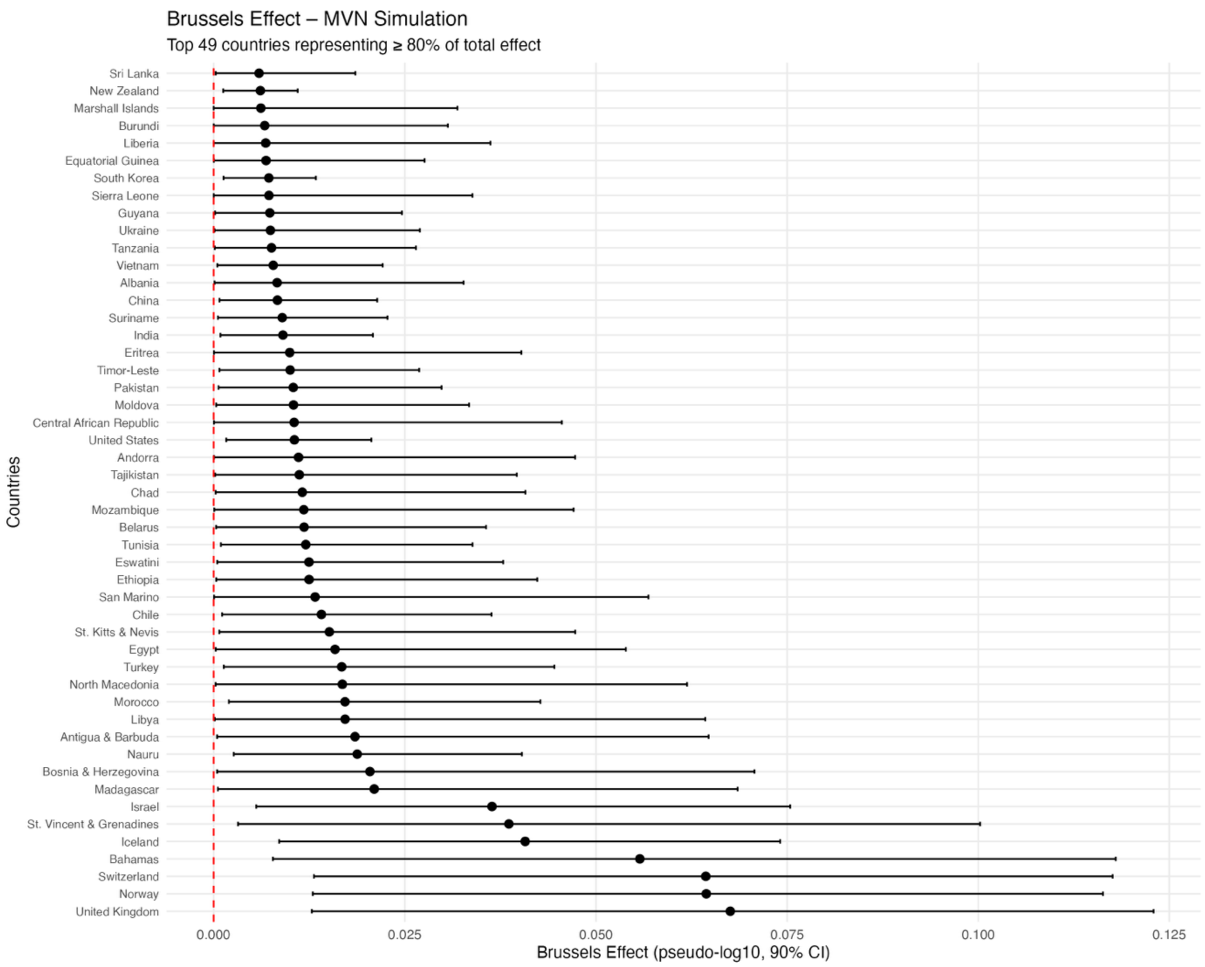


Figure 3 ranks the top 49 countries in terms of the magnitude of the "Brussel Effects" and provides its 90% confidence interval. It is worthwhile noting that for more developed countries having a relatively low expected value (point) of their "Brussels Effects", the confidence interval (bar) is nevertheless narrower compared to countries with close ranks, making these countries more likely to be positively influenced by the EU-ETS regulation. It is typically the case of United States, South Korea and New-Zealand. Taken together, these results highlight that a "Brussels Effect" does exist in the context of ETS adoption, but its scope is limited and non-decisive. In other words, the EU ETS does not trigger adoption decisions among partner countries; rather, it accelerates adoption where favourable conditions already exist. Moreover, engaging in trade with the EU does not automatically translate into policy alignment on climate matters. Other structural factors—most notably the level of economic development—also play a key role. This is consistent with the literature on environmental policy diffusion, including the Environmental Kuznets Curve hypothesis, which links environmental commitment to stages of economic development.

5.4 Sensitivity analysis

As stated by Lu and White (2014), a robustness check is a common exercise in empirical studies, where researchers examine how certain core regression coefficient estimates behave when the regression specification is modified by adding or removing regressors. They add that if the coefficients are plausible and robust, this is commonly interpreted as evidence of structural validity.

We propose six robustness tests to validate our findings. The first involves changing the estimation method: while the initial regression (Table 2) was estimated using MCMC with informative priors derived from maximum likelihood, we re-estimate the same model using diffuse (non-informative) priors that "let the data speak for themselves" (Wang et Kockelman, 2009). As shown in the first regression of Table 3, the results remain stable, particularly the coefficient of interest $\boldsymbol{\rho}$ (0.2912), which is positive and statistically significant at the 1% level. Notably, Education (2.4330), Unemployment Rate (–1.1880), and Quality of Traded Goods (–1.5551) become statistically significant.

In the second and third tests, we retain the same estimation method but modify the spatial weighting structure. In the initial regression (Table 2), the matrix $\mathbf{W}$ was constructed using export flows only, resulting in an asymmetric weight matrix between country pairs $\{i, j\}$. By contrast, we now construct $\mathbf{W}$ based on total bilateral trade flows, that is, the sum of exports and imports, which yields a symmetric spatial weight matrix. The estimated coefficient $\boldsymbol{\rho}$ (0.3389) remains positive and significant at the 1% level, while Inflation (–0.2235) becomes significant at the 5% level. As shown in the third column of Table 3, after removing four variables from the model to test its robustness against potential specification bias, $\boldsymbol{\rho}$ (0.3295) remains positive and significant at the 1% level, and the other coefficients retain their signs and significance.

In the fourth test, we apply the same method as in the second but modify the coding of our outcome variable and use informative priors. Specifically, we code as 1 the countries that have adopted an ETS, whether at the subnational or national level, which increases the number of countries classified as ETS adopters from 12 to 15. As shown in the fourth column, and compared to the baseline regression in Table 2, the coefficients remain stable both in terms of significance and sign.

For the last two tests, the objective is to assess the consistency of our hypothesis regarding the presence of potential endogeneity, particularly arising from reverse causality between the adoption of an ETS and a country's macroeconomic and trade outcomes. As previously discussed, the implementation of a carbon pricing policy such as an ETS may improve a country's economic performance, for instance through the double dividend hypothesis. This is why we initially selected 2004, a pre-EU ETS year, as the reference date. To test this intuition, we re-estimated the model using the same set of variables, replacing only the reference year with a more recent one, 2023, noting that the spatial weight matrix was constructed using

2023 data for column 5 and 2004 data for the last column. The results support our concern by producing coefficients with counterintuitive signs. For instance, the coefficient of the education variable turns negative, suggesting that more educated countries are less inclined to adopt environmental policies, a finding that clearly contradicts the economic literature. Moreover, while in all previous tests the cross variables Gini*GDP and GDP per capita remained significant, they lose significance in this specification. Thus, even though the coefficient $\boldsymbol{\rho}$ remains positive and significant, it is reasonable to assume that estimates of this variant of the model are subject to an endogeneity bias.

Table 3: Robustness Checks

	(1) Bayesian MCMC	(2) Bayesian MCMC	(3) Bayesian MCMC	(4) Bayesian MCMC	(5) Bayesian MCMC	(6) Bayesian MCMC
Quality of governance	5.0704*** (1.2554)	5.3122*** (1.5591)	4.7836*** (1.5062)	2.0526*** (0.5982)	1.4858*** (0.5284)	1.5140*** (0.5258)
Export intensity	2.4423*** (0.5791)	2.6897*** (0.6492)	1.7931*** (0.6350)	0.3937** (0.1813)	0.4975** (0.2071)	0.4895** (0.1967)
Carbon intensity	-0.1504 (0.1169)	-0.1760 (0.1097)	-0.0524 (0.0964)	-0.0435 (0.0557)	-0.1037 (0.0631)	-0.1049 (0.0635)
Education	2.4330** (1.1220)	3.0129** (1.2546)	1.6875* (0.9327)	-0.1676 (0.3449)	-0.8743* (0.4467)	-0.8881** (0.4394)
Unemployment rate	-1.1880** (0.5449)	-1.4079** (0.5431)	-0.6240 (0.5009)	-0.2552 (0.1931)	-0.2784 (0.2134)	-0.3125 (0.2124)
GDP*Gini index	-0.5779*** (0.1992)	-0.5887*** (0.2081)	-0.6171*** (0.2123)	-0.1506** (0.0704)	0.0107 (0.0796)	0.0100 (0.0792)
GDP per capita	1.6268** (0.8029)	1.5624* (0.8585)	1.7071** (0.8447)	0.6646** (0.2923)	0.4134 (0.3243)	0.4225 (0.3216)
Democracy	-1.0271 (1.003)	-1.2076 (1.0530)		0.1690 (0.4469)	-0.3747 (0.3835)	-0.3949 (0.3823)
Inflation	-0.1686 (0.1143)	-0.2235** (0.0921)		-0.0196 (0.0228)	-0.0054 (0.0084)	-0.0056 (0.0085)
Trade openness	0.5994 (0.4892)	-0.4068 (0.4603)		-0.0197 (0.1823)	0.0098 (0.1452)	0.0059 (0.1478)
Quality of traded goods	-1.5551*** (0.5016)	-1.9436*** (0.5788)		-0.0480 (0.1665)	0.1579 (0.1742)	0.1634 (0.1801)
Rho	0.2912*** (0.0524)	0.3389*** (0.0646)	0.3295*** (0.0753)	0.3217** (0.1432)	0.4681*** (0.1215)	0.4625*** (0.1174)
N observations	161	161	161	161	160	160
Diffuse priors	Yes	Yes	Yes	No	No	No
N draws	5000	3000	3000	3000	3000	3000
N omit (burn-in)	1000	1000	1000	1000	300	300
Log Likelihood	-26.0052	-27.5607	-33.7136	-21.0543	-26.6842	-27.4367

Notes: ***p<0.01, **p<0.05, *p<0.1. Standard errors in parentheses

6 Conclusions

The rise of climate emergencies has driven countries and economic blocs to seek measures to address them. One prominent response has been the increasing implementation of emissions trading systems, leading to a total of 38 operational schemes worldwide by 2025. As the oldest ETS in the world, the EU ETS has served as a cornerstone of the development of carbon markets worldwide and a model for other jurisdictions implementing or considering similar policies.

This paper sets out to empirically assess whether the EU ETS generates international spillover effects, commonly referred to as the "Brussels Effect", in the domain of climate policy. Purposedly, a spatial autoregressive probit model was employed, incorporating a spatial weight matrix based on bilateral trade intensity. The results yield two central findings with significant policy implications.

First, the estimated coefficient of trade-based spillovers is positive and statistically significant, providing robust evidence of spatial diffusion in ETS adoption among trade-connected countries. This supports the idea that trading with a country operating an ETS increases the probability that its trade partners will adopt a similar policy. It's worth noting that this spatial dependence appears to be specific to ETS adoption, as it disappears when carbon pricing is considered more broadly, including both ETS and carbon taxes. This result lends empirical support to the European Commission's claim that the EU ETS generates positive international spillover effects based on experience feedback and lessons from the European ETS. Rather than being viewed with scepticism as mainly a potential source of carbon leakage or competitiveness concerns, the EU ETS should also be recognized and promoted as a necessary and effective policy tool for addressing climate change both within Europe and beyond.

Second, the analysis reveals that while a "Brussels Effect" does exist, its scope remains limited and non-decisive. The effect is most pronounced in countries that already exhibit a significant probability of ETS adoption even in the absence of EU ETS influence. This suggests that the EU ETS does not trigger adoption decisions among partner countries but rather accelerates adoption where favourable conditions are already in place, such as strong institutional governance and higher levels of economic development. This finding leads us to conclude that the EU ETS constitutes a necessary but not sufficient condition for effectively addressing climate change on a global scale. It underscores the need for complementary policy instruments such as the Carbon Border Adjustment Mechanism to reinforce the EU's climate leadership, enhance policy coherence, and promote alignment among its member states and international trading partners.

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8 Appendices

8.1 Marginal Effects tables

A variable is considered significant when the 90% credible intervals for its direct, indirect, and total effects do not include zero. In such cases, the posterior distribution is sufficiently far from zero to support the variable's important role in explaining a country's decision to adopt an ETS.

Table 4: Direct effects

Variables	Lower_005	Posterior_mean	Upper_095
Democracy	-0.037	0.006	0.058
Quality of governance	0.040	0.105	0.190
Inflation	-0.003	-0.001	0.001
Export intensity	0.002	0.020	0.043
Carbon intensity	-0.012	-0.004	0.001
Education	-0.040	-0.004	0.033
Unemployment rate	-0.041	-0.015	0.002
GDP per capita	0.007	0.036	0.077
GDP*Gini index	-0.020	-0.009	-0.002
Trade openness	-0.019	0.001	0.022
Quality of traded goods	-0.025	-0.004	0.014

Table 5: Indirect effects

Variables	Lower_005	Posterior_mean	Upper_095
Democracy	-0.015	0.002	0.024
Quality of governance	0.016	0.042	0.077
Inflation	-0.001	-0.001	0.001
Export intensity	0.001	0.008	0.018
Carbon intensity	-0.005	-0.001	0.000
Education	-0.016	-0.001	0.014
Unemployment rate	-0.016	-0.006	0.001
GDP per capita	0.003	0.014	0.031
GDP*Gini index	-0.008	-0.003	-0.001
Trade openness	-0.008	0.001	0.009
Quality of traded goods	-0.010	-0.001	0.005

Table 6: Total effects

Variables	Lower_005	Posterior_mean	Upper_095
Democracy	-0.053	0.009	0.082
Quality of governance	0.057	0.148	0.267
Inflation	-0.004	-0.001	0.002
Export intensity	0.003	0.028	0.061
Carbon intensity	-0.018	-0.006	0.002
Education	-0.057	-0.005	0.046
Unemployment rate	-0.058	-0.021	0.003
GDP per capita	0.010	0.051	0.108
GDP*Gini index	-0.028	-0.012	-0.003
Trade openness	-0.027	0.001	0.030
Quality of traded goods	-0.036	-0.005	0.019

8.2 Trace Plots of MCMC Chains

The trace plot shows the evolution of MCMC draws for a parameter over the iterations. It is used to visually check the stability and mixing of the chain: after a burn-in phase, the values are expected to fluctuate around a stable level without any marked trend. These plots are therefore essential tools for assessing the convergence of the simulation and ensuring that the retained sample is representative of the posterior distribution.

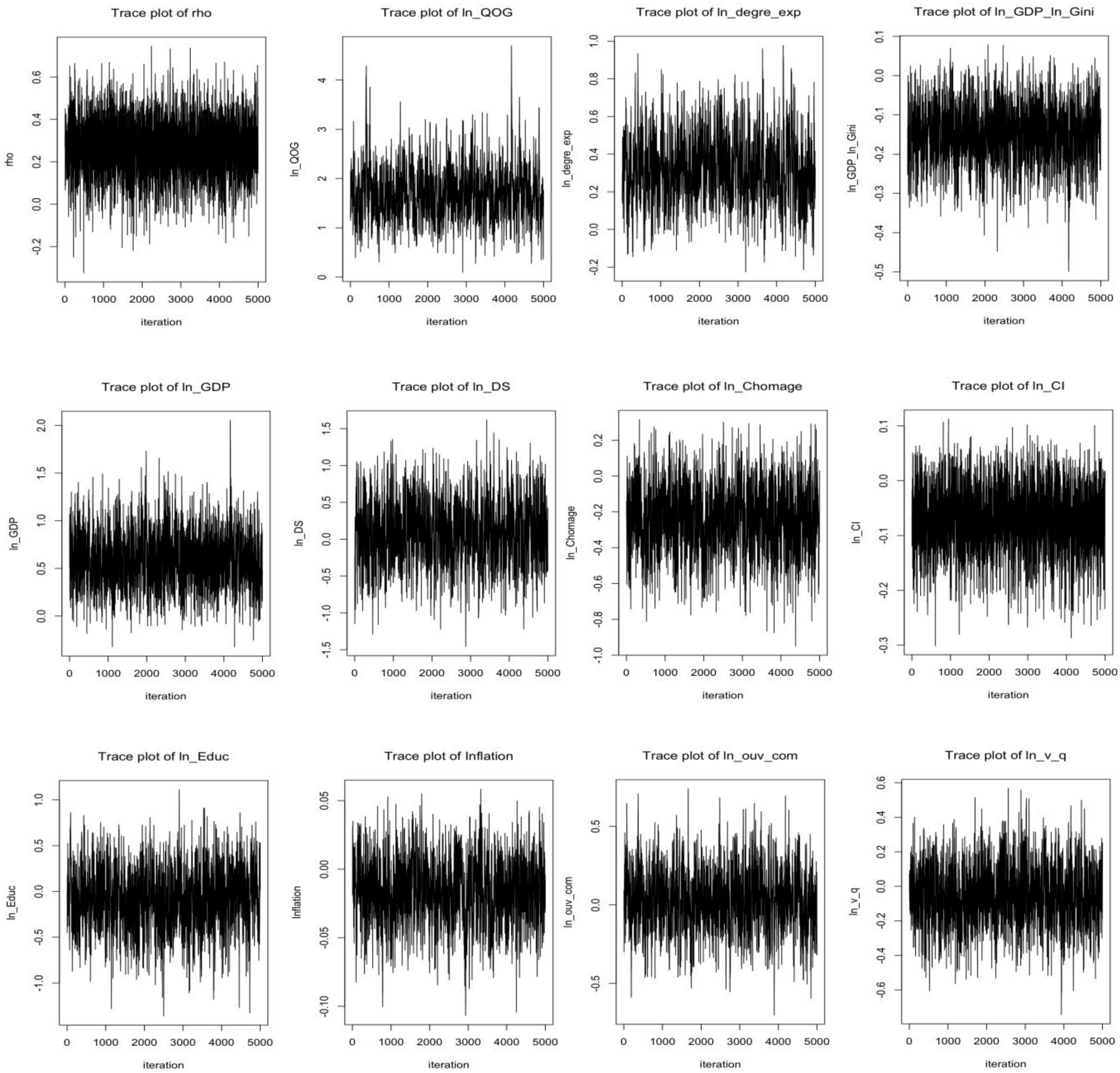

Figure 1: Trace plot

8.3 Posterior Distributions of Model Parameters

The posterior distribution represents the estimated probability density of a parameter after combining the information from the data and the priors. It provides a clear view of the parameter's most probable central value as well as the associated uncertainty. In a Bayesian framework, these plots are indispensable because they directly illustrate how inference relies on a distribution rather than on a single point estimate.

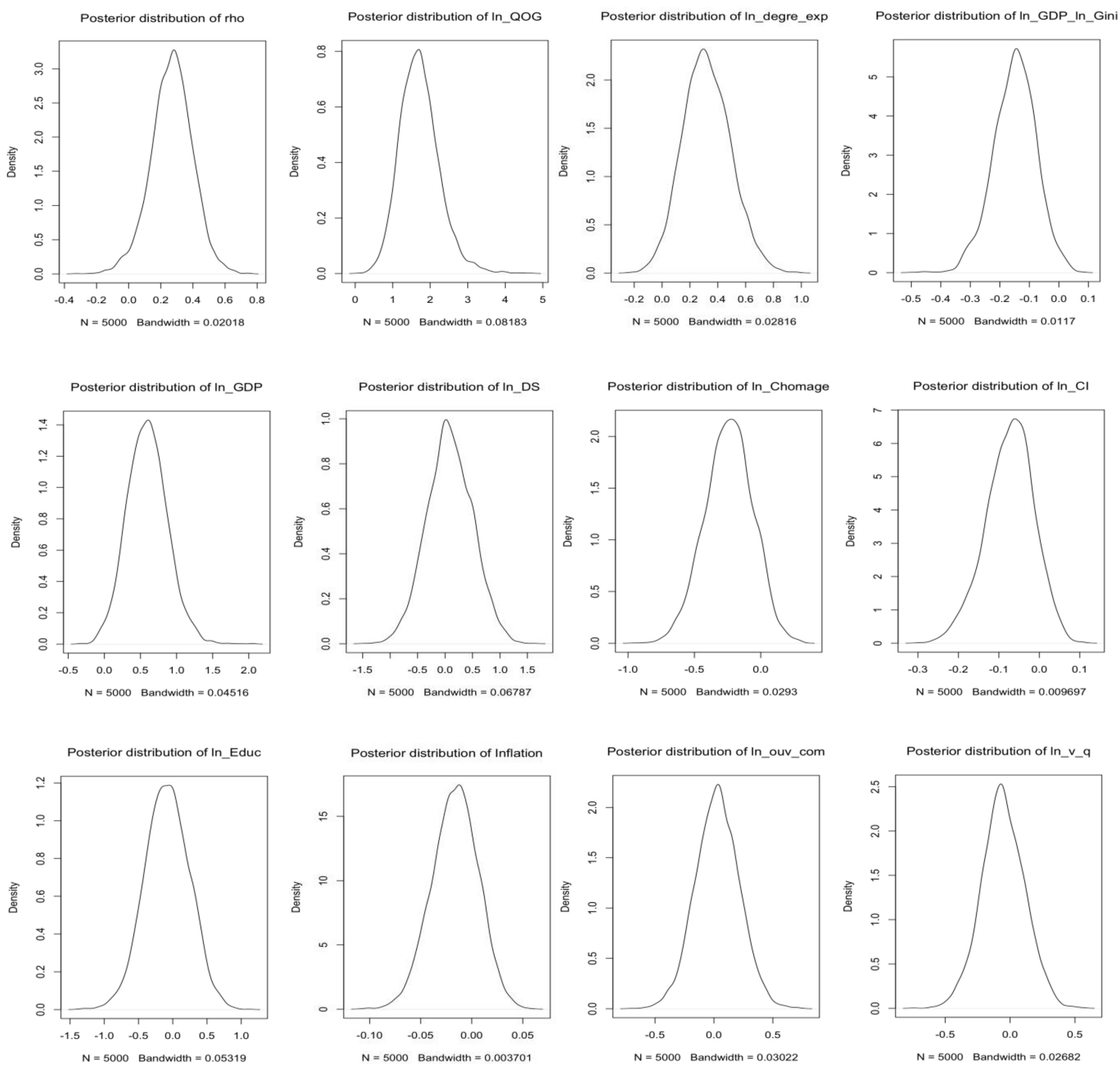

Figure 2: Posterior distribution

8.4 Autocorrelation Function (ACF) Plots

The autocorrelation function plot evaluates the degree of dependence between successive draws of the MCMC chain. A low and rapidly decaying correlation indicates good mixing and a large effective sample size. These diagnostics are crucial for assessing the quality of the simulated sample: if autocorrelations persist, additional iterations or adjustments to the simulation parameters may be necessary.

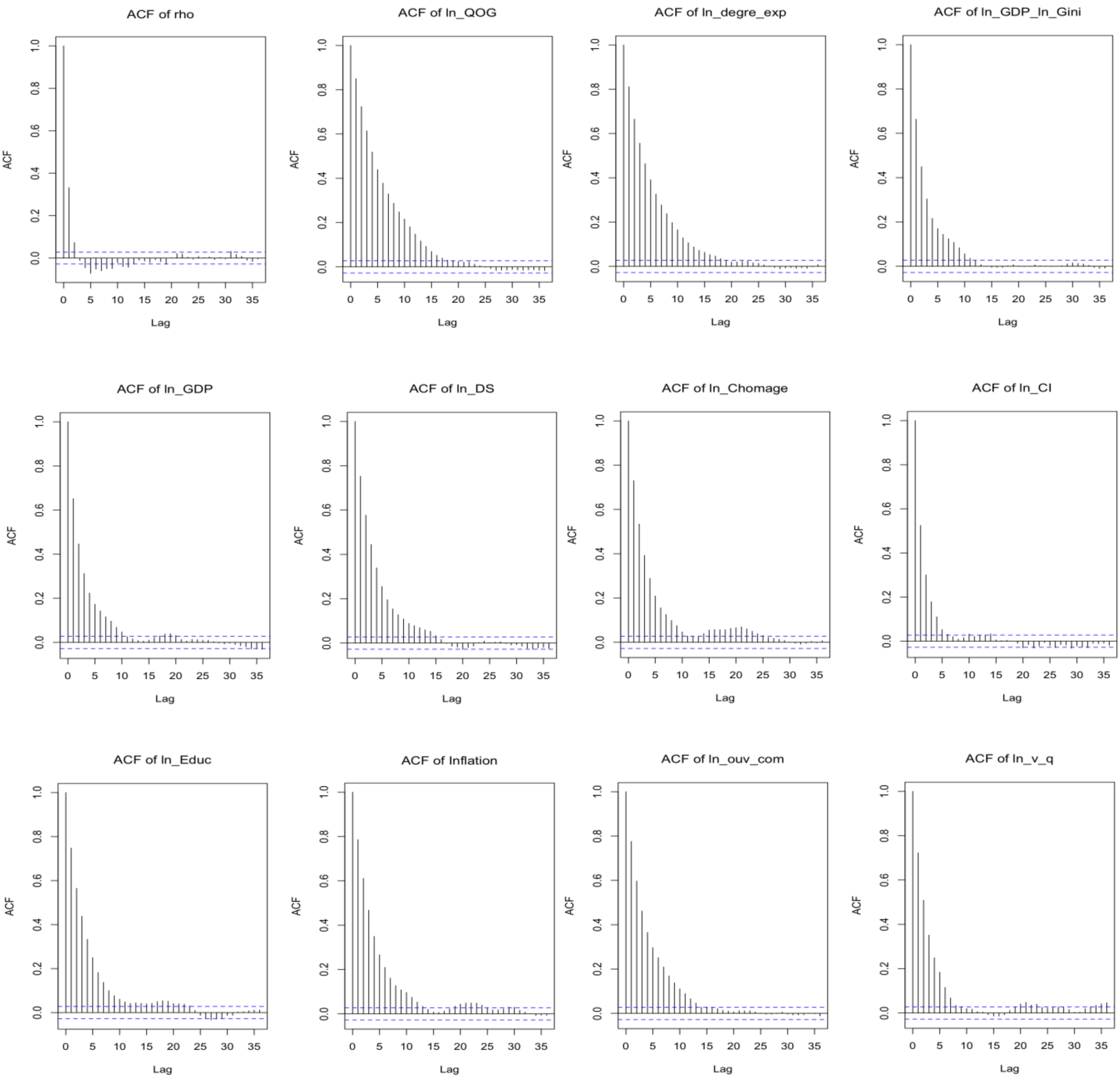

Figure 3: Autocorrelation Function

8.5 Probabilistic Estimation of the "Brussels Effect"

Table 7: "Brussels Effect"

Country	"Brussels Effect"	With EU_ETS	Without EU_ETS
United Kingdom	.0715	.4911	.4196
Switzerland	.0703	.6245	.5542
Norway	.0699	.6349	.565
Bahamas	.0562	.2195	.1633
Iceland	.0443	.6692	.6249
Israel	.0369	.2381	.2013
Saint Vincent	.0345	.098	.0635
Nauru	.0189	.2017	.1828
Morocco	.0158	.0933	.0775
Madagascar	.0157	.0525	.0368
Turkiye	.0148	.0794	.0646
Bosnia	.0135	.0331	.0196
Chile	.0128	.1056	.0928
Antigua	.0122	.0263	.0141
Saint Kitts	.0116	.0369	.0253
USA	.0111	.3205	.3094
Egypt	.0105	.0335	.023
Tunisia	.0103	.0594	.0491
North Macedonia	.0102	.0242	.014
Eswatini	.01	.0651	.0551
Libya	.01	.0277	.0177
Belarus	.0098	.0741	.0644
India	.0091	.1816	.1725
Ethiopia	.0091	.0404	.0313
Timor-Leste	.009	.0921	.0831
Pakistan	.0087	.0548	.046
Suriname	.0084	.1289	.1206
Chad	.008	.0324	.0245
Rep. of Moldova	.0079	.0484	.0404
Rep. of Korea	.0077	.4173	.4096
China	.0076	.1011	.0935
Tajikistan	.0075	.0343	.0268
Viet Nam	.0067	.0774	.0707
New Zealand	.0066	.5989	.5923
Mozambique	.0059	.0144	.0085
San Marino	.0058	.013	.0072
Japan	.0056	.5144	.5087
Malaysia	.0053	.1511	.1458
Tanzania	.0051	.0317	.0265
Guyana	.0051	.0323	.0272
Uganda	.0049	.0598	.0549
Albania	.0047	.0179	.0132
Ukraine	.0047	.0291	.0244
Canada	.0047	.4293	.4246
Eritrea	.0047	.0156	.0109
Sri Lanka	.0046	.0476	.043
Andorra	.0045	.0091	.0046
Central African	.0044	.0097	.0053
Belize	.0044	.0675	.0631
Thailand	.0041	.0704	.0664
Singapore	.004	.3621	.3581
Australia	.0035	.4374	.4339
Equatorial Guinea	.0035	.0188	.0153
Cuba	.0034	.0526	.0491
Kuwait	.0032	.1164	.1132
Bahrain	.0031	.1074	.1043
Barbados	.0026	.076	.0734
Saudi Arabia	.0025	.0284	.0259
Burundi	.0024	.0088	.0064
Jamaica	.0024	.012	.0095
Peru	.0024	.0304	.0281
Costa Rica	.0023	.05	.0477
United Arab Emirates	.0023	.1241	.1218
Sierra Leone	.0023	.0048	.0025
Mauritius	.0022	.0151	.0129
Indonesia	.0022	.0404	.0382
Bangladesh	.0021	.013	.0109
Argentina	.002	.0227	.0207
Trinidad and Tobago	.0019	.0522	.0503
Cameroon	.0019	.0052	.0034
Burkina Faso	.0018	.0455	.0437
Seychelles	.0018	.0049	.0032
Turkmenistan	.0017	.0298	.0282
Ecuador	.0017	.0167	.015
Namibia	.0017	.015	.0133
Qatar	.0016	.035	.0333
Syria	.0015	.0087	.0072
Philippines	.0015	.0585	.0571
Uruguay	.0014	.0268	.0255
Malawi	.0014	.0395	.0381
Liberia	.0014	.0027	.0013
Cambodia	.0014	.0179	.0166
Ghana	.0013	.0056	.0043
Nepal	.0013	.0367	.0354
Lao People's Dem. Rep.	.0013	.0031	.0018
Marshall Isds	.0012	.0031	.0019
Sao Tome and Principe	.0012	.0098	.0086
Russian Federation	.0012	.0073	.0062
Cabo Verde	.0012	.0037	.0025
Kazakhstan	.0011	.0362	.035
Oman	.0011	.1004	.0993
Brazil	.0011	.0122	.0111
Mali	.0011	.0077	.0066
Dominica	.001	.0344	.0333
Tuvalu	.001	.0021	.0011
Solomon Isds	.001	.0735	.0725

Country	"Brussels Effect"	With EU_ETS	Without EU_ETS
Panama	.001	.0054	.0044
Senegal	.0009	.017	.0161
Kenya	.0008	.0086	.0078
Bolivia	.0008	.0055	.0046
Botswana	.0007	.0195	.0188
Iran	.0007	.0058	.0051
Lebanon	.0007	.018	.0174
Guinea-Bissau	.0006	.0017	.0011
El Salvador	.0006	.0234	.0228
Jordan	.0006	.0474	.0468
Venezuela	.0006	.0022	.0017
Niger	.0006	.0036	.003
Gambia	.0005	.0037	.0032
Mongolia	.0005	.0514	.0509
Georgia	.0005	.0072	.0068
New Guinea	.0005	.0102	.0097
Azerbaijan	.0005	.0148	.0143
Uzbekistan	.0005	.0066	.0061
Kyrgyzstan	.0004	.0368	.0364
South Africa	.0004	.003	.0026
Benin	.0004	.0165	.0161
Rep. of Korea	.0004	.0293	.0289
Mauritania	.0004	.0022	.0019
Mexico	.0003	.0536	.0532
Vanuatu	.0003	.0904	.0901
Grenada	.0002	.001	.0008
Nicaragua	.0002	.0134	.0131
Algeria	.0002	.0004	.0002
Armenia	.0002	.0058	.0056
Zambia	.0002	.004	.0038
Saint Lucia	.0002	.0068	.0066
Rwanda	.0002	.0005	.0003
Samoa	.0002	.0129	.0127
Honduras	.0002	.0063	.0062

Country	"Brussels Effect"	With EU_ETS	Without EU_ETS
Fiji	.0002	.015	.0148
Sudan (...2011)	.0001	.0004	.0003
Myanmar	.0001	.0022	.002
Guinea	.0001	.0096	.0094
Maldives	.0001	.0026	.0025
Gabon	.0001	.0011	.001
Brunei Darussalam	.0001	.0411	.0409
Tonga	.0001	.0118	.0117
FS Micronesia	.0001	.0247	.0246
Togo	.0001	.0015	.0014
Bhutan	.0001	.0277	.0276
Guatemala	.0001	.0058	.0057
Colombia	.0001	.0027	.0027
Congo	.0001	.0001	.0001
Yemen	0	.0003	.0002
Afghanistan	0	.002	.002
Nigeria	0	.0001	.0001
Paraguay	0	.0004	.0004
Djibouti	0	.0004	.0003
Palau	0	.0033	.0033
Dominican Rep.	0	.0003	.0002
Zimbabwe	0	.0003	.0003
Kiribati	0	.0019	.0019
Lesotho	0	.0017	.0017
Comoros	0	.0001	.0001
Rep. of the Congo	0	0	0
Angola	0	0	0
Haiti	0	0	0
Somalia	0	0	0
Iraq	0	0	0

Notes: "With EU_ETS" represents the probability that each country adopts a national ETS under the influence of the EU ETS. "Without EU_ETS" represents the probability of adoption when simulating the absence of the EU ETS. The "Brussels Effect" thus measures the additional probability attributable to the diffusion impact of the EU ETS.

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