RESEARCH ARTICLE

Does Environmental Tax Revenue Track the Energy Transition? Panel Evidence from the EU-27, 2004–2023

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Abstract

Environmental tax revenue as a share of gross domestic product is used in European Union policy documents as a proxy for environmental fiscal effort, and effort is expected to show up in the energy transition. This paper tests the second link directly. Using a balanced panel of the 27 member states over 2004–2023, with 540 country-year observations, two-way fixed effects and standard errors clustered by country, it estimates the association between environmental tax revenue, disaggregated into energy, transport and pollution components, and three transition outcomes: the renewable share of energy, energy intensity and carbon dioxide emissions per capita. The results do not support the expected relationship. No component of environmental tax revenue is significantly associated with the renewable share, and the point estimates are negative. Energy tax revenue is positively and significantly associated with energy intensity (0.034, p = 0.015) and with emissions per capita (0.052, p = 0.011), the opposite of the sign an incentive story predicts. The paper argues that this is not evidence that environmental taxation fails, but evidence that a revenue ratio measures the size of the taxed base rather than the strength of the price signal: energy tax revenue relative to output is, by construction, the implicit tax rate on energy multiplied by energy intensity, so a positive association with intensity is partly mechanical. The indicator used to monitor environmental fiscal effort in the Union cannot detect the effect it is meant to monitor, and the implicit tax rate should be reported alongside it.

Keywords: carbon pricing; renewable share; emissions per capita; fiscal indicators; fixed effects; European Union
JEL Classification: Q58; Q48; H23; C23

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1. INTRODUCTION

The policy case for environmental taxation rests on a price mechanism. Taxing an environmentally harmful base raises its relative price, consumption of that base falls, and the composition of energy use shifts towards cleaner alternatives. If the mechanism works, countries that tax more should show a faster transition. This is the proposition the present paper puts to the data, and the answer it returns is not the one the policy framework assumes.

Care is needed in performing the test because the variable normally used to measure how much a country taxes is a revenue ratio, and a revenue ratio is the product of a rate and a base. The

ambiguity is acknowledged in passing in most applied work and then generally set aside. A member state can post a high ratio because it charges high rates or because it consumes a great deal of the taxed good. If the second influence dominates, the observed correlation between revenue and environmental outcomes will carry the wrong sign, and a researcher who did not anticipate this will report a puzzle. For energy taxes the point is exact: revenue divided by output is identically the implicit tax rate on energy multiplied by energy intensity, so one of the outcomes this paper examines is built into the regressor, in the direction a base effect predicts.

This paper reports exactly such a sign and argues that it is not a puzzle. The contribution has three parts: an estimate of the association between disaggregated environmental tax revenue and three transition outcomes on a two-way fixed-effects panel of the 27 member states over 2004–2023, which removes both time-invariant national characteristics and shocks common to the Union; a demonstration that the null result on the renewable share and the positive coefficients on energy intensity and emissions are jointly consistent with a base effect and jointly inconsistent with an incentive effect, and that the identity just stated makes the first of those positive coefficients close to tautological; and the measurement conclusion that follows, namely that the indicator cannot be used for the monitoring purpose to which it is currently put, together with a statement of what should be reported instead.

The present analysis extends a companion study (Nicolescu, 2026) that decomposed the same revenue ratio and documented, on a slightly longer panel, that the aggregate declined over 2000–2023, that its composition tilted towards energy taxes, and that β-convergence and σ-divergence coexist in the series. That paper asked what the indicator shows about the tax systems themselves. The present one asks whether the indicator carries any information about the environmental outcomes it is supposed to track. The two questions are distinct, the results do not overlap, and the answer to the second sharpens the conclusion of the first.

What the paper does not establish should be stated with equal care. The estimates are associations, not causal effects. No instrument is used, no discontinuity is exploited, and the direction of causality between taxation and consumption is not identified. The claim is narrower and, for that reason, defensible: whatever the true causal structure, the published indicator does not move with transition outcomes in the direction the policy framework assumes, and the reason is visible in how the indicator is constructed. Section 2 reviews the literature and closes with two competing hypotheses, Section 3 describes the data and the estimation strategy, Section 4 reports the results, Section 5 interprets them, and Section 6 concludes with limitations and directions for further work.

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2. LITERATURE REVIEW

2.1 Environmental Taxes and the Energy Transition

The theoretical case is old and uncontroversial. Pigou (1920) showed that a tax set equal to marginal external damage internalises the externality. Applied to energy, the prediction is that a higher effective tax rate on fuels reduces their consumption, lowers energy use per unit of output, and raises the share of untaxed or lightly taxed renewable sources in the energy mix. Goulder (1995) added the fiscal dimension, arguing that the proceeds can be used to reduce distortionary taxes elsewhere, which is the origin of the double-dividend claim; Bovenberg and de Mooij (1994) showed that the second dividend is not guaranteed once the interaction with pre-existing labour taxes is taken into account. Whatever the fate of the second dividend, the first depends on the rate, since it is the rate that enters the consumer's decision.

Between taxation and the transition lie three margins that the present paper takes as its outcomes. A tax on fossil fuels raises the relative price of fossil energy and so favours substitution towards renewables, visible in the renewable share of gross final consumption. It raises the price of energy generally and so favours conservation, visible in energy intensity. And it does both at once for carbon-intensive fuels, visible in emissions per capita. The three outcomes are not independent, but they respond to different aspects of the price signal, and a revenue indicator that carried information about the signal should move with all three in the same direction.

European policy documents treat environmental tax revenue as if it did. The European Green Deal and the European Semester both refer to the revenue ratio as a measure of the greening of tax systems, and the Commission's annual Taxation Trends report tabulates it for every member state alongside the implicit tax rate on energy (European Commission, 2024). The European Court of Auditors (2022) reviewed energy taxation and carbon pricing across the Union and observed that energy tax levels are poorly aligned with the carbon content of fuels, that the ratio of environmental taxes to total taxation has been broadly flat, and that revenue data cannot on their own reveal whether taxes are changing behaviour. The European Environment Agency (2023) reports that the Union's renewable share and emissions trajectory have improved on schedule, while noting that the fiscal instruments responsible are difficult to isolate at the aggregate level. The tension between those observations is where the present paper starts.

2.2 Carbon Pricing Effectiveness

The empirical literature that evaluates actual tax instruments, rather than revenue aggregates, generally finds the expected sign. Andersson (2019) estimated the effect of the Swedish carbon tax on transport emissions using a synthetic control built from other OECD countries and found a reduction of close to 11 per cent relative to the counterfactual, with a price elasticity roughly three times that of a market-

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driven price change of the same size. The result matters here for two reasons: it measures a rate rather than a revenue, and it documents that a tax which works erodes its own base.

Metcalf and Stock (2023) took a broader view, using a panel of European countries with carbon taxes over more than three decades to estimate the dynamic macroeconomic effects of the tax. Their central finding is that carbon taxes have had no discernible negative effect on employment or output growth and that the emissions response is negative and grows over time. Their identification rests on variation in the tax rate and in its coverage, both measured directly, with country and year effects and dynamic responses estimated by local projections. The contrast with the present exercise is instructive: where they observe the rate and the coverage, the monitoring framework observes only the revenue that results, and revenue conflates the two with the base.

Green (2021) reviewed 37 ex-post evaluations of carbon pricing schemes and concluded that the measured effects on emissions are real but modest, typically in the range of zero to two per cent per year, and that the size of the effect scales with the level of the price. The meta-analysis by Döbbeling-Hildebrandt et al. (2024), covering 21 schemes, found average reductions of between 5 and 21 per cent, with heterogeneity driven by coverage and price levels rather than by the label attached to the instrument. Timilsina (2022) surveyed the carbon tax literature and reached a similar conclusion on design: the effect depends on the rate, the base and the treatment of revenue. Lilliestam et al. (2021) found little ex-post evidence that carbon pricing at observed levels has induced the technological change required for full decarbonisation, which is consistent with a price signal too weak, in most jurisdictions, to be visible in the composition of the energy mix. Best et al. (2020) exploited cross-country variation in carbon prices and found that jurisdictions with a price experienced annual emissions growth roughly two percentage points lower than those without. On the trading side, Dechezleprêtre et al. (2023) compared installations inside and outside the European Union Emissions Trading System and estimated reductions of around 10 per cent between 2005 and 2012 with no adverse effect on economic performance. The OECD's Effective Carbon Rates series (OECD, 2023), which combines fuel excise duties, carbon taxes and permit prices into a single price per tonne, exists precisely because a revenue figure cannot stand in for the price signal.

Two features of this literature matter for what follows. Every credible estimate of effectiveness uses a rate, a price or a discrete policy change as the treatment variable, and none uses revenue as a share of output. And the estimated effects, though real, are modest relative to the variation in consumption that drives revenue: if a tax lowers emissions by a few per cent per year while receipts fluctuate with the business cycle, fuel prices and vehicle stocks, the revenue series will be dominated by the base.

2.3 Environmental Tax Revenue Erosion

A tax that discourages the activity it falls on erodes its own base. This is not a side effect; it is the purpose. The consequence for revenue has been documented repeatedly. The OECD's guide for policy

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makers (OECD, 2011) noted that environmental tax revenues tend to decline as a share of output once the tax has induced the intended behavioural change, and warned against reading a falling ratio as a weakening of policy. Eurostat's statistical guide (Eurostat, 2013) defines environmental taxes by the physical base on which they fall rather than by the purpose for which they were introduced, so the aggregate includes long-standing excise duties whose rates have often been frozen in nominal terms and whose real value has been eroded by inflation.

Union-wide data bear this out. Environmental tax revenue in the EU-27 fell from 2.4 per cent of gross domestic product in 2009 to about 2 per cent in 2023, with the fall concentrated in energy taxes, which make up more than three quarters of the total (Eurostat, 2024). The companion paper (Nicolescu, 2026) showed that the decline was accompanied by a shift in composition towards energy and away from transport taxes, and that the cross-country dispersion of the ratio widened even as poorer starters caught up. Both findings are consistent with an indicator that responds to the base. The IMF's Fiscal Monitor (International Monetary Fund, 2023) makes the fiscal implication explicit: revenue from fossil fuel taxation is projected to shrink as the transition proceeds, so a government that relies on it faces a structural revenue gap precisely when its climate policy succeeds. The Commission's Taxation Trends report shows the same thing from the other direction, since the implicit tax rate on energy, which divides revenue by consumption, has moved quite differently from the revenue ratio in a number of member states (European Commission, 2024).

In response, the measurement literature has built indicators that separate the rate from the base, among them the OECD environmental policy stringency index (Kruse et al., 2022), which combines instrument-level measures rather than revenue outcomes, and the effective carbon rate. Neither is yet available on a consistent basis for all 27 member states over two decades, which is why the revenue ratio remains in use and why the question this paper asks has not, to the author's knowledge, been answered directly on a full Union panel.

2.4 Panel Methods and Their Limits

The estimation strategy follows the standard two-way fixed-effects design, with country and year effects and standard errors clustered at the country level. Clustering is justified because the policy variation is national, the series are strongly persistent, and ordinary standard errors understate uncertainty when errors are serially correlated within units. Cameron and Miller (2015) set out the practitioner's case for cluster-robust inference and the reasons for caution when the number of clusters is small; with 27 clusters, inference should use the t distribution with 26 degrees of freedom rather than the normal, and the present paper does so.

Two further strands of the panel literature bear on the design. The first concerns dynamics. Nickell (1981) showed that a lagged dependent variable in a fixed-effects model produces a bias of order 1/T, which shrinks as the time dimension grows; the generalised method of moments estimators of Arellano and Bond (1991) and Blundell and Bond (1998) were developed for panels where T is too

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short for that bias to be ignored. With 20 periods the bias is modest, so the dynamic specification is reported as a check rather than as the preferred estimate, and Section 6 returns to the case for a GMM extension. The second strand concerns the interpretation of two-way fixed-effects coefficients when the response is heterogeneous. Imai and Kim (2021) showed that the design identifies a weighted average of within-unit contrasts whose weights need not be those a researcher would choose, and Callaway and Sant'Anna (2021) developed alternatives for staggered discrete treatments. The regressors here are continuous and not staggered, so those alternatives do not apply directly, but the caution about reading a single pooled coefficient as an average effect applies and reinforces the decision to describe the estimates as associations.

The panel also sits in a tradition, going back to Grossman and Krueger (1995) and reviewed critically by Stern (2004), that relates environmental outcomes to income on cross-country panels. That literature established the scale, composition and technique effects through which income moves emissions, and it is the reason the logarithm of real income per capita enters every specification here as a control; the sign of the income coefficient in each equation is interpreted in its light in Section 5.

2.5 Hypotheses

Two competing hypotheses are formulated. Under the incentive hypothesis, higher environmental tax revenue reflects a stronger price signal and should be associated with a higher renewable share, lower energy intensity and lower emissions per capita. Under the base hypothesis, revenue is driven by the volume of taxed consumption, so the association with the two volume-based outcomes runs the other way, and the association with the renewable share, a composition variable rather than a volume variable, is absent or weak. For energy taxes the base hypothesis has an exact form, because the identity in Equation (2) below makes the revenue ratio the product of the implicit tax rate and energy intensity: if the rate is roughly stable within a country, the ratio moves one for one with intensity. The two hypotheses make different sign predictions, and the data can distinguish them.

3. METHODOLOGY

3.1 Panel and Data Sources

The panel covers the 27 current member states of the European Union over 2004–2023 and contains 540 country-year observations with complete data on every variable. The binding constraint on the period is the renewable share series, which begins in 2004 in the Eurostat energy statistics; the fiscal series are available from 2000 and are used from that year in the companion paper, but the present analysis needs all three outcomes for every observation.

Fiscal variables come from the Eurostat environmental tax accounts, dataset env_ac_tax (Eurostat, 2025a), and are expressed as percentages of gross domestic product. Total environmental tax revenue is used in the first two specifications and is then disaggregated into its three Eurostat

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categories: energy taxes, which include excise duties on fuels and electricity and the carbon component of those duties; transport taxes, which include vehicle registration and circulation taxes; and taxes on pollution and resources. The classification follows Eurostat's statistical guide (Eurostat, 2013), which assigns a tax to the environmental category on the basis of its physical base rather than its stated purpose.

Outcomes and controls come from two sources. The renewable share of gross final energy consumption is taken from Eurostat dataset nrg_ind_ren (Eurostat, 2025b) and is measured in percentage points. Energy intensity, measured as primary energy use per unit of gross domestic product at purchasing power parity, and carbon dioxide emissions per capita, measured in tonnes, come from the World Bank's World Development Indicators (World Bank, 2025), as do the three controls: real gross domestic product per capita at purchasing power parity, trade openness measured as exports plus imports as a percentage of gross domestic product, and the urban population share. Energy intensity, emissions per capita and income per capita enter in logarithms, so the coefficients on the fiscal variables in those equations are read as approximate percentage changes in the outcome for a one percentage point change in the revenue ratio. The renewable share enters in levels, and its coefficients are read in percentage points.

3.2 Specification

The baseline is a two-way fixed-effects model, given in Equation (1):

$$y_{it} = \alpha_i + \lambda_t + \beta_1 \mathrm{ENERGY}_{it} + \beta_2 \mathrm{TRANSPORT}_{it} + \beta_3 \mathrm{POLLUTION}_{it} + \gamma' X_{it} + \varepsilon_{it} \quad (1)$$

where y_{it} is one of the three outcomes for country i in year t, α_i are country fixed effects, λ_t are year fixed effects, and X_{it} is the control vector containing the logarithm of income per capita, trade openness and the urban population share. Country effects absorb geography, resource endowment, the inherited energy mix, legacy nuclear and hydroelectric capacity, and any other time-invariant national characteristic. Year effects absorb Union-wide shocks, including the 2008 financial crisis, the 2020 pandemic and the 2021–2022 energy price episode, together with the common trend in renewable deployment that the Union's directives have imposed on all member states. What remains for the fiscal coefficients to explain is within-country variation over time, net of what all countries experienced in common.

The identity that motivates the base hypothesis for the energy component is given in Equation (2):

$$\mathrm{ENERGY}_{it} / \mathrm{GDP}_{it} = (\mathrm{ENERGY}_{it} / \mathrm{FEC}_{it}) \times (\mathrm{FEC}_{it} / \mathrm{GDP}_{it}) = \mathrm{ITR}_{it} \times \mathrm{EI}_{it} \quad (2)$$

where FEC is final energy consumption, ITR is the implicit tax rate on energy as defined in the Commission's Taxation Trends report (European Commission, 2024), and EI is energy intensity measured on final consumption. The energy intensity series used as an outcome is measured on primary rather than final energy, so Equation (2) holds for the regression variable only up to the ratio

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of primary to final energy, which moves slowly within a country and is absorbed to a first approximation by the country effect. In logarithms the point is direct: the log revenue ratio equals the log implicit rate plus log intensity, and a regression of the second term on the sum of the two recovers a positive coefficient whenever the variance of the first term is not large relative to that of the second.

Three specifications are reported for the renewable share. The first, M1, regresses the share on total environmental tax revenue with the logarithm of income per capita and the urban population share as controls. The second, M2, adds trade openness. The third, M3, replaces the aggregate with its three components and keeps the full control set, and is then applied to energy intensity and to emissions per capita. The urban population share is included in every specification, including the two equations in Table 2; its coefficient is never significant and is not reported in the tables for brevity, as the table notes state.

3.3 Inference and Diagnostics

Standard errors are clustered by country throughout, since the policy variation is national and clustering accommodates both heteroskedasticity and serial correlation of arbitrary form within a country (Cameron & Miller, 2015). Because there are 27 clusters, the t statistics are compared with the t distribution on 26 degrees of freedom rather than with the standard normal, and all p-values reported below are computed on that basis. The correction matters at the margin: a coefficient with a t statistic of 2.6 has a p-value of about 0.009 under the normal and about 0.015 under t(26), and the stars in the tables reflect the latter.

Diagnostic statistics are reported for the renewable-share equation, which has the most persistent dependent variable and is therefore where the assumptions are most strained: variance inflation factors for the regressors, a Breusch–Pagan test for heteroskedasticity, a Durbin–Watson statistic for first-order serial correlation and a Jarque–Bera test for normality of the residuals. They inform the choice of standard errors rather than the choice of specification, since the fixed-effects design is dictated by the research question.

A dynamic version of Equation (1), adding the lagged dependent variable to the right-hand side, is estimated as a robustness check for each of the three outcomes. The lag absorbs the persistent component of the outcome and turns the fiscal coefficients into short-run associations; the static coefficients are, by comparison, closer to long-run associations. As noted in Section 2.4, the dynamic fixed-effects estimator carries a bias of order 1/T (Nickell, 1981); with T equal to 20 the bias is small relative to the standard errors reported here, but the dynamic model is used to check the sign and significance of the static results rather than to replace them.

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4. RESULTS

4.1 Descriptive Pattern

Figure 1 plots the two series at the centre of the paper, each as an unweighted cross-country mean for the 27 member states. The renewable share rises steadily across the whole period, from a little above 12 per cent in 2004 to above 27 per cent in 2023, with a visible acceleration after 2019. Energy tax revenue relative to output falls from 2004 to 2008, recovers to a peak of about 2.2 per cent of output in 2016, and then falls without interruption to below 1.8 per cent in 2023. If the two series moved together as the incentive hypothesis requires, the picture would look different. The decline in energy tax revenue after 2016 coincides with the fastest growth in the renewable share, which is what a base effect predicts: as fossil energy is displaced, the base on which energy taxes are levied shrinks, and revenue falls. The formal estimates confirm what the figure suggests.

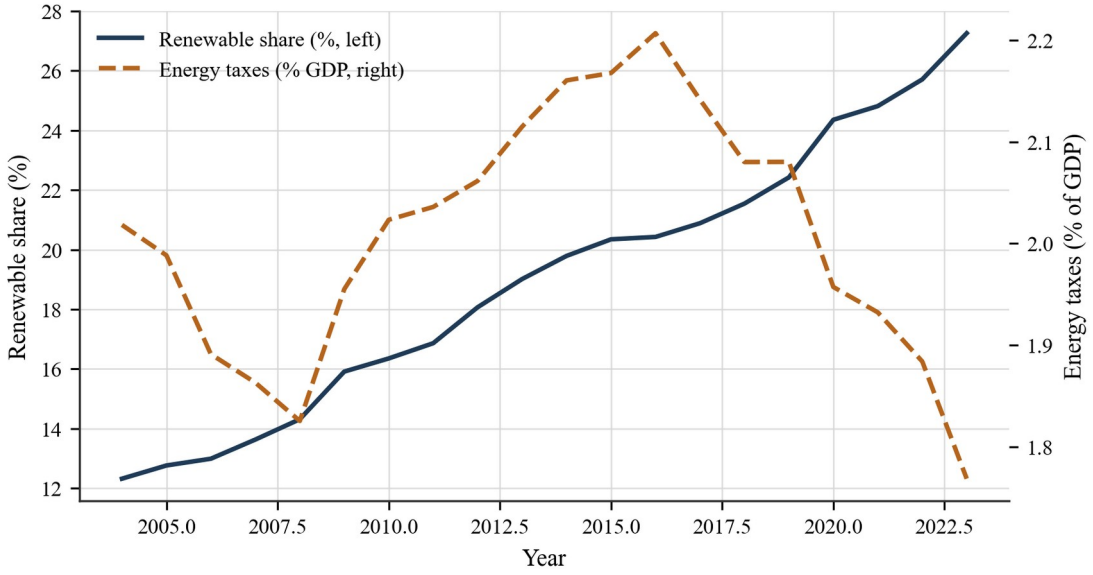


Figure 1. Renewable share of energy and energy tax revenue in the EU-27, 2004–2023. Both series are unweighted cross-country means. The renewable share is read on the left axis, energy tax revenue on the right.

Source: Author's own elaboration on Eurostat and World Bank data.

4.2 Environmental Tax Revenue and the Renewable Share

Table 1 reports the three specifications for the renewable share. In every column the fiscal variables are insignificant, and every point estimate is negative. The aggregate enters at −0.963 in M1 and −0.979 in M2, with standard errors close to 0.8, so the confidence intervals comfortably include zero. In the disaggregated model the coefficient on energy taxes is −0.718 ($p = 0.359$), on transport taxes −1.809 ($p = 0.352$) and on pollution and resource taxes −9.148 ($p = 0.150$). The last of these is large in absolute value, but the pollution and resource base is tiny, typically a tenth of a percentage point of output, so the coefficient describes a change few member states have experienced within the sample, as its standard error of 6.169 shows. Within a country, and net of common shocks, environmental tax revenue does not move with the renewable share of energy.

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Income is the one control that carries a significant coefficient. The logarithm of real income per capita enters at −6.202 in M1 (p = 0.018), −6.240 in M2 (p = 0.028) and −6.563 in M3 (p = 0.012). Within a country, a ten per cent rise in income per capita is associated with a fall in the renewable share of a little over 0.6 percentage points, holding the year effects and the fiscal variables constant. This sign is discussed in Section 5.3; for the moment it is enough to observe that it is the sign a denominator effect would produce, since income growth raises total final energy consumption faster than it raises the renewable component in the short run, and that it reinforces rather than undermines the reading of the fiscal coefficients.

The R-squared exceeds 0.97 in all three columns, a mechanical consequence of the country and year effects: the renewable share is a slow-moving series with strong national levels and a common upward trend, and the dummies absorb almost all of its variation. The statistic says nothing about the explanatory power of the fiscal variables.

Table 1.
Environmental tax revenue and the renewable share of energy, EU-27, 2004–2023

Variable	M1	M2	M3
Total environmental taxes (% GDP)	−0.963 (0.790)	−0.979 (0.851)	n/a
Energy taxes (% GDP)	n/a	n/a	−0.718 (0.769)
Transport taxes (% GDP)	n/a	n/a	−1.809 (1.909)
Pollution and resource taxes (% GDP)	n/a	n/a	−9.148 (6.169)
ln(GDP per capita)	−6.202** (2.466)	−6.240** (2.673)	−6.563** (2.443)
Trade openness	n/a	−0.002 (0.018)	−0.003 (0.018)
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	540	540	540
R^2	0.976	0.976	0.977

Note: Dependent variable: renewable share of gross final energy consumption (%). Standard errors clustered by country in parentheses; p-values computed on the t distribution with 26 degrees of freedom. **** p < 0.01,*** *p < 0.05, * p < 0.10. The urban population share is included in all specifications; its coefficient is never significant (−0.013 with a standard error of 0.209 in M2) and is not reported for brevity. n/a: variable not included in that specification.*

Source: Author's own calculations on Eurostat and World Bank data.

4.3 Energy Intensity and Emissions

Table 2 applies the disaggregated specification to the two volume-based outcomes, and here the coefficients on energy taxes are significant and point in the wrong direction for an incentive story. Energy tax revenue enters the energy intensity equation at 0.034 (p = 0.015) and the emissions equation at 0.052 (p = 0.011). Because the outcomes are in logarithms, a one percentage point increase in energy tax revenue relative to output is associated with roughly 3.4 per cent higher energy intensity and 5.2 per cent higher emissions per capita, within country and net of year effects. The interpretation is a within-country one: when energy consumption rises within a member state, energy tax receipts rise with it, and the revenue ratio records the rise as if it were an increase in fiscal effort.

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Read as an incentive effect, the coefficients would say that taxing energy raises energy use, which is not credible. Read as a base effect, they say something almost obvious: energy tax receipts are large where energy consumption is large, and Equation (2) shows why the association with intensity in particular is close to mechanical. The base hypothesis predicted this sign; the incentive hypothesis did not. That the emissions coefficient exceeds the intensity coefficient also fits the base reading, since emissions per capita combine the intensity of energy use with the scale of output per head, and energy tax revenue responds to both.

Transport taxes and pollution and resource taxes are insignificant in both equations, at −0.018 and 0.163 for intensity and 0.125 and 0.279 for emissions. The transport tax base is the vehicle stock and its registration flow rather than fuel consumption, and the pollution and resource base is administratively determined and small, so neither is expected to track energy volumes closely; their insignificance fits the base reading.

The income coefficients are informative in their own right. Income per capita enters the intensity equation at −0.442 and the emissions equation at 0.551, both with p-values below 0.001. Within a country, a rise in income is associated with lower energy use per unit of output and with higher emissions per head, the combination of technique and scale effects familiar from Grossman and Krueger (1995). Trade openness enters the intensity equation with a small negative coefficient significant at the five per cent level and the emissions equation with one that is not.

Table 2.
Environmental tax revenue, energy intensity and emissions, EU-27, 2004–2023

Variable	ln(energy intensity)	ln(CO_2 per capita)
Energy taxes (% GDP)	0.034** (0.013)	0.052** (0.019)
Transport taxes (% GDP)	−0.018 (0.071)	0.125 (0.102)
Pollution and resource taxes (% GDP)	0.163 (0.110)	0.279 (0.243)
ln(GDP per capita)	−0.442 (0.105)	0.551 (0.120)
Trade openness	−0.001** (0.001)	−0.001 (0.001)
Country fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	540	540
R^2	0.988	0.959

Note: Standard errors clustered by country in parentheses; p-values computed on the t distribution with 26 degrees of freedom. **** p < 0.01,*** *p < 0.05, * p < 0.10. The urban population share is included in both specifications; its coefficient is not significant and is not reported for brevity.*

Source: Author's own calculations on Eurostat and World Bank data.

Figure 2 brings the three disaggregated equations together by plotting the coefficient on each fiscal component against each outcome with its 95 per cent confidence interval, and the picture summarises the paper. For the renewable share, all three intervals straddle zero and all three point estimates lie to the left of it. For energy intensity and emissions, the energy tax interval excludes zero on the right, while the transport and pollution intervals are wide and centred close to zero. The one component with

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a base large enough to move with consumption is the one with a significant coefficient, and its sign is the sign of the base.

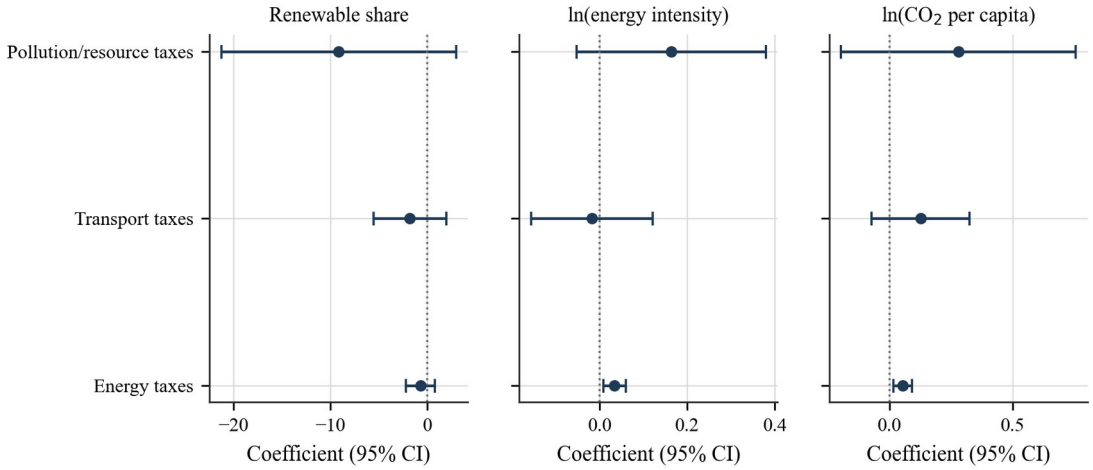


Figure 2. Coefficients on the three environmental tax components across the three outcome variables, with 95 per cent confidence intervals. Estimates come from the disaggregated two-way fixed-effects specification.

Source: Author's own elaboration.

4.4 Diagnostics and Robustness

Multicollinearity is not a concern. Variance inflation factors for the fiscal variables and the controls range from 1.12 to 1.51, well below any conventional threshold, so the three tax components are not so closely related within countries as to make their separate coefficients unstable. The Breusch–Pagan statistic of 208.35 ($p < 0.001$) indicates heteroskedasticity, and the Durbin–Watson statistic of 0.643 indicates strong positive serial correlation, which is expected in a panel of slow-moving national series and is the main reason why ordinary standard errors would mislead here. Clustering by country addresses both. The Jarque–Bera statistic of 61.45 ($p < 0.001$) rejects normality of the residuals; at 540 observations this has little bearing on inference, but it is reported for completeness.

Figure 3 displays the diagnostic plots for the renewable-share model. Panel (a) shows that the fitted values track the actual values closely across the whole range of the share, from below 5 per cent to above 60 per cent, with no systematic under- or over-prediction at either end. Panel (b) shows residuals against fitted values with no obvious funnel, although the spread is wider for the small number of observations with fitted values above 40 per cent. Panel (c), the normal quantile-quantile plot, shows the heavier tails responsible for the Jarque–Bera rejection: a handful of large positive residuals in the upper tail and a single large negative residual in the lower one, with the central mass of the distribution close to the reference line.

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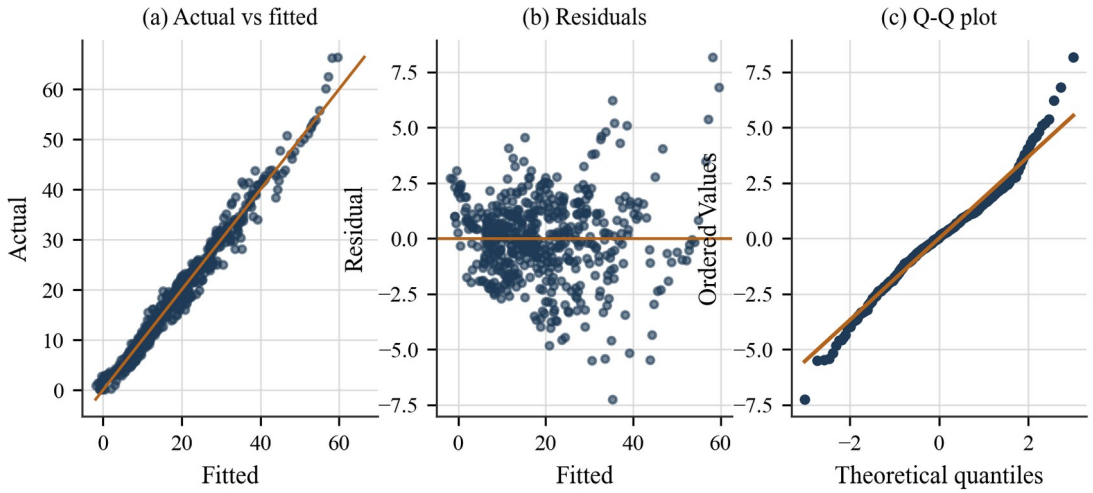


Figure 3. Diagnostics for the renewable-share model: (a) actual against fitted values, (b) residuals against fitted values, (c) normal quantile-quantile plot.

Source: Author's own elaboration.

Because the serial correlation is severe, the dynamic specification described in Section 3.3, with the lagged dependent variable added to the disaggregated model, is estimated for each of the three outcomes. For the renewable share the lag enters at 0.822 ($p < 0.001$), confirming the persistence of the series, and the fiscal coefficients remain insignificant: energy taxes at −0.052 ($p = 0.762$) and transport taxes at −0.872 ($p = 0.104$). The coefficient on pollution and resource taxes is not reported in the dynamic renewable-share model because the pollution and resource series begins later than the other two components for several member states, so that once a lag is taken the usable panel for that component is shorter than 540 observations and the estimate is not comparable with the static one. The null result on the renewable share does not depend on the static specification.

For the two equations where the static results are affirmative the dynamic check matters more, since there a persistent outcome could in principle produce a spurious association. For energy intensity and for emissions per capita, the lagged dependent variable enters with a large and highly significant coefficient, as expected, and the coefficient on energy taxes keeps its positive sign in both equations while falling in magnitude, which is the usual consequence of moving from a long-run to a short-run association. The transport and pollution coefficients remain insignificant in both. The full dynamic estimates for these two outcomes are contained in the replication file described in the data availability statement. The substantive conclusion, that the association between energy tax revenue and the two volume outcomes is positive rather than negative, survives the introduction of dynamics. The dynamic model remains a check rather than the preferred estimate because of the Nickell (1981) bias discussed above; with 20 periods the bias is of order five per cent of the lag coefficient and is unlikely to overturn either a coefficient close to zero or one whose sign is the object of interest.

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5. DISCUSSION

5.1 A Measurement Result, Not a Policy Verdict

The findings should not be read as evidence that environmental taxation does not work. Evidence that it does work exists, and it comes from studies that measure rates and discrete policy changes: the Swedish carbon tax examined by Andersson (2019), the European carbon taxes examined by Metcalf and Stock (2023), the trading system examined by Dechezleprêtre et al. (2023), and the ex-post evaluations reviewed by Green (2021) and by Döbbeling-Hildebrandt et al. (2024). What the present results show is that the aggregate published indicator does not carry that information. The two claims are compatible, and keeping them apart is the main analytical point of the paper.

Nothing in the pattern of coefficients favours the alternative reading. If revenue were a good proxy for the price signal, the renewable share equation would show a positive coefficient on the fiscal variables and the intensity equation a negative one. Instead the first is null and the second is positive. A base effect predicts both; an incentive effect predicts neither. Equation (2) makes the intensity result close to a matter of accounting. Energy tax revenue relative to output is the implicit tax rate multiplied by energy intensity, so if the implicit rate moves less within a country than intensity does, the regression of intensity on the revenue ratio will return a positive coefficient whatever the incentive effect of the rate itself. The regression is, under the base hypothesis, nearly tautological. That is not a weakness of the design; it is the reason the indicator fails as a measure of effort, made explicit.

Magnitudes are consistent with that reading too. If the implicit rate were constant, a one percentage point increase in a revenue ratio whose mean is about two per cent of output would correspond to a change in intensity of roughly 50 per cent. The estimated 3.4 per cent is far smaller, which says that the implicit rate does move within countries, through indexation, discretionary rate changes and the compensation measures adopted during the 2021–2022 price episode, and that its movements are largely uncorrelated with intensity. The coefficient is small because the rate varies; it is positive because the base varies too, in the direction the identity dictates.

5.2 What This Means for Monitoring

The European Semester and the Green Deal monitoring framework use environmental tax revenue as an indicator of fiscal ambition. A member state that reduced consumption of taxed fuels through an effective tax, or through any other policy, would appear on that indicator to have reduced its ambition. The indicator penalises success. The OECD (2011) made the point in general terms fifteen years ago and the European Court of Auditors (2022) repeated it; the present results give it an empirical form on the full Union panel.

Three practical implications follow. The implicit tax rate on energy should be reported alongside the revenue ratio wherever it is available, since it is the rate rather than the revenue that carries the price signal, and the Commission already publishes it for most member states (European

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Commission, 2024). The revenue ratio should be disaggregated, because the components behave differently: the energy component tracks the base almost mechanically, the transport component tracks vehicle regimes, and the pollution component is too small to track anything at the aggregate level. And cross-country comparisons based on the aggregate alone should not be used to rank environmental effort, since the ranking will reward member states with large fossil energy bases and penalise those that have reduced theirs. The effective carbon rate compiled by the OECD (2023) is a template for a price-based indicator built for comparison across jurisdictions.

A fiscal implication runs the other way and is equally direct. If the transition proceeds as the European Environment Agency (2023) projects, the energy tax base will continue to erode and the revenue ratio will continue to fall, whether or not member states raise their rates; the International Monetary Fund (2023) has drawn attention to the structural revenue gap that follows. A monitoring framework that reads the falling ratio as declining ambition will draw the wrong conclusion about the policy and, at the same time, miss the fiscal problem the falling ratio actually signals.

5.3 The Income Coefficient in the Renewable Share Equation

The negative and significant coefficient on income per capita in Table 1 deserves comment, because on its face it says that richer countries are less renewable, which contradicts the cross-sectional pattern in which the Nordic states combine high income with high renewable shares. The contradiction dissolves once the fixed effects are taken into account: the cross-sectional pattern is absorbed by the country effects, and what the coefficient measures is the within-country association between changes in income and changes in the share, net of the common trend.

Within a country, that association has a denominator component. The renewable share divides renewable consumption by gross final consumption, and gross final consumption is procyclical. When income falls, as it did in the Baltic states in 2009 and in Greece over 2010–2013, total consumption falls quickly while renewable output, which depends on installed capacity and on hydrology rather than on demand, does not, so the share rises; when income recovers, the share falls back. Year effects absorb the Union-wide component of the cycle but not the country-specific component, and it is the latter that identifies the coefficient. The income coefficient is, in other words, a second base effect: volume variables move with income, and a ratio with a volume denominator moves against it. It is consistent with the paper's reading of the fiscal coefficients, and it would be a mistake to read it as evidence that growth is bad for the transition.

In Table 2 the income coefficients tell the complementary story. Higher income within a country is associated with lower energy intensity, at −0.442, and with higher emissions per head, at 0.551. The first is the technique effect and the second the scale effect of Grossman and Krueger (1995), and their coexistence within the same panel is a reminder that the environmental Kuznets literature reviewed by Stern (2004) has always been about the balance between the two rather than

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about either one alone. For the Union over 2004–2023 the balance within countries has been on the side of scale.

5.4 Relation to the Companion Study

The companion paper (Nicolescu, 2026) documented that the aggregate revenue ratio fell over 2000–2023 while β-convergence and σ-divergence coexisted, and attributed the divergence to the migration of the tax base into the energy component, where national discretion is widest. The present results explain part of that. If the energy component tracks the energy base, differences in the pace of the transition across member states will produce differences in the ratio that have nothing to do with fiscal ambition, and the dispersion of the ratio will widen as the transition proceeds unevenly. The two papers make a single argument from two directions: the first shows that the indicator's dynamics are not those of a measure of effort, and the second shows why.

6. CONCLUSIONS

This paper asked whether environmental tax revenue tracks the energy transition in the European Union, using a two-way fixed-effects panel of the 27 member states over 2004–2023 with standard errors clustered by country and inference on 26 degrees of freedom. It does not. No component of environmental tax revenue is significantly associated with the renewable share of energy in any specification, and the point estimates are negative. Energy tax revenue is positively associated with energy intensity, at 0.034 ($p = 0.015$), and with emissions per capita, at 0.052 ($p = 0.011$). Transport and pollution taxes are insignificant throughout. The results are robust to the inclusion of a lagged dependent variable for all three outcomes.

The sign is the finding. It is the sign a base effect predicts and the opposite of the sign an incentive effect predicts, and it therefore identifies what the indicator is measuring. Environmental tax revenue as a share of gross domestic product is a measure of how much taxed activity a country has, not of how hard it taxes that activity. For the energy component the point is an identity: the revenue ratio equals the implicit tax rate multiplied by energy intensity, and the positive coefficient on intensity is the identity showing through the regression.

For the monitoring framework, the implication is direct. An indicator that falls when the policy succeeds cannot be used to assess whether the policy is succeeding. The Union has a better instrument in the implicit tax rate on energy and in the effective carbon rate, and it should extend their coverage rather than continue to rank member states on a ratio whose movements it cannot interpret. Where the revenue ratio continues to be reported, it should be disaggregated and accompanied by the rate.

The conclusions are bounded by four limitations. The estimates are associations; no causal design is used, and reverse causality between consumption and revenue is not merely possible but is the mechanism the paper proposes, so the coefficients should not be read as effects of taxation in

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either direction. The renewable share is a composition measure that responds to instruments other than taxation, notably feed-in tariffs, capacity auctions and the trading system, none of which is observed here. The dynamic robustness check for energy intensity and emissions is reported qualitatively and rests on a fixed-effects estimator with a small-sample bias, and the pollution component could not be included in the dynamic renewable-share model because of its shorter panel. And the panel ends in 2023, so the fiscal response to the 2021–2022 price shock, which took the form of temporary excise reductions in several member states, is observed only in its first two years.

Three directions for further work follow from these limits. The first is to repeat the exercise on the implicit tax rate on energy where member-state coverage allows, which would test the base interpretation directly: under that interpretation, the rate should carry the negative sign that the revenue ratio does not. The second is to estimate the dynamic specification with the system generalised method of moments estimator of Blundell and Bond (1998), building on Arellano and Bond (1991), which would remove the Nickell bias at the cost of instrument proliferation in a panel of 27 units and would separate short-run from long-run associations formally. The third is to bring the trading system into the analysis alongside taxation, using the effective carbon rate as the treatment variable, so that the price signal is measured rather than inferred from the revenue it leaves behind. Each would move the question from what the indicator measures to what the policy does, which is the question the monitoring framework needs answered and the revenue ratio cannot answer.

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AUTHOR CONTRIBUTIONS

Conceptualisation, D.O.N.; methodology, D.O.N.; software, D.O.N.; formal analysis, D.O.N.; data curation, D.O.N.; writing, original draft, D.O.N.; writing, review and editing, D.O.N. The author has read and agreed to the published version of the manuscript.

DATA AVAILABILITY

The panel is assembled from publicly available sources: the Eurostat environmental tax accounts (dataset env_ac_tax), the Eurostat renewable energy statistics (dataset nrg_ind_ren) and the World Bank World Development Indicators (energy intensity level of primary energy, carbon dioxide emissions per capita, GDP per capita at purchasing power parity, trade as a percentage of GDP and urban population share). The assembled dataset, the estimation code and the full dynamic estimates for all three outcomes are available from the author on reasonable request.

DECLARATION OF INTEREST

The author declares no competing interests. The panel used here is also used, for a different research question, in a companion article published in the supplement to No. 73 of this journal (Nicolescu, 2026); the two articles do not share results.

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