Discussion Paper

To Auction or to Give for Free: Does the Allowance Allocation Regime Matter for Renewable Deployment in the EU ETS?

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Key Points

- The choice between auctioning and free allocation of allowances in the EU ETS had no significant impact on renewable energy deployment.
- Fossil fuel use depends on cost pass-through rather than on the allocation regime itself.
- Empirical evidence shows that renewables expanded across all EU ETS countries in Phase III, but the pace of deployment did not differ between auctioning countries and derogated countries that continued free allocation.
- Derogated countries performed similarly to auctioning countries when reinvestment rules were enforced for derogated countries.
- Policy effectiveness depends more on governance and enforcement than on allocation design.

Abstract

Phase III of the European Union Emissions Trading System (EU ETS) marked a shift in the power sector from free allocation to auctioning as the default method of distributing allowances. To ease the transition, some lower-income countries were granted derogations that allowed them to retain free permits, provided the equivalent monetary value was invested in renewable energy and modernization of energy infrastructure. This created a policy divergence between auctioning and derogated countries. Did these contrasting allocation regimes lead to different renewable deployment outcomes between the two groups? We address this question using a partial equilibrium model and an empirical analysis of EU ETS data. The model shows that fossil fuel use in power generation depends on the degree of cost pass-through, rather than the allocation rule itself. With full cost pass-through, auctioning does not raise carbon costs for power generators, while free allocation creates windfall profits. In neither case do renewables gain a relative cost advantage, suggesting that the method of allocation is unlikely to produce differences in renewable deployment. Consistent with this prediction, our difference-in-differences estimates indicate that renewable capacity expanded and power sector emissions declined during Phase III, yet there is no evidence of differential outcomes between auctioning and derogated countries. As more countries implement emissions trading systems, our findings suggest that their effectiveness in promoting renewable deployment depends less on the allocation method than on clear, enforceable rules that channel resources toward the clean energy transition.

Keywords: EU ETS, Emissions Trading Systems, Allowance Allocation, Renewable Energy, Climate Policy
JEL classification: Q48, Q52, Q58

Introduction

01

Emissions trading systems (ETSs) have become a central policy instrument for decarbonization worldwide, with 38 systems currently operating and 20 under development or consideration – an increasing number in developing and emerging economies (ICAP 2025).[1] These systems vary widely in design, with challenges emerging in areas such as market stability, sectoral coverage, and the allocation of allowances (whether auctioned, allocated for free, or distributed under conditional schemes).

The European Union Emissions Trading System (EU ETS) is the world's largest and most mature emissions trading system, widely recognized for its innovative use of market mechanisms to promote renewable energy deployment and decarbonization. As the most established system, it offers practical lessons for countries now developing their own emissions trading systems, with design features that can be replicated or adapted to local contexts.

Established in 2005, the EU ETS employs market-based mechanisms to reduce greenhouse gas emissions from the power and industrial sectors, operating under the cap-and-trade principle. This framework limits total emissions while allowing firms to trade allowances. During Phase I (2005-2007) and Phase II (2008-2012), most emission permits were allocated to firms at no cost (free allocation) based on historical emissions, a method known as grandfathering.[2] While politically expedient, this approach resulted in over-allocation, windfall profits, and limited incentives for decarbonization – ultimately prompting significant reform.

In Phase III (2013-2020), the EU ETS ended free allocation in the power sector, requiring the full auctioning of allowances. This shift was motivated by concerns that free allocation enabled generators to pass through carbon costs to consumers while securing windfall profits. Another aim was to strengthen the carbon price signal and accelerate investment in clean energy, given the power sector's central role in the broader economy.[3] Moreover, policymakers believed the power sector could decarbonize more readily and faced a lower risk of carbon leakage compared to other industries, even though empirical evidence for such risks was limited at the time – and remains debated (e.g., Verde et al. 2019; Grubb et al. 2022).

However, the reform of allowance allocation was tempered by a major compromise: Article 10c of Directive 2003/87/EC, introduced by the 2009 revision. Beginning in 2013, this provision allowed 10 lower-income countries to continue allocating allowances for free instead of transitioning immediately to full auctioning in the power sector.[4] Nevertheless, this derogation came with a strict condition: the

equivalent monetary value of the free allowances had to be invested in clean technologies, energy system modernization, diversification of the energy mix, and network upgrades. This arrangement created a unique natural experiment, contrasting auctioning with a free allocation regime tied to mandatory, binding investment obligations. Adding another twist, two of the 10 countries eligible for derogation – Latvia and Malta – chose to forgo this option and implemented full auctioning instead.

This divergence in policy implementation across countries within an international emissions trading system presents a compelling and timely empirical puzzle: Did auctioning in the EU ETS truly provide more substantial incentives for renewable energy deployment, or can free allocation deliver comparable outcomes when subject to binding reinvestment mandates? Understanding this question is essential, first, for assessing how the power sector responds to different allocation regimes, and more broadly for informing the design of emissions trading systems. The issue is particularly relevant as many countries move toward establishing such systems and seek to balance economic efficiency with the practical need to expand renewable capacity.

To study this policy variation, we combine a theoretical model with an empirical analysis. First, we develop a partial-equilibrium model of power generators' choices between fossil fuels and renewables. The model shows that fossil fuel use depends on the extent to which carbon costs are passed on to consumers, but not on the method of allowance allocation, while renewable deployment depends on relative costs and policy support. The allowance allocation method affects profits but not input choices.

We then test these theoretical predictions using panel data for European countries from 2005 to 2020, leveraging policy differences that emerged in Phase III. Our empirical analysis applies a difference-in-differences design, comparing renewable capacity growth between countries required to auction allowances and those eligible for derogation. We account for both legal eligibility and actual implementation.

We find that, following the 2013 reform, renewable capacity increased and power sector emissions declined on average across EU ETS countries. However, we find no evidence of differential growth in renewable capacity or emissions reductions between auctioning and derogated countries, which runs counter to the conventional expectation that auctioning provides more substantial investment incentives.

The remainder of the paper is as follows. Section 2 reviews the institutional context of the EU ETS, focusing on the evolution of allowance allocation and situating our contribution within the literature. Section 3 develops a theoretical model of power generators' input choices, emphasizing the roles of carbon cost pass-through and allowance allocation. Section 4 describes the empirical strategy and presents the results along with robustness checks. Section 5 concludes.

EU ETS Design and Renewable Investment

02

The evolution of the EU ETS reveals a tension between economic theory and political feasibility, with allowance allocation emerging as a major institutional fault line. Policymakers and economists increasingly advocate auctioning as the most transparent, efficient, and economically sound method, widely praised for aligning with the polluter pays principle and avoiding the market distortions of free allocation (Keohane 2009; Bushnell, Chong, and Mansur 2013; Schmalensee and Stavins 2017).

Unlike free allocation, auctioning is seen as strengthening incentives for cleaner technologies, curbing rent-seeking behavior, and generating public revenue that can be recycled into energy transition policies. Revenues raised from auctioning flow to national (and partly EU) budgets, and while their specific allocation varies across countries and over time, EU law has encouraged that at least half of these revenues be directed toward climate and energy purposes, including renewable generation and efficiency improvements.[5]

2.1 Free Allocation Versus Auctioning

Free allocation of allowances was originally intended to protect emissions-intensive, trade-exposed sectors from the risk of carbon leakage – that is, the relocation of production to jurisdictions with weaker climate regulations and enforcement. This allocation strategy reflected a pragmatic policy choice aimed at ensuring a gradual adjustment to carbon pricing while safeguarding the competitiveness of vulnerable industries. In the power sector, nearly 100% of allowances in Phase I and about 90% in Phase II were allocated for free, primarily through grandfathering, with only small volumes auctioned.

In its first two phases, the EU ETS offered a cautionary tale. Although politically expedient, free allocation led to overallocation, low carbon prices, and windfall profits in the power sector (Betz and Sato 2010; Kill et al. 2010; Ben-David et al. 2021; Bartram, Hou, and Kim 2022). These rents arose because electricity producers could pass through the cost of carbon to consumers even when allowances were received for free (Sijm, Neuhoff, and Chen 2006; Laing et al. 2013). This pass-through, which occurred at the wholesale level despite partially regulated retail markets, enabled generators to raise prices and capture profits without incurring real costs. As a result, carbon price signals were weak, incentives to shift to renewables remained limited, auction revenues were scarce, and the retirement of fossil assets was delayed (Müller and Teixidó 2021).

Empirical studies consistently find that power producers in the EU ETS internalize the carbon price and pass it through almost fully – sometimes even above unity – a pattern observed as

early as Phase I (Hintermann 2016; Fabra and Reguant 2014; Zachmann and von Hirschhausen 2008; Alexeeva-Talebi 2011; Jouvet and Solier 2013). Policymakers therefore argued that a higher share of auctioning was needed "to ensure the carbon-price signal trickles through to all consumers, and to avoid huge windfall profits for power producers" (Brookings Institute 2009). Recital 19 of the revised ETS Directive (2009/29/EC) emphasized that "auctioning should be the basic principle for allocation, as it is the simplest and generally considered to be the most economically efficient means of doing so."[6]

In the EU electricity markets, wholesale prices are typically set by the marginal fossil fuel generator. Because these generators incorporate the carbon allowance price into their bids, the cost is passed through almost fully to consumers. This high degree of pass-through contrasts with emissions-intensive, trade-exposed industries, where international competition or regulated pricing limits cost recovery. In countries with administered electricity tariffs, pass-through is also much lower. These market conditions reinforced concerns that free allocation did not serve efficiency or fairness goals in the power sector, leading to the shift to auctioning as the default method in Phase III (Burtraw et al. 2002).

Despite its merits, auctioning faced resistance from lower-income countries with coal-dependent energy systems, where governments feared higher energy prices would adversely affect households and firms (Grajewski 2008; Stearns 2008). To address these concerns, 10 countries were granted a temporary derogation from full auctioning under Article 10c of the revised ETS Directive, adopted in 2009. As the Commission explained, "the main motivation of the countries which asked for this provision has been a desire to prevent too sharp increases in energy prices for households."[7] Countries could continue granting free allowances, but only under strict conditions defined in a complementary derogation package adopted in 2011.[8] Each country had to submit a National Investment Plan (NIP), and the monetary value of free allowances had to be matched by renewable investments or power sector modernization. Because these allowances were deducted from the country's auctioning quota, derogation did not provide governments with extra resources; rather, it redirected the value of allowances away from auction revenues and into earmarked investments carried out by utilities.

This design effectively turned derogation into an earmarked modernization fund, providing a temporary co-financing mechanism rather than a simple production subsidy. It addressed a classic investment-financing constraint in the power sector, particularly for aging operating utilities, often state-owned fossil fleets that faced simultaneous demands for retrofits, new low-carbon capacity, and grid reinforcement, just as auctioning threatened their cash flow. By linking free allocation to a Commission-approved NIP, what might otherwise have been a distortionary subsidy became a conditional reinvestment scheme. In this way, the measure reconciled short-term liquidity relief with long-term efficiency by internalizing carbon pricing while mitigating the risk of carbon lock-in. It thus addressed transitional equity concerns without undermining the efficiency objectives of the EU ETS.[9]

2.2 Renewable Deployment and Emissions

The broader literature generally finds that ETSs, particularly the EU ETS, are effective in reducing emissions (e.g., Ellerman, Convery, and de Perthuis 2010; Anderson and Di Maria 2011; Laing et al. 2014; Bel and Joseph 2015; Dechezleprêtre, Nachtigall, and Venmans 2023; Colmer et al. 2025) and in supporting the expansion of renewable energy (Pietzcker, Osorio, and Rodrigues 2021; Bai and Ru 2022; Perdiguero and Sanz 2025). At the same time, some studies note a lack of comprehensive empirical evidence on low-carbon technology adoption and innovation during Phase III (Teixidó, Verde, and Nicolli 2019). Recently, Eslahi, Creti, and Sanin (2026) provided an EU ETS-wide counterfactual assessment of the power sector, showing that the system only delivered statistically significant emissions reductions from Phase II onward, with the strongest effects in Phase III. While this confirms the overall effectiveness of the scheme in aggregate, their analysis does not consider cross-country heterogeneity in allowance allocation within Phase III or its implications for renewable energy deployment. Our paper offers a complementary perspective on this question.

Renewable support mechanisms can also interact with ETS markets. Some evidence suggests that such policies contributed to lower EU ETS allowance prices during Phases I and II (Van den Bergh, Delarue, and D'haeseleer 2013; De Jonghe et al. 2009; Landis and Heindl 2019), highlighting the importance of coordinating emissions trading systems with complementary policies.

For our purposes, an important feature of Phase III is the distinction between higher-income countries that were required

to auction allowances and lower-income countries that could continue free allocation under Article 10c. Additional variation arises from Latvia and Malta, which were eligible for derogation but chose full auctioning instead.[10] This institutional setup provides variation that we can exploit to compare countries under auctioning with those under derogation. Yet the literature on this policy shift is scarce: Bordignon and Gamannossi degl'Innocenti (2023) examine its effect on emissions reductions, while Müller and Teixidó (2021) focus on energy mix diversification in Poland. Our contribution is to extend this work by systematically examining the impact of the 2013 policy reform and comparing renewable energy capacity growth among European countries in the EU ETS using auctioning and free allocation for allowance allocation.

A Theoretical Model of Allowance Allocation, Pass-Through, and State Support

03

This section develops a partial equilibrium model of a representative power generator operating under two allowance allocation regimes: free allocation and auctioning. The firm produces electricity using fossil fuels and renewables, and it can pass on carbon costs to consumers. The power generator participates in secondary trading of allowances in an emissions trading system, and the static nature of the model ignores banking of allowances and revenue recycling from auctioning. The model offers a theoretical lens for understanding the rationale behind the EU ETS Phase III reform and its implications for renewable deployment. Two mechanisms are central: carbon cost pass-through and the reinvestment obligations under Article 10c.

3.1 Model Structure

We focus on input choices and direct cost incentives of a representative power generator in a country categorized by its relative income level *k*, where $k = L$ denotes lower-income and $k = H$ denotes higher-income. This distinction reflects Article 10c eligibility. The power-generating firm uses fossil input F_k and renewable input R_k. Electricity supply is represented by a constant elasticity of substitution (CES) function:

$$Q_k = \left(\delta_k F_k^{\frac{\sigma-1}{\sigma}} + \lambda_k R_k^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \quad (1)$$

where $\delta_k + \lambda_k = 1$, with $\delta, \delta \in (0, 1)$, denoting the input shares. The parameter $\sigma > 0$ represents the elasticity of substitution between the two inputs. We let lower-income countries rely more on fossil fuels than higher-income countries in their energy mix, such that $\delta_L > \delta_H$ and $\lambda_L < \lambda_H$.[11]

Fossil energy use generates emissions in proportion to its carbon intensity $\tau_k > 0$, such that emissions are given by

$$E_k = \tau_k F_k \quad (2)$$

We also allow carbon intensity to be higher in lower-income countries, $\tau_L > \tau_H$, reflecting their greater reliance on carbon-intensive fossil fuels (e.g., lignite, older coal plants) and comparatively less efficient generation infrastructure.[12]

For simplicity, we now drop the *k* subscript, reintroducing *L* and *H* only when contrasting income groups.

Let pc denote the carbon price in the emissions trading system – that is, the allowance price in the secondary market. The allowance market is not modeled, and firms take the prevailing carbon price as given. Firms can pass a fraction of this cost to consumers through electricity prices at a rate θ. A higher θ indicates greater cost recovery, with $\theta = 1$ indicating full cost pass-through and $\theta = 0$ indicating none.[13]

The price of electricity usage for consumers is expressed as:

$$P = P_0 + \theta\, p_c\, \frac{E}{Q} \tag{3}$$

where P_0 is the base electricity price in the absence of carbon pricing, the ratio E denotes the emissions intensity of power generation. Multiplying this by the carbon price p_c Eyields the implied carbon cost per unit of electricity. The term $\theta\, p_c\, E$ then captures the share of this cost that is passed through to consumers in the electricity price. Multiplying Equation (3) by output yields total revenue for the producer:

$$PQ = P_0 Q + \theta\, p_c\, E. \tag{4}$$

Let A denote the free allocation of allowances, with $A = 0$ under auctioning and $A > 0$ for free allocation. The firm may sell any surplus or buy any shortfall of allowances on the secondary market at the carbon price pc.

The firm chooses its inputs to maximize profits:

$$\max_{F,R} \Pi = PQ - c^F F - c^R (1-\rho) R + p_c (A - E), \tag{5a}$$

where c^F and c^R are the unit costs for fossil and renewable inputs, respectively. We assume competitive input markets, so the firm's decisions do not affect input prices.

The parameter $\rho \in [0, 1)$ denotes the degree of policy-induced support for renewable investment. For lower-income countries under Article 10c derogation, ρ_L incorporates the support implied by reinvestment requirements to expand renewables. The term $(1 - \rho)$ thus reduces the effective cost of renewables, whether via budgetary instruments (e.g., investment grants, subsidized loans, tax incentives, feed-in tariffs/premiums) or via mandated reinvestment of allowance value.[14] Finally, p_c *(A − E)* denotes the firm's net cash flow from allowance trading at the market price. The power generator can earn revenues from selling unused allowances when allowances exceed its emissions, $A > E$. In contrast, emissions exceeding the allowances – this is, $A < E$, would require buying allowances in the secondary market and therefore induce losses to the firm.[15]

Substituting Equations (2) and (4) into Equation (5a) and rearranging, we obtain

$$\max_{F,R} \Pi = P_0 Q - c^F F - c^R (1-\rho) R + p_c [-(1-\theta)\tau F + A], \tag{5b}$$

Here, the last bracket $p_c - (1 - \theta)\, \tau F + A$ contains all carbon-related components. This expression can be separated into two distinct parts. The first, $-p_c\, \tau\, (1 - \theta)\, F$, represents the total carbon-cost term arising from the marginal wedge $p_c\, \tau\, (1 - \theta)$ per unit of fossil input. The wedge depends both on the carbon intensity of fossil generation τ and on the degree of pass-through θ. A higher τ raises the burden directly, while a higher θ shifts more of the cost onto consumers, thereby lowering the burden borne by the firm. The second, $p_c\, A$, is a lump-sum transfer arising from free allocation. Hence, the allocation regime shifts profits and cash-flow through A but does not change the marginal carbon wedge that governs input choices.

3.2 Allocation Method, Pass-Through, and Fossil Fuel Use

From the problem in Equation (5b), the first-order condition for fossil fuel use is

$$\frac{\partial \Pi}{\partial F} = 0 \;\rightarrow P_0 \delta \left(\frac{Q}{F}\right)^{1/\sigma} = c^F + p_c \tau\, (1 - \theta), \tag{6}$$

and the optimal fossil input per unit of output is

$$\frac{F^*}{Q} = \left(\frac{P_0 \delta}{c^F + p_c \tau (1-\theta)}\right)^{\sigma} \tag{7}$$

The numerator, $P_0\, \delta$, represents the base price weighted by the fossil share. A higher value increases the incentive to use the fossil input. The denominator, $c^F + p_c\, \tau(1\text{-}\theta)$, captures the net marginal cost of fossil fuel use. It is the sum of the direct fuel cost c^F and the carbon wedge, which, as mentioned above, grows with carbon intensity and shrinks as pass-through rises.

Table 1 summarizes the mechanisms. Consider first the free allocation regime. With no pass-through (Case 1), the marginal carbon wedge is $p_c\, \tau$, so the effective marginal cost of fossil

input rises and fossil demand decreases. The net carbon cash flow is p_c *(A − E)*, which adds to profit if allowances exceed emissions (*A > E*, overallocation) and subtracts from profit if allowances are fewer than emissions *(A < E)*. With full pass-through (Case 2), the carbon wedge is zero, so the firm's marginal cost of using *F* is unchanged, and the optimal F is the same as without carbon pricing – because the cost of carbon pricing is fully passed through onto consumers. However, free allocation generates pure rents $p_c A$ – that is, windfall profits, since allowances are received for free and the carbon burden is fully passed through.

Turning to auctioning, with no pass-through (Case 3), firms bear the full burden $p_c \tau$ of carbon cost, which raises the marginal cost of fossil use and reduces fossil demand. With *A* = 0, they must buy *E* allowances for compliance, so the trading cash flow is negative, $-p_c E$, given that these costs are not passed through to consumers. With full pass-through (Case 4), the wedge becomes zero, so the marginal cost of *F* is unchanged. Firms purchase *E* allowances ($-p_c E$) but receive an equal price uplift in revenue ($+p_c E$) under full pass-through – so the net-carbon cash flow is zero.

Table 1. Allocation and pass-through: Effects on profits and fossil demand.

Case	Allocation	Pass-through (θ)	Marginal carbon wedge	Net carbon cash-flow	Fossil demand (F ∗)
(1)	Free (A > 0)	None (0)	$p_c \tau$	p_c (A − E)	Decreases
(2)	Free (A > 0)	Full (1)	0	$p_c A$	No change
(3)	Auctioning (A = 0)	None (0)	$p_c \tau$	$-p_c E$	Decreases
(4)	Auctioning (A = 0)	Full (1)	0	0	No change

Notes: Results derive from Equations (5b) and (7). The marginal carbon wedge equals $p_c \tau$ (1 − θ) and is independent of the allocation regime. A affects rents and cash flow only.

Taken together, the comparison of the cases in Table 1 shows that fossil demand is identical under (1) and (3), and likewise under (2) and (4). Thus, the allocation regime does not affect the input choice – it only influences profits. With pass-through, free allocation generates windfall rents, while without pass-through, auctioning implies shortfalls. In our framework, these profit shifts enter as lump-sum terms and therefore do not alter the firm's optimal fossil use.

3.3 State Support and Renewable Deployment

The first-order condition for renewables yields

$$\frac{\partial \Pi}{\partial R} = 0 \rightarrow P_0 \lambda \left(\frac{Q}{R}\right)^{1/\sigma} = c^R (1-\rho) \quad (8)$$

which implies the optimal renewable intensity is

$$\frac{R^*}{Q} = \left(\frac{P_0 \lambda}{c^R (1-\rho)}\right)^{\sigma} \quad (9)$$

The numerator, $P_0 \lambda$, is the renewables-weighted component of the electricity price and increases the incentive to deploy *R*. The denominator, c^R (1-ρ), is the net marginal cost of renewables (i.e., renewable deployment cost discounted by state support), so lower net marginal cost of deployment raises *R∗/Q*.[16] Importantly, neither the carbon price pc, nor pass-through θ, nor the free allocation *A* enters Equations (8) or (9). Hence, renewable deployment is governed by costs and support, not by the allocation regime.

To compare country types, we allow primitives to differ exogenously across lower- and higher-income countries (*L* vs. *H*), as shown in Table 2: energy-mix weights (λ_L , λ_H), renewable cost (c_L^R, c_H^R), and support (ρ_L , ρ_H). We assume $\lambda_L < \lambda_H$(a more fossil-heavy mix in L), $c_L^R > c_H^R$ (higher deployment costs in *L*), and $\rho_L \geq \rho_H$ (higher state support for renewables in *L*, including Article 10c's conditions).

Table 2. Determinants of renewable deployment (comparative statics).

Factor	Across types	Renewable demand R∗/Q
Share of renewables in energy mix	$\lambda_L < \lambda_H$	Lower in *L*; higher in *H*
Marginal cost of renewables deployment	$c_L^R > c_H^R$	Lower in *L*; higher in *H*
State support for renewables deployment	$\rho_L > \rho_H$	Higher in *L*; lower in *H*

Notes: Results derive from Equation (9). Statements are ceteris paribus.

The results for renewables indicate that exogenous differences in λ, c^R, and ρ drive comparative statics in R^*/Q; the allocation method A and pass-through (θ) per se do not. Lower-income countries' (*L*) lower share of renewables in the energy mix and higher marginal cost of renewables imply that the optimal level of renewables per unit of electricity output must be higher for higher-income countries.

Empirical Analysis

04

Building on the theoretical prediction that allowance allocation does not systematically change incentives for renewable energy deployment in the power sector, we now turn to the data. We employ a difference-in-differences (DiD) design that exploits the policy variation created by the 2013 reform, allowing us to identify the causal impact of the allocation method on renewable capacity growth, while accounting for pre-2013 differences between country groups, macroeconomic factors, and energy system characteristics.

4.1 Data

We use a panel dataset of 30 European countries from 2005 to 2020 – all 27 EU member states, plus Iceland, Norway, and the United Kingdom.[17] We exclude observations for Bulgaria and Romania prior to their accession in 2008. Table 3 shows the countries by allocation regime status, distinguishing among auctioning countries, derogated countries, and derogated-but-opted-out countries.

Table 3. Classification of European countries by allocation regime status in Phase III.

Allocation regime	Countries
Auctioning (de jure)	Austria, Belgium, Croatia, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom
Derogated (de jure)	Bulgaria, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania
Opted out (de facto auctioning)	Latvia, Malta

Notes: Countries are classified by their allocation status in Phase III of the EU ETS. Auctioning (de jure) refers to countries required to auction allowances. Derogated (de jure) refers to countries formally eligible for derogation under Article 10c. Opted out (de facto auctioning) highlights that Latvia and Malta, while de jure derogated, implemented auctioning in practice.

In our main estimations, the dependent variable – renewables net capacity per capita (RC) – is constructed by dividing total installed renewable energy generation capacity (in megawatts, MW), sourced from IEA (2025a), by country population data from Our World in Data (OWID). To account for cross-country differences in economic development, we include real gross domestic product per capita (GDP, in 2015 U.S. dollars), with data obtained from the World Bank's World Development Indicators. The share of renewables – measured as the percentage of renewable energy in total energy consumption – aims to control for preexisting trends or policy momentum favoring renewable deployment, using data from IEA (2025b). Finally, energy import dependency, sourced from Eurostat and defined as the proportion of total energy needs met through imports, can capture structural energy security considerations that may influence renewable investment decisions.

4.2 Identification Strategy

We leverage the quasi-experimental nature of the EU ETS Phase III reform and isolate the causal effect of the allocation method (auctioning vs. derogation) on renewable energy deployment using a difference-in-differences (DiD) framework. The reform created a policy divergence among countries – allowing us to distinguish treated and control groups. We estimate the following equation:

$$\ln(RC_{ct}) = \beta_1 * Post2013 + \beta_2 * Auctioning_c + \beta_3 * Post2013 * Auctioning_c + \gamma X'_{ct} + \varepsilon_{ct} \quad (10)$$

where ln (RC_{ct}) denotes the natural logarithm of renewable capacity per capita in country *c* in year *t*. *Post-2013* is a dummy variable equal to 1 for the 2013-2020 period (post-reform) and 0 for the 2005-2012 period (pre-reform). Auctioning is a dummy equal to 1 for countries with power sector auctioning under the EU ETS after 2013 and 0 for derogated countries. *X'* denotes control variables, including GDP per capita, share of renewables in energy consumption, and energy import dependency. In this setting, the coefficient of interest, β_3, captures whether renewable capacity growth differed systematically between auctioning and derogated countries in Phase III (2013) compared to the earlier periods of Phase I (2005-2008) and Phase II (2009-2012).

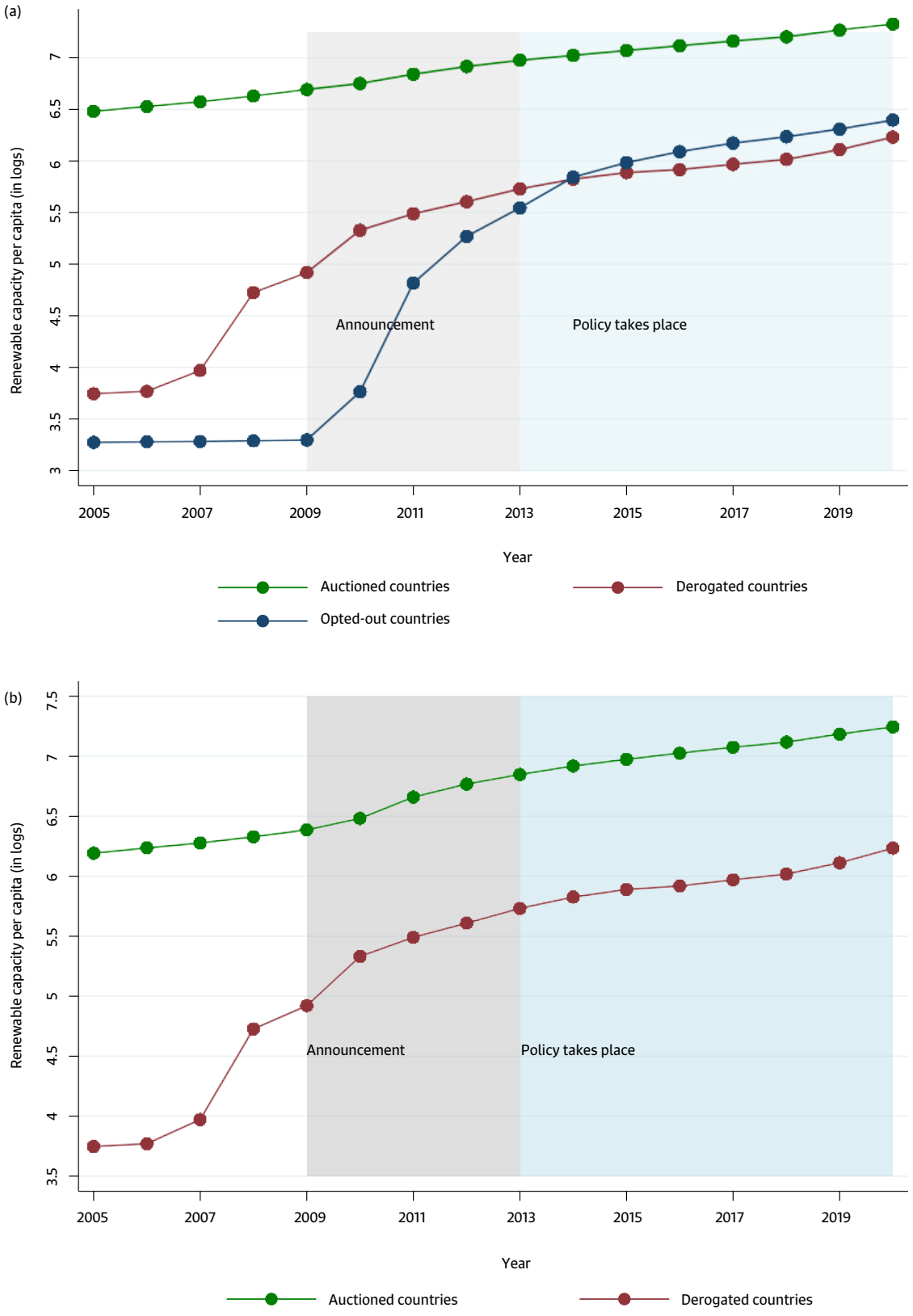
The allocation regime was not chosen unilaterally by individual countries but determined by EU legislation. Given the supranational determination of auctioning and derogation with the strict oversight of reinvestment obligations, the allocation regime can be considered exogenous to national renewable investment trajectories. This supports the validity of our DiD approach. Moreover, the free allocation for derogated countries was tied to National Investment Plans approved by the European Commission, with binding reinvestment of allowance value into renewables and modernization. This external oversight makes it unlikely that domestic renewable trajectories drove eligibility.

Higher-income countries generally possess larger fiscal space, stronger administrative capacity, and more mature energy markets, enabling them to support renewable investments more effectively. By contrast, lower-income countries often face budgetary constraints and stronger political resistance to higher energy costs. These structural differences may influence renewable deployment even under common EU-level rules. Our treatment dummy helps absorb such systematic differences and controls for time-invariant heterogeneity.

In addition, auctioning countries may already have stronger renewable policies, while derogated countries may have faced greater modernization needs. To mitigate such potential omitted-variable bias over time, we include controls for the share of renewables in energy consumption and for energy import dependency.

A key identifying assumption of our DiD design is that, absent the reform, derogated and auctioning countries would have followed parallel trends. Figure 1 depicts renewable capacity per capita for each group between 2005 and 2020.

Figure 1. Trends in renewable capacity per capita.



Note: Figure shows group averages of renewable capacity per capita (in natural logarithms). The shift to auctioning as the default allocation method was announced in 2009 (gray shading) and implemented in 2013 (turquoise shading). In Panel 1a, Latvia and Malta are included in the opted-out group, while in Panel 1b they are classified with auctioned countries.

Panel 1a presents the groups separately and shows that derogated countries expanded capacity substantially during 2005-2009, while opted-out countries grew mainly during 2009-2013. Then, both experienced relatively stable growth. These patterns likely reflect policy anticipation, as fossil-dependent countries responded to the EU ETS's introduction in 2005, noting that renewable investments generally take four to five years to materialize. Panel 1b compares auctioning countries (including Latvia and Malta) with derogated countries.

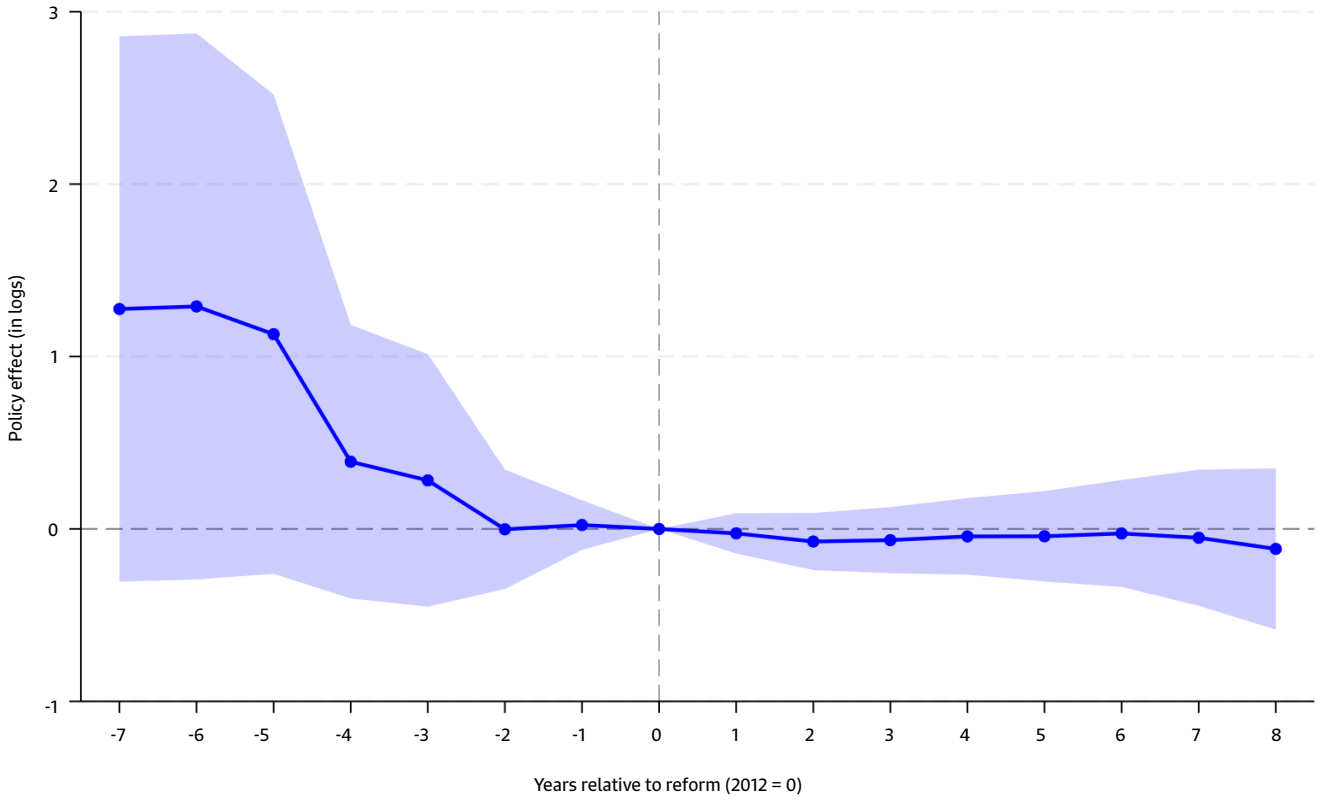
Although derogated countries displayed faster growth before the reform's announcement, both groups followed similar trajectories afterward. Taken together, Figure 1 provides strong visual evidence that auctioning and derogated countries shared a common underlying trend.

To assess and further validate the parallel trends assumption, we examine whether any systematic differences in renewable capacity trends existed between auctioning and derogated countries before the reform. We estimate an event-study specification in which the treatment indicator is interacted with a full set of year dummies. The year 2012 is used as the reference period, as it represents the final year before the reform.

$$\ln(RC_{ct}) = \sum_{t \neq 2012} \gamma_t \, Year_t + \delta * Auctioning_c + \sum_{t \neq 2012} \beta_t \, (Auctioning_c * Year_t) + \gamma X'_{ct} + \varepsilon_{ct} \quad (11)$$

Figure 2 presents the estimated coefficients. Each β_t represents the average difference in the treatment effect between auctioning and derogated countries for the corresponding relative period, ranging from -7 to 8, with 2012 as the reference year. The coefficients in the pre-reform period are statistically indistinguishable from zero and display no systematic trend, confirming that renewable capacity in both groups evolved in parallel before the policy change, which is a key condition for the credibility of the difference-in-differences approach.

Figure 2. Parallel trends test.



Note: Estimated coefficients (β_t) for each period from Equation (11). 2012 is the omitted reference year. The shaded area represents 95% confidence intervals. The results correspond to Figure 1b, where Latvia and Malta are classified among auctioning countries.

Figure 2 also offers an interesting insight: after the policy came into effect, there is no visible break in the trajectory of renewable capacity between the two groups. The estimated effects remain close to zero, suggesting that the parallel evolution continued even after the reform. This persistence raises the possibility that the shift to auctioning did not generate a distinct change in renewable deployment, a question we investigate in the next section.

4.3 Main Results

Table 4 presents the baseline estimates from Equation (10). Across all panels and specifications, the coefficient on Post-2013 is positive and significant, indicating a broad expansion of renewable capacity after the start of Phase III. Moreover, the positive and significant coefficient on auctioning confirms our descriptive evidence that auctioning countries had higher renewable energy capacity per capita than derogated countries during the entire sample period.

Panel A assigns treatment based on legal derogation eligibility: auctioning countries are those required to auction, while derogated countries include all 10 eligible states, among them Latvia and Malta. The interaction term *Post-2013 × Auctioning* is negative and statistically significant. This implies that compared to the pre-reform period, auctioning countries' renewable capacity in the post-reform period grew more slowly relative to those classified as derogated by eligibility.

Panel B refines the classification by excluding Latvia and Malta from the derogated category. The coefficient magnitudes are similar, and the results remain essentially the same: the interaction term remains negative and significant, pointing to relatively slower growth in auctioning countries.

Panel C classifies countries by the allocation method they actually implemented in Phase III. This specification therefore reflects the real-world distinction between countries that auctioned allowances and those that continued free allocation. In this setup, *Post-2013 × Auctioning* is statistically insignificant, indicating that, in practice, renewable capacity growth did not differ systematically between the two regimes.

The change in results is explained by the treatment of Latvia and Malta. When they are classified as derogated, their strong renewable growth makes derogated countries appear to perform better; excluding them reduces the imbalance but leaves a contrast with auctioning countries; once they are grouped with auctioning countries, the difference disappears. That their inclusion or exclusion alone alters the coefficient indicates that there has not been a systematic effect of the allocation method implemented in the power sector on renewable energy deployment in the EU ETS.

Among the controls, the share of renewables is positively associated with capacity per capita, pointing to a reinforcing effect of existing renewable infrastructure or policy momentum. By contrast, there is no robust relationship between energy import dependency and renewable capacity, as the sign and significance of the coefficient vary across specifications. GDP per capita is also not statistically significant.[18]

Table 4. Impact of auctioning on renewables capacity.

	(1)	(2)	(3)	(4)	(5)
Panel A: Eligibility (Latvia and Malta as derogated)					
Post-2013	1.414***	1.376***	1.156**	1.405***	1.155**
	(0.442)	(0.465)	(0.425)	(0.440)	(0.442)
Auctioning	2.107***	1.837**	1.852***	2.003***	1.765***
	(0.612)	(0.752)	(0.476)	(0.579)	(0.612)
Post-2013 × Auctioning	-0.947**	-0.922*	-0.960**	-0.933**	-0.950**
	(0.448)	(0.461)	(0.445)	(0.447)	(0.455)
GDP		0.271			0.082
		(0.340)			(0.357)

Table 4. Impact of auctioning on renewables capacity (continued).

	(1)	(2)	(3)	(4)	(5)
Share of renewables			4.476*** (0.588)		4.250*** (0.595)
Energy import dependency				-0.341***	-0.060
				(0.056)	(0.054)
Observations	474	474	474	473	473
R-squared	0.390	0.399	0.668	0.475	0.671
Panel B: Eligibility (Latvia and Malta excluded)					
Post-2013	1.175***	1.124***	0.936***	1.173***	0.929**
	(0.320)	(0.351)	(0.318)	(0.315)	(0.337)
Auctioning	1.891***	1.434**	1.621***	1.816***	1.406**
	(0.485)	(0.627)	(0.408)	(0.455)	(0.556)
Post-2013 × Auctioning	-0.709**	-0.678*	-0.714**	-0.701**	-0.698*
	(0.329)	(0.350)	(0.333)	(0.324)	(0.346)
GDP		0.443			0.216
		(0.316)			(0.335)
Share of renewables			4.047*** (0.502)		3.736*** (0.475)
Energy import dependency				-0.320***	-0.060
				(0.038)	(0.048)
Observations	442	442	442	441	441
R-squared	0.395	0.427	0.691	0.500	0.703
Panel C: Implementation (Latvia and Malta as auctioning)					
Post-2013	1.175***	1.103***	0.901***	1.172***	0.867**
	(0.320)	(0.355)	(0.321)	(0.313)	(0.350)
Auctioning	1.628***	1.041	1.328***	1.559***	0.917
	(0.541)	(0.758)	(0.479)	(0.513)	(0.665)
Post-2013 × Auctioning	-0.544	-0.511	-0.547	-0.537	-0.524
	(0.372)	(0.395)	(0.377)	(0.368)	(0.393)
GDP		0.618			0.445
		(0.368)			(0.332)
Share of renewables			4.628*** (0.855)		4.326*** (0.797)
Energy import dependency				-0.379***	-0.045
				(0.083)	(0.058)
Observations	474	474	474	473	473
R-squared	0.255	0.307	0.551	0.361	0.582

Notes: The dependent variable is the log of renewable energy capacity per capita. Post-2013 = 1 for 2013-2020, 0 for 2005-2012. Real GDP per capita is in natural logarithm. Share of renewables represents the percentage of renewables in energy consumption. Energy import dependency is the percentage of net energy imports in gross available energy. Panel A classifies countries by de jure derogation eligibility, treating Latvia and Malta as derogated. Panel B uses the same classification but excludes Latvia and Malta from the sample. Panel C classifies countries by de facto implementation, comparing those that auctioned allowances (including Latvia and Malta) with those that used derogation. Standard errors are clustered at the country level. ***, **, * denote significance at 1%, 5%, and 10%.

4.4 Robustness and Extensions

The baseline model in Equation (10) controls for group-level (auctioning vs. derogated) and period-level (pre-/post-reform) differences. To capture within-group heterogeneity and year-specific effects, we re-estimate the model using two-way fixed effects, replacing *Post-2013* with year fixed effects and auctioning with country fixed effects:

$$\ln(RC_{ct}) = \eta_t + \xi_c + \beta_3 * Post2013 * Auctioning_c + \gamma X'_{ct} + \varepsilon_{ct} \quad (12)$$

Table 5 reports the results of this estimation. The coefficient on the interaction term remains similar to the baseline estimates in both statistical significance and magnitude. Using more disaggregated controls for treatment (i.e., country-level indicators instead of the auctioning-versus-derogated grouping) and period (i.e., individual years instead of a binary pre/post indicator) does not change our findings.

Table 6 returns to the baseline specification and shifts the treatment period to begin in 2010, accounting for the possible anticipatory effects of Directive 2009/29/EC. The interaction terms remain insignificant when countries are classified by their de facto implementation of auctioning and derogation (Panel C).

Since the COVID-19 pandemic created extraordinary disruptions to investment decisions across the economy, we test whether our results are robust to this outlier year. Table 7 excludes 2020 to control for pandemic-related anomalies. The results remain substantively unchanged.

We further test the robustness of our findings by excluding hydropower from the measure of renewable capacity. Hydropower is largely a legacy technology. In many European countries, most of the economically viable capacity was already installed before Phase III of the EU ETS. Table A1 in Appendix A reports the results using renewable capacity excluding hydropower (data from IEA 2025a). The interaction terms remain statistically insignificant, confirming that our main conclusion does not hinge on the inclusion of hydropower.

We also use the share of renewables in total installed generation capacity as the dependent variable. This measure provides a relative indicator that accounts for differences in overall system size and the expansion of conventional capacity. It is particularly useful because renewable deployment may appear large in absolute or per capita terms but remain modest when fossil capacity expands simultaneously, or vice versa. Table A2 in the Appendix reports the results, which are consistent with our main findings.

Table 5. Estimations with two-way fixed effects.

	(1)	(2)	(3)	(4)	(5)
Panel A: Eligibility (Latvia and Malta as derogated)					
Post-2013 × Auctioning	-0.910**	-0.920**	-0.910**	-0.913**	-0.918**
	(0.444)	(0.442)	(0.444)	(0.443)	(0.443)
GDP		-0.068			-0.039
		(1.520)			(1.550)
Share of renewables			-0.122		-0.193
			(1.658)		(1.757)
Energy import dependency				-0.071	-0.072
				(0.288)	(0.291)
Observations	474	474	474	473	473
Country FEs	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes
R-squared	0.869	0.869	0.869	0.869	0.869
Panel B: Eligibility (Latvia and Malta excluded)					
Post-2013 × Auctioning	-0.666*	-0.811*	-0.666*	-0.670*	-0.812*
	(0.332)	(0.420)	(0.332)	(0.329)	(0.419)
GDP		-1.165			-1.151
		(1.175)			(1.189)
Share of renewables			-0.221		-0.597
			(1.512)		(1.552)
Energy import dependency				-0.173	-0.176
				(0.260)	(0.269)
Observations	442	442	442	441	441
Country FEs	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes
R-squared	0.901	0.904	0.901	0.901	0.905
Panel C: Implementation (Latvia and Malta as auctioning)					
Post-2013 × Auctioning	-0.503	-0.398	-0.502	-0.506	-0.399
	(0.373)	(0.576)	(0.373)	(0.372)	(0.579)
GDP		0.990			1.015
		(2.187)			(2.221)
Share of renewables			-0.322		-0.068
			(1.704)		(1.831)
Energy import dependency				-0.166	-0.145
				(0.262)	(0.281)
Observations	474	474	474	473	473
Country FEs	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes
R-squared	0.852	0.854	0.852	0.852	0.855

Notes: See Table 4 for general definitions. This table reports the baseline estimations provided in Table 4, using two-way fixed effects as specified in Equation (12).

Table 6. Role of the announcement of Directive 2009/29/EC.

	(1)	(2)	(3)	(4)	(5)
Panel A: Eligibility (Latvia and Malta as derogated)					
Post-2010	1.730***	1.707***	1.452**	1.716***	1.456**
	(0.549)	(0.565)	(0.532)	(0.545)	(0.542)
Auctioning	2.513***	2.210**	2.249***	2.401***	2.133***
	(0.753)	(0.895)	(0.618)	(0.720)	(0.746)
Post-2010 × Auctioning	-1.252**	-1.237**	-1.250**	-1.231**	-1.243**
	(0.554)	(0.565)	(0.549)	(0.550)	(0.555)
GDP		0.309			0.114
		(0.325)			(0.342)
Share of renewables			4.462*** (0.585)		4.235*** (0.604)
Energy import dependency				-0.341***	-0.057
				(0.054)	(0.053)
Observations	474	474	474	473	473
R-squared	0.407	0.418	0.683	0.492	0.687
Panel B: Eligibility (Latvia and Malta excluded)					
Post-2010	1.530***	1.508***	1.259**	1.524***	1.268**
	(0.492)	(0.519)	(0.490)	(0.484)	(0.504)
Auctioning	2.283***	1.808**	1.993***	2.203***	1.761**
	(0.633)	(0.793)	(0.563)	(0.601)	(0.712)
Post-2010 × Auctioning	-1.053**	-1.043*	-1.029**	-1.039**	-1.025*
	(0.498)	(0.520)	(0.501)	(0.490)	(0.512)
GDP		0.472			0.239
		(0.305)			(0.323)
Share of renewables			4.023*** (0.496)		3.699*** (0.472)
Energy import dependency				-0.319***	-0.059
				(0.037)	(0.047)
Observations	442	442	442	441	441
R-squared	0.416	0.452	0.709	0.521	0.723
Panel C: Implementation (Latvia and Malta as auctioning)					
Post-2010	1.530***	1.500***	1.219**	1.523***	1.218**
	(0.492)	(0.525)	(0.492)	(0.482)	(0.516)
Auctioning	1.984***	1.385	1.657**	1.909***	1.239
	(0.692)	(0.917)	(0.634)	(0.661)	(0.823)
Post-2010 × Auctioning	-0.879	-0.876	-0.846	-0.867	-0.846
	(0.530)	(0.554)	(0.536)	(0.522)	(0.551)
GDP		0.646*			0.465
		(0.362)			(0.324)
Share of renewables			4.610*** (0.856)		4.296*** (0.795)
Energy import dependency				-0.378***	-0.045
				(0.082)	(0.057)
Observations	474	474	474	473	473
R-squared	0.268	0.326	0.563	0.374	0.596

Notes: See Table 4 for general definitions. This table shifts the treatment period to 2010 to test for anticipatory effects.

Table 7. Excluding 2020 (COVID-19).

	(1)	(2)	(3)	(4)	(5)
Panel A: Eligibility (Latvia and Malta as derogated)					
Post-2013	1.374***	1.341***	1.129**	1.364***	1.130**
	(0.436)	(0.458)	(0.420)	(0.434)	(0.437)
Auctioning	2.107***	1.857**	1.847***	2.001***	1.774***
	(0.612)	(0.760)	(0.474)	(0.579)	(0.619)
Post-2013 × Auctioning	-0.933**	-0.912*	-0.943**	-0.919**	-0.935**
	(0.441)	(0.454)	(0.439)	(0.440)	(0.448)
GDP		0.251			0.068
		(0.352)			(0.373)
Share of renewables			4.578*** (0.620)		4.358*** (0.627)
Energy import dependency				-0.347***	-0.059
				(0.058)	(0.057)
Observations	444	444	444	444	444
R-squared	0.384	0.391	0.663	0.469	0.666
Panel B: Eligibility (Latvia and Malta excluded)					
Post-2013	1.137***	1.092***	0.910***	1.133***	0.905**
	(0.317)	(0.346)	(0.317)	(0.311)	(0.336)
Auctioning	1.891***	1.447**	1.616***	1.815***	1.408**
	(0.485)	(0.635)	(0.408)	(0.455)	(0.565)
Post-2013 × Auctioning	-0.697**	-0.671*	-0.699**	-0.688**	-0.685*
	(0.324)	(0.344)	(0.332)	(0.320)	(0.343)
GDP		0.432			0.208
		(0.326)			(0.349)
Share of renewables			4.119*** (0.522)		3.815*** (0.494)
Energy import dependency				-0.324***	-0.059
				(0.039)	(0.050)
Observations	414	414	414	414	414
R-squared	0.389	0.419	0.686	0.494	0.697
Panel C: Implementation (Latvia and Malta as auctioning)					
Post-2013	1.137***	1.073***	0.876**	1.132***	0.845**
	(0.316)	(0.350)	(0.321)	(0.310)	(0.349)
Auctioning	1.628***	1.042	1.321**	1.558***	0.906
	(0.541)	(0.770)	(0.479)	(0.513)	(0.678)
Post-2013 × Auctioning	-0.533	-0.508	-0.534	-0.525	-0.515
	(0.367)	(0.388)	(0.374)	(0.363)	(0.390)
GDP		0.616			0.449
		(0.381)			(0.348)
Share of renewables			4.738*** (0.897)		4.448*** (0.845)
Energy import dependency				-0.386***	-0.042
				(0.086)	(0.062)
Observations	444	444	444	444	444
R-squared	0.246	0.297	0.545	0.352	0.575

Notes: See Table 4 for general definitions. This table excludes 2020 (COVID-19 shock).

As the primary goal of the EU ETS is to reduce greenhouse gas emissions, we extend our analysis beyond renewable capacity and examine power sector emissions as an alternative outcome. First, we use per capita emissions, which provide a direct measure of decarbonization progress and complement our renewables capacity-based approach (data from IEA 2025b). Table 8 reports the results. Second, we use emissions intensity by using power sector emissions per gross electricity production as the dependent variable (data from IEA 2025c). This measure controls for differences in output levels and therefore provides an indicator of decarbonization efficiency within the sector. Table 9 presents the results from this specification. In both tables, the interaction terms are insignificant across panels, suggesting that the choice of allocation method did not produce a differential effect on emissions reductions.

Table 8. Impact of auctioning on power sector emissions.

	(1)	(2)	(3)	(4)	(5)
Post-2013	-0.342***	-0.315***	-0.056	-0.340***	-0.025
	(0.061)	(0.073)	(0.100)	(0.062)	(0.133)
Auctioning	-0.705*	-0.487	-0.392	-0.659*	-0.278
	(0.378)	(0.379)	(0.306)	(0.373)	(0.378)
Post-2013 × Auctioning	-0.053	-0.065	-0.049	-0.055	-0.049
	(0.096)	(0.094)	(0.075)	(0.097)	(0.078)
GDP		-0.229			-0.118
		(0.330)			(0.229)
Share of renewables			-4.822*** (1.508)		-5.122*** (1.794)
Energy import dependency				0.251***	-0.096
				(0.034)	(0.137)
Observations	474	474	474	473	473
R-squared	0.098	0.108	0.551	0.163	0.559

Notes: See Table 4 for general definitions. The dependent variable is the log of power sector emissions per capita.

Table 9. Power sector emissions per gross electricity production.

	(1)	(2)	(3)	(4)	(5)
Post-2013	-0.148***	-0.140***	-0.110***	-0.148***	-0.105***
	(0.027)	(0.030)	(0.032)	(0.027)	(0.035)
Auctioning	-0.359***	-0.289**	-0.317***	-0.350***	-0.269**
	(0.107)	(0.119)	(0.107)	(0.108)	(0.121)
Post-2013 × Auctioning	0.041	0.037	0.042	0.041	0.040
	(0.032)	(0.034)	(0.034)	(0.032)	(0.035)
GDP		-0.074			-0.051
		(0.052)			(0.043)
Share of renewables			-0.650*** (0.133)		-0.627*** (0.136)
Energy import dependency				0.049***	0.002
				(0.008)	(0.011)
Observations	474	474	474	473	473
R-squared	0.366	0.388	0.534	0.416	0.545

Notes: See Table 4 for general definitions. The dependent variable is power sector emissions per gross electricity production.

On the other hand, in both Table 8 and Table 9, the Post-2013 coefficient is uniformly negative, indicating a broad decline in emissions across all countries, consistent with the intended decarbonization goals of the EU ETS. The estimated effect ranges between -0.1 and -0.376. Hence, in Phase III, emissions declined by 10% (measured as the emissions intensity of electricity generation) and 31%[19] (measured as emissions per capita) compared to Phases I and II. This result aligns with the recent findings of Eslahi, Creti, and Sanin (2026), who estimate a 19% decline in EU ETS emissions during Phase III, with the reduction lying between 13% and 24%.

Overall, these robustness checks and extensions confirm that our results are not sensitive to alternative outcome definitions or sample restrictions. Across all specifications, we find no evidence that the method of allowance allocation systematically affected renewable deployment or emissions in Phase III.

05 Conclusion

This paper investigated whether the method of allowance allocation in the EU ETS (i.e., auctioning versus free allocation) had a discernible effect on renewable energy deployment and emissions outcomes in the power sector. We developed a partial equilibrium model showing that fossil fuel use depends on the degree of carbon cost pass-through — while the allocation method itself does not. Moreover, neither allocation method nor pass-through decisively shapes the deployment of renewables — whereas state support plays a key role. Both our theoretical model and empirical analysis converge on the same result: even though renewable deployment increased and power sector emissions declined during Phase III of the EU ETS, the allocation regime did not systematically influence renewable capacity growth or emissions reductions.

These findings challenge the conventional wisdom that auctioning is inherently superior to free allocation for incentivizing low-carbon transitions. While auctioning embodies the efficiency principle, a derogation regime with binding reinvestment obligations can yield comparable outcomes when governance structures are credible and enforced. The paper emphasizes that when a mechanism such as Article 10c is governed by enforceable mandates to reinvest the full value of allowances into energy modernization, it can deliver outcomes comparable to those under an auction-based system.

From a policy perspective, the key lesson is that the effectiveness of emissions trading systems depends less on allocation rules than on governance. What matters is the creation of mechanisms ensuring that the value of allowances is transparently directed to renewable energy and modernization. For policymakers introducing ETSs — especially in emerging and developing economies — or reforming existing ones, the priority should be to establish credible, enforceable, and transparent rules that link allowance value — whether originating from auctioning or from conditional free allocation — to strategic decarbonization investments.

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Endnotes

[1] For example, India and Türkiye are among those moving concretely toward binding ETS frameworks in high-emitting sectors, with legal and regulatory bases, cap-and-trade designs, and Monitoring, Reporting and Verification (MRV) systems. The United Arab Emirates has established the National Register for Carbon Credits, including mandatory MRV and trading obligations for entities with substantial emissions (exceeding 0.5 million metric tons of CO_2 equivalent annually), while those below the threshold may participate voluntarily. Saudi Arabia and other Gulf countries remain mainly in earlier stages, exploring ETS options, developing crediting mechanisms, voluntary markets, or studying institutional design (ICAP 2025; World Bank 2025; Zakkour, Gasim, and Luomi 2025).

[2] Recently, institutions such as the World Bank and the International Carbon Action Partnership (ICAP) have started using the term "grandparenting" in place of "grandfathering."

[3] Phase III also reformed industrial free allocation by introducing benchmarking and activity-level thresholds, intended to reduce overallocation and better align allocation with actual output. Yet these measures also created distortions (Branger et al. 2015). Although they applied to energy-intensive industries rather than the power sector, they illustrate the wider allocation reforms under Phase III.

[4] The eligible countries were Bulgaria, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, and Romania.

[5] Governments retain discretion in allocating these revenues, meaning that auction proceeds may also support sectors beyond power generation. For more detailed information regarding the size of revenues generated from auctioning in the EU ETS, see: https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/auctioning-allowances_en#documentation.

[6] See https://eur-lex.europa.eu/eli/dir/2003/87/oj/eng.

[7] See https://climate.ec.europa.eu/document/download/0578f25d-59d2-4c02-9215-0d11c7280099_en?filename=hungary_qa_en.pdf.

[8] See https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/free-allocation/allocation-modernise-energy-sector_en.

[9] As of 2025, derogation remains legally available under Phase IV (2021-2030), but only Bulgaria, Hungary, and Romania continue to apply it. The EU phased out derogation since auctioning provides governments with revenues with greater transparency under the polluter pays principle and avoids the oversight required under Article 10c.

[10] The reasons for their choice are not documented in publicly available Commission materials, but the option to opt out of derogation was permitted under the rules.

[11] The data of the International Energy Agency (IEA) for 2023 suggest that $\delta_L = 0.46 > \delta_H = 0.25$. Our assumption relies on these statistics.

[12] Allowing heterogeneity in the fossil fuel shares (δ_k) or carbon intensity (τ_{ik}) does not alter the model's core results.

[13] While some studies report pass-through rates above 100%, most estimates fall between 0% and 100% (Verde et al. 2019).

[14] For institutional completeness, one may link support to the value of free allocation at the country level: $c^R R\rho \leq \phi p_c A$, where $\phi \in (0, 1]$ captures earmarking efficiency. This policy-side budget link does not enter the firm's optimization and therefore leaves the first-order conditions unchanged.

[15] One might wonder whether free allocation could be set such that A ≡ E – that is, allowances exactly match contemporaneous emissions. However, in the EU ETS power sector, free allocation (whether under early grandfathering or the later derogations of Article 10c) is defined ex ante rather than updating with realized emissions. In line with the so-called "independence property" of cap-and-trade systems (see Hahn and Stavins 2011; Müller and Teixidó 2021), our analysis therefore treats A as an exogenous endowment.

[16] For $\rho \in [0, 1)$, the effective marginal cost of renewables remains strictly positive, ensuring an interior solution. In contrast, when $\rho = 1$, the marginal cost of renewables falls to zero, and the model collapses to a corner solution in which renewables dominate and fossil use is driven to zero in equilibrium.

[17] We exclude Liechtenstein from our sample because the dependent variable for this country is not available for some years.

[18] This lack of robustness is consistent with the broader argument of Gueye et al. (2025) that the EU energy system remains characterized more by addition than substitution: despite growth in renewable output, it has catered to rising demand rather than reducing reliance on energy imports.

[19] Computed as $\exp(-0.376) - 1 \approx -31.4\%$.

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Appendix

Additional Robustness Checks

Table A1. Excluding hydropower.

	(1)	(2)	(3)	(4)	(5)
Post-2013	1.558**	1.323**	1.938***	1.561**	1.667***
	(0.639)	(0.568)	(0.666)	(0.631)	(0.571)
Auctioning	0.124	-1.787*	0.540	0.187	-1.658
	(0.794)	(0.993)	(0.849)	(0.810)	(1.224)
Post-2013 × Auctioning	-0.410	-0.304	-0.406	-0.436	-0.299
	(0.707)	(0.651)	(0.731)	(0.699)	(0.662)
GDP		2.010*** (0.713)			2.354*** (0.641)
Share of renewables			-6.419*** (1.800)		-6.450*** (1.566)
Energy import dependency				0.347***	0.208
				(0.124)	(0.183)
Observations	474	474	474	473	473
R-squared	0.052	0.191	0.195	0.073	0.371

Note: See Table 4 for general definitions. The dependent variable is the log of renewable energy capacity per capita, excluding hydropower.

Table A2. Share of renewables in total installed capacity.

	(1)	(2)	(3)	(4)	(5)
Post-2013	0.281	1.024	-0.666	0.268	0.405
	(0.415)	(0.941)	(0.866)	(0.420)	(0.800)
Auctioning	3.834	9.905	2.780	3.553	10.122
	(2.857)	(8.691)	(2.034)	(2.790)	(7.956)
Post-2013 × Auctioning	-1.525	-1.881	-1.517	-1.508	-1.955
	(1.195)	(1.261)	(1.176)	(1.190)	(1.328)
GDP		-6.363			-7.803
		(6.739)			(6.642)
Share of renewables			15.981		13.061
			(12.544)		(12.772)
Energy import dependency				-1.505*** (0.359)	-1.581** (0.606)
Observations	473	473	473	472	472
R-squared	0.004	0.026	0.018	0.011	0.049

Notes: See Table 4 for general definitions. The dependent variable is the share of renewables in total installed generation capacity.

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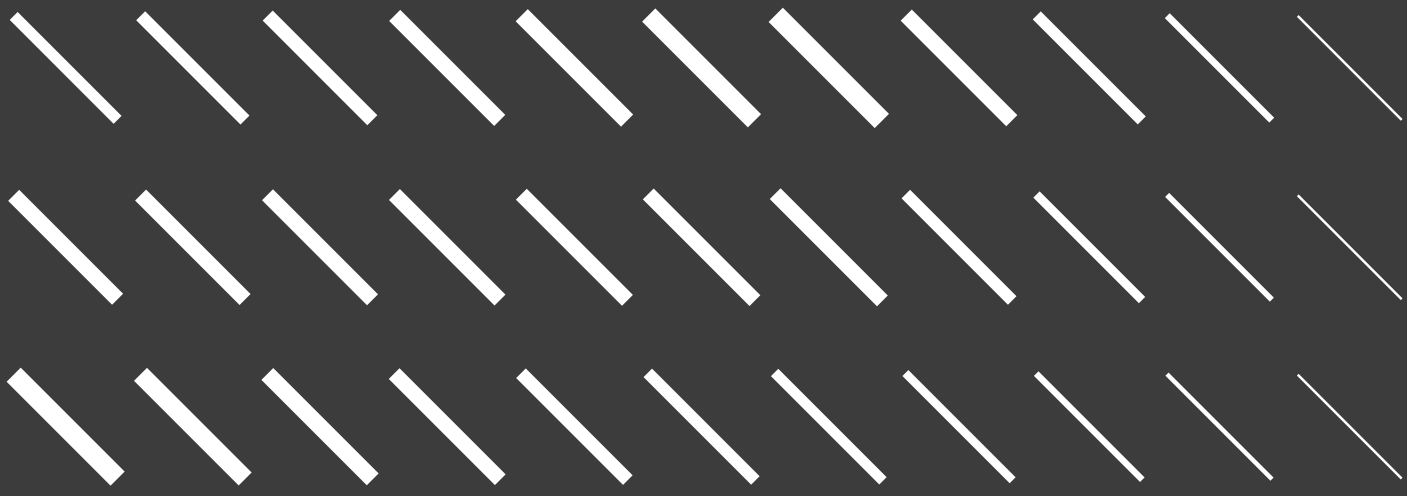
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About the Project

This study examines how the method of allocating carbon allowances – whether auctioned or given for free – affects renewable energy deployment under the European Union Emissions Trading System (EU ETS). By combining a theoretical model of power generators' input choices with an empirical analysis using panel data for 30 European countries from 2005 to 2020, the project investigates the policy divergence introduced in Phase III of the EU ETS, when most countries transitioned to full auctioning while some lower-income member states retained free allocation under conditional reinvestment rules. The findings show that, despite substantial growth in renewable capacity and declining power sector emissions across the EU, the choice between auctioning and free allocation did not lead to systematic differences in renewable deployment outcomes. The results highlight that the effectiveness of emissions trading systems depends less on allocation design and more on robust governance frameworks that ensure the transparent reinvestment of carbon revenues into low-carbon technologies.





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