Utrecht University

Evaluating the Impact of the CO_2 Performance Ladder in Public Procurement

Jihwan Ryu (j.ryu@uu.nl)
Prof. dr. ir. Fredo Schotanus (f.schotanus@uu.nl)
Dr. Vitezslav Titl (V.Titl@uu.nl)

Table of Contents

1 Introduction

Public procurement has the potential to drive sustainability and reduce environmental impact, as it accounts for about 15% of global greenhouse gas (GHG) emissions (Hildebrandt et al., 2022). As a policy tool, the CO_2 Performance Ladder (CO_2PL) is designed to incentivize firms to lower their CO_2 emissions while rewarding environmentally responsible practices in public procurement. Despite its growing adoption, the extent to which CO_2PL effectively drives environmental improvements through public procurement remains an open question.

This study addresses this question by combining municipal-level public procurement records with satellite-based CO_2 emissions data from the Open-Data Inventory for Anthropogenic Carbon dioxide (ODIAC). This data-driven approach enables a systematic assessment of the environmental impact of the CO_2PL, with particular attention to sectors where its effects are expected to be most significant.

This study is part of Work Package 7 (WP7), commissioned by SKAO and conducted by the Utrecht University Centre for Public Procurement (UUCePP). While previous evaluations have primarily examined the impact of the CO_2PL as a management system on businesses and municipalities, this report expands the scope to assess the effectiveness of the CO_2PL as a procurement tool, focusing on both the demand and supply sides of the market. WP7 seeks to address key research questions in collaboration with SKAO and other stakeholders. One of these questions is,

To what extent does the application of the CO_2Performance Ladder in public procurement lead to increased sustainability?

A key focus of this analysis is the public procurement of construction work tenders (CPV Division 45), as this sector is a major contributor to emissions. In the Netherlands, the construction industry is responsible for 50% of total resource consumption, 40% of total energy consumption, and 35% of CO_2 emissions (Government of the Netherlands, 2019). Additionally, within our public procurement dataset, 95% of works contracts are related to construction, representing an estimated 98% of the total value of works procurement. Given the construction sector's dominant presence in public procurement and its significant environmental impact, this study examines construction work tenders as a crucial domain for assessing the effectiveness of sustainability-driven procurement policies.

At the national level, the Netherlands has made measurable progress in reducing per capita emissions, aligning itself with broader European Union's efforts to transition toward sustainability. Figure 1 highlights the downward trend in per capita emissions in the Netherlands, positioning it favorably among comparable European countries. However, the comparison also highlights opportunities for further improvement. Countries such as Sweden and Denmark consistently report lower per capita emissions, indicating that the Netherlands may benefit from refining its sustainable procurement strategies to further accelerate emissions reductions.

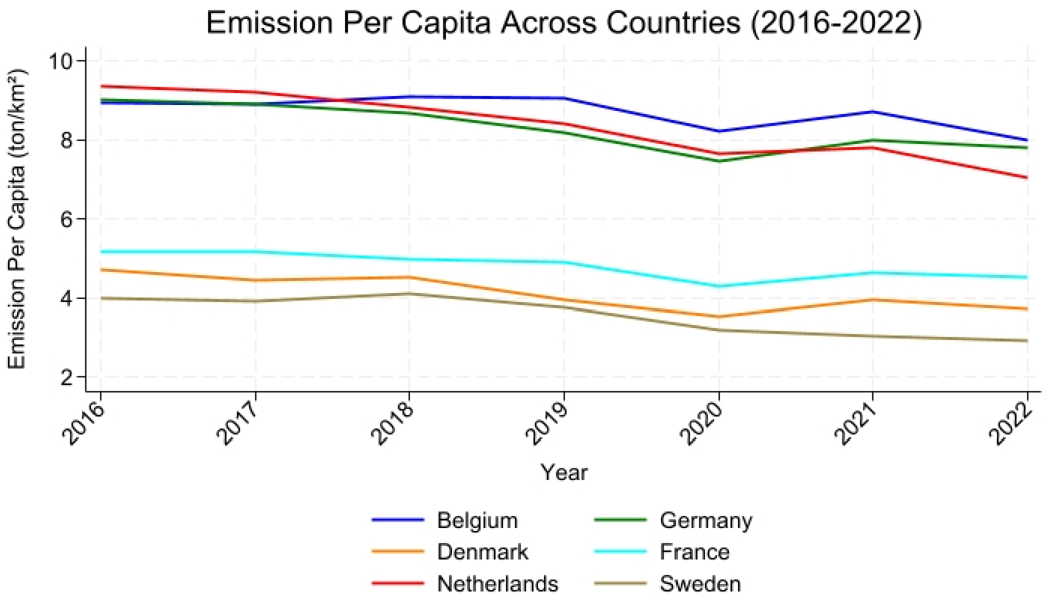

Figure 1: Emission per capita across countries (2016–2022)

The findings provide evidence-based insights to support SKAO's efforts in scaling the CO_2PL across Europe. By assessing the link between CO_2PL usage in public procurement and emissions reduction, this study offers input for understanding how sustainability certification may shape market behavior and environmental outcomes. However, it is important to recognize the limitations of the data and the scope of this analysis as we explain in more detail in later chapters.

While this report provides empirical insights into the potential role of CO_2PL in emissions reduction, further research is necessary to isolate its direct impact and to assess its effectiveness under different regulatory and economic conditions. These results should be interpreted as part of a broader discussion on sustainable public procurement rather than as definitive evidence of CO_2PL's causal effect on emissions.

The rest of this report is structured as follows: Chapter 2 analyzes municipal-level emission trends through a regression analysis using ODIAC satellite data. Chapter 3 presents additional suggestive evidence on the effectiveness of CO_2PL adoption, drawing on alternative model specifications. Finally, Chapter 4 presents the conclusions and policy recommendations derived from the study's findings.

2 Municipal-Level Analysis Using ODIAC Data

This section presents an analysis of the relationship between public procurement practices involving the CO_2PL and mean emissions at the municipal level. Emissions data are aggregated to the annual level for each municipality, leveraging the ODIAC fossil fuel emission dataset, which provides global CO_2 emissions estimates up to 2023 (Oda et al., 2018). Given that self-reported emissions data from municipalities are not standardized or directly comparable, we specifically use satellite-derived emissions data. The ODIAC dataset offers a high spatial resolution of 1 km × 1 km, enabling a more detailed and consistent comparison across municipalities.

ODIAC builds on national-level CO_2 emission estimates from the Carbon Dioxide Information Analysis Center (CDIAC), provided as the baseline. To produce 1 km × 1 km annual global grids, ODIAC applies a hybrid spatial allocation that assigns reported emissions from large point sources (e.g., fossil-fuel power plants) to their geolocated facilities and distributes the remaining emissions using satellite-observed nighttime lights (Oda et al., 2018; Oda and Maksyutov, 2025). The resulting dataset offers consistent coverage across urban and rural areas and has been extensively employed in atmospheric transport modeling, inversion studies, and policy-relevant analyses of emission patterns (Oda et al., 2018; Oda and Maksyutov, 2025; Chen et al., 2020).

To ensure comparability and relevance, municipalities where more than 40% of the land area falls within Natura 2000 protected zones, designated to protect Europe's most valuable and threatened habitats, are excluded. These areas are subject to strict environmental regulations and typically have lower anthropogenic emissions from construction or industrial activity, limiting the potential influence of CO_2PL-related procurement. After this exclusion, 185 municipalities remain in the sample, with 140 municipalities removed—105 of which have over 90% of their area designated as Natura 2000.

For public procurement data, we use tender records from TenderNed, the official Dutch procurement database. To identify contracts that explicitly reference the CO_2PL, we incorporate data from TenderGuide, which aggregates procurement information and flags tenders using relevant keywords[1]. While TenderGuide data is available from 2016 onward, we extend the coverage by conducting our own keyword-based search to identify CO_2PL references in tender documents dating back to 2012. However, only the TenderGuide dataset provides detailed information on how the CO_2PL was applied.

Our analysis focuses exclusively on the construction sector. To ensure that we capture local emission impacts, we restrict the sample to contracts that clearly specify the geographic location of the assignment. This means we exclude nationally scoped projects or those spanning multiple municipalities. Within this filtered construction dataset, we identify a total of 5,360 contracts, of which 1,191 explicitly mention the CO_2PL[1] .

[1] *The following search terms were used to identify CO_2PL mentions: CO_2-Prestatieladder, CO_2Prestatieladder, CO_2 Prestatieladder, CO_2 performance, CO_2-performance, CO_2PL, CO_2ladder, CO_2-Ladder, CO_2 Ladder, CO_2 ambitieniveau, CO_2-ambitieniveau, CO_2-bewust Certificaat, CO_2 bewust Certificaat, CO_2-bewustcertificaat, CO_2 bewustcertificaat.*

2.1 Correlation between procurement spending and emissions

To further validate the use of satellite-derived emissions data (ODIAC) and support the premise that public procurement in construction contributes meaningfully to local emissions, we examine the correlation between logged public procurement spending on construction and logged emissions. We replace zero values with missing before taking logs. This analysis includes only those contracts that specify the exact location of the assignment, ensuring a more accurate spatial match between procurement and emissions data.

Figure 2 shows a strong national-level correlation between total construction spending and emissions trends. However, to understand the robustness of this relationship across spatial units, we examine correlations at different geographic levels. The correlation coefficients (r) between logged total construction spending and logged emissions are as follows:

- National level: $r = 0.9090$
- Provincial (NUTS-2) level: $r = 0.7548$
- NUTS-3 level (40 regions): $r = 0.5659$
- Municipality level: $r = 0.3217$

While the correlation weakens at finer spatial resolutions, this is expected due to increased noise and confounding factors at the municipal level, such as spillovers from adjacent areas, unobserved emission sources, and potential mismatches in project location assignment (e.g., contracts implemented near municipal borders). Nevertheless, the correlation remains positive and notable even at the municipality level, supporting the validity of the emission data and its relevance for analyzing the impact of local procurement.

Nonetheless, the high correlations observed at higher aggregation levels provide strong support for the idea that construction-related procurement activity is closely linked to emission trends. This reinforces two key arguments: (1) satellite-based emission estimates are capturing real variation in local CO_2 output, and (2) public construction procurement plays a measurable role in shaping those emissions.

Figure 2: Logged total construction spending and emissions over time (national level)

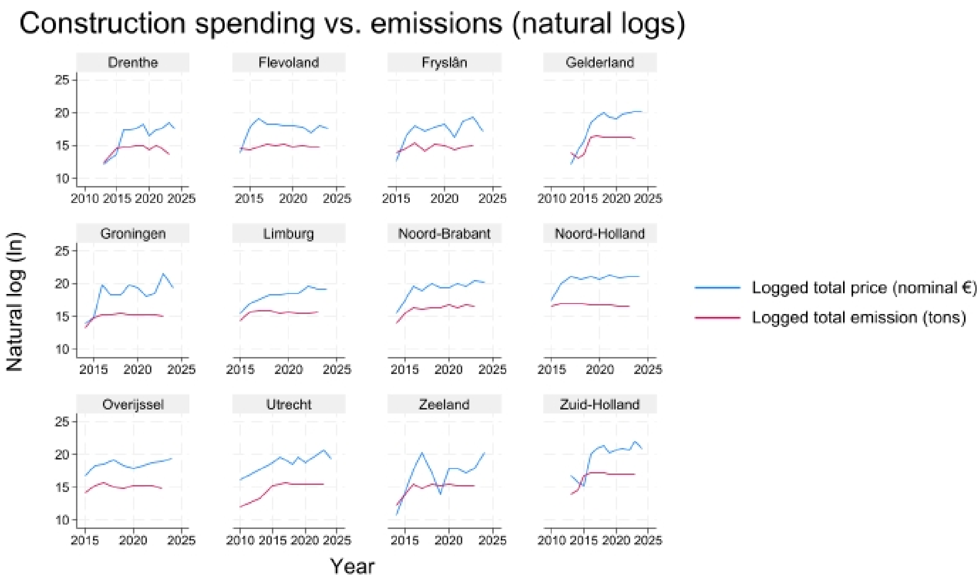

Figure 3: Logged total construction spending and emissions by province

Together, these findings suggest that despite the complexity of municipal-level dynamics, using satellite-based emissions data for evaluating the impact of CO2PL adoption remains a valid and informative approach.

2.2 Data aggregation and key variables

The analysis begins with calculating and aggregating key variables at the municipal level to capture procurement activities and emissions patterns. The following metrics were constructed:

- **Mean emissions:**
  - We calculated the mean annual CO_2 emissions per municipality, expressed in tons per square kilometer, using the ODIAC fossil fuel emission dataset. Emission values were winsorized at the 1% level to reduce the impact of extreme outliers.
- **Contracts that applied CO_2PL:**
  - For each municipality and year, we calculated the total contract value of tenders that explicitly applied the CO_2PL as part of the procurement procedure. A contract was classified as CO_2PL-applied if the CO_2PL was referenced either as a requirement or as part of the award criteria. Identification was based on keyword searches in tender documents, supplemented by metadata from TenderGuide, which flags tenders involving CO_2PL.
- **Certified firms:**
  - For each municipality and year, we calculated the total contract value awarded to firms certified at level 5. Because CO_2PL benefits can be granted based on a commitment to future certification, we classified a contract as awarded to a level 5-certified firm if all winning firms obtained level 5 certification within two years of the award. SKAO rules allow firms up to one year after award to demonstrate CO_2PL compliance, either at the organisational or project level. We therefore adopt a conservative two-year window when coding certification status, to ensure delayed compliance is properly captured. In cases with multiple winners, the contract was only counted as awarded to certified firms if *all* winners met this criterion.

    Our focus on level 5-certified firms is motivated by the fact that certification at levels 4 and 5 entails broader supply chain and sector-wide sustainability commitments, extending beyond a firm's internal operations. In practice, most firms obtain certification at either level 3 or level 5. In our dataset, 75% of certified firms were at level 5, 22% at level 3, and only 3% at level 4. Given their dominance in the sample and the more ambitious sustainability scope associated with level 5, our main analysis centers on these firms to better capture potential impacts on emissions.

- **Contracts with both CO_2PL and certified winners:**
  - We identified the total contract value of tenders that applied CO_2PL and were awarded to level 5-certified firms.

2.3 Proportional metrics

To standardize the data and enable comparative analysis across municipalities, the following proportional metrics were calculated:

- **Tenders that used CO_2PL:**
  - **Share of contract value using CO_2PL**: This captures the proportion of total municipal contract value associated with tenders that explicitly applied CO_2PL, either as an award criterion or as a requirement.
    Example: If a municipality issued €10 million in contracts and €3 million applied CO_2PL, the share would be 30%.
- **Certified firms winning contracts:**
  - **Share of contract value won by certified firms**: This measures the share of total contract spending allocated to level 5-certified firms. The exact amount received by each winner is not always available, especially in cases where multiple firms win a contract. The total contract price is divided by the number of winners to approximate the value awarded per firm. This per-firm contract value is then multiplied by the number of certified winners within the contract to estimate the total amount won by certified firms.
    Example: If a municipality awarded €5 million in contracts, and certified firms won €2 million of that, the proportion would be 40%.
- **Tenders that used CO_2PL and were won by certified firms:**
  - **Share of contract value for CO_2PL and certified firms**: This measures the proportion of total contract spending allocated to tenders that both applied CO_2PL criteria and were awarded to level 5-certified firms.
    Example: If the total contract spending in a municipality was €15 million, and €6 million went to tenders that both used CO_2PL and were won by level 5-certified firms, the proportion would be 40%.

2.4 Regression analysis

To assess the impact of CO_2PL adoption and certified firm participation on emissions outcomes, we conducted a fixed-effects panel regression analysis using mean emissions as the dependent variable. The key independent variables are the proportional metrics related to CO_2PL usage and certified firms, as defined in the previous section. Given that the environmental impact of green public procurement may not be immediate, we include up to three years of lags for each key variable to capture potential delayed associations. All models include municipality and year fixed effects, with the year variable corresponding to the year in which the contract was awarded. Robust standard errors clustered at the municipality level are used to correct for heteroskedasticity and autocorrelation.

Model Specification

The regression model takes the following form:

$$\text{Mean Emissions}_{i,t} = \beta_0 + \beta_1 X_{i,t-k} + \gamma_t + \delta Z_{i,t} + \alpha_i + \epsilon_{i,t}, \quad \text{for } k = 0, 1, 2, 3 \tag{1}$$

where:

- Lags $k = 1, 2, 3$ refer to calendar years relative to the award year t.
- Mean Emissions$_{i,t}$ is the average CO_2 emissions per square kilometer in municipality i at year t.
- $X_{i,t-k}$ is the key CO_2PL-related variable (e.g., value share of level 5-certified winners) lagged by k years.
- $Z_{i,t}$ is a vector of control variables.
- α_i represents municipality fixed effects, which control for unobserved time-invariant factors at the municipal level. In other words, the model removes constant differences between municipalities such as infrastructure, geographical factors, etc. This ensures that the analysis isolates the impact of time-varying factors, such as CO_2PL adoption.
- γ_t represents year fixed effects, which account for unobserved time-specific shocks that might influence emissions across all municipalities in a given year. These effects capture broader trends such as economic cycles, policy changes, technological advancements, or external environmental factors that could impact emissions across all municipalities in a given period.
- $\epsilon_{i,t}$ is the error term.

2.4.1 Regression results

Appendix 1.1 presents the results of the regression analysis without control variables, examining the relationship between CO_2PL adoption, certified firm participation, and emissions outcomes. However, CO_2 emissions are likely influenced by various other factors beyond procurement behavior. To account for these influences, we introduce a set of control variables that may affect average emissions at the municipal level.

Given that the dependent variable in our analysis is expressed as mean CO_2 emissions per square kilometer, all control variables are scaled accordingly by dividing them by the land area of each municipality (in km^2). This ensures consistency in units and better captures the intensity of energy use, population concentration, and economic activity per unit area—factors that may more directly influence localized emissions.

The regression results incorporating these controls are presented in Table 1. The following variables are included:

1. **Grid-based energy delivery per km^2** Data on grid-based energy delivery is sourced from the Dutch Central Bureau of Statistics (CBS). We use:
   - **Electricity supply per km^2 (1,000 kWh/km^2):** Annual electricity delivered via the national grid (TenneT and regional distributors), divided by the municipality's land area. This variable reflects the spatial intensity of electricity consumption.
   - **Natural gas supply per km^2 (1,000 m^3/km^2):** Annual natural gas delivered through the public grid (via GTS, Zebragas, and others), also divided by land area. This captures natural gas consumption intensity across sectors.
2. **Population density (inhabitants/km^2):**
   A direct measure of population per land area, which distinguishes between urban and rural municipalities and helps control for structural differences in emission sources.
3. **GDP per km^2 at the NUTS 3 level (million euros/km^2):**
   While GDP data is only available at the NUTS 3 level, we allocate this to municipalities and scale it by land area to reflect regional economic intensity, which may drive both energy consumption and emissions.

We interpret the results from the model with controls as our main specification, as it accounts for key drivers of municipal emissions. Below, we summarize the key findings:

- **Contract value share of certified firms is negatively associated with emissions**
  Our results indicate a statistically significant negative relationship between the contract value share awarded to level 5-certified firms and mean municipal CO_2 emissions. Specifically, a 1 percentage point increase in the value share of contracts awarded to level 5 firms is associated with a reduction of up to 1.64 tons/km^2 in emissions after two years ($p < 0.01$). This suggests that public procurement contracts awarded to firms with level 5 certification may contribute meaningfully to lowering local emissions. The findings provide empirical support for the idea that firms meeting higher certification standards adopt operational practices that reduce fossil-fuel-based emissions within the municipalities where their projects are carried out.

- **CO_2PL usage predicts short-term reductions, but effects are less robust than certification** Tenders that applied CO_2PL show a statistically significant reduction in emissions at the time of contract award (lag 0, $p < 0.05$), suggesting that procurement procedures incorporating sustainability criteria may play a role in curbing emissions. However, this effect is not consistently observed at longer lags, and its magnitude is less robust than the reductions associated with firm-level certification.

  Similarly, when we examine tenders that both applied CO_2PL and were awarded to level 5-certified firms, we find a significant negative effect at lag 0 ($p < 0.05$), but the impact does not persist beyond the year of award. This indicates that the emissions-reducing effect is likely driven primarily by the actions of certified firms, rather than the formal inclusion of CO_2PL in tender procedures.

  Variation in how CO_2PL is implemented, such as differences in ambition, enforcement, or whether it is used as an award criterion versus a requirement, may limit its effectiveness. Moreover, selection bias may be present if CO_2PL is more frequently applied to large or emission-intensive projects, which are inherently harder to decarbonize. These factors likely dilute the marginal effect of CO_2PL relative to firm-level certification.

- **Estimated associations are largest within two years post-award, consistent with typical project durations.**
  The emission reductions associated with certified firms are statistically significant up to two years after the contract award, aligning closely with the average project duration of approximately 1.5 years. Since emission-reducing measures, such as the use of cleaner equipment or improved waste management, are typically implemented during the execution phase, the observed effects appear to be concentrated within the project timeline.

This pattern suggests that certified firms likely make efforts to reduce emissions during project delivery. The fact that negative effects persist through the second year implies sustained reductions throughout the implementation phase, rather than one-off or symbolic actions.

The findings indicate that awarding a higher share of contract value to level 5-certified firms is significantly associated with lower CO_2 emissions at the municipal level, with the effect materializing primarily within two years after contract award. This suggests that certified firms are likely to adopt more emission-reducing practices during the execution phase of projects. We also find that tenders applying CO_2PL as part of the procurement process are associated with modest emission reductions, particularly around the time of contract award. However, these effects are less consistent and less persistent over time than those observed for certified firms.

Importantly, we do not observe additional reductions when CO_2PL application in tenders is combined with winners being certified at level 5. This may reflect variation in how CO_2PL is implemented across tenders—ranging from symbolic inclusion to binding criteria—or selection bias, as CO_2PL may be applied more frequently to complex projects where achieving reductions is more difficult. Overall, the results suggest that while procurement-level tools like CO_2PL can contribute to emission reductions, firm-level certification remains a more consistent driver of short-term local climate impact.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CO_2PL contract value share				Level 5 winner value share			
	Lag 0	Lag 1	Lag 2	Lag 3	Lag 0	Lag 1	Lag 2	Lag 3
Coefficient	-2.184*	-2.240	-1.616	-1.513	-1.441*	-1.714*	-1.613*	-0.172
T-statistic	(-2.19)	(-1.60)	(-1.71)	(-1.37)	(-2.31)	(-2.11)	(-1.98)	(-0.32)
Constant	14749.1***	22547.4***	18318.1***	17359.1***	15040.1***	22618.6***	18221.8***	17423.1***
T-statistic	(5.43)	(4.28)	(3.45)	(3.91)	(5.37)	(4.24)	(3.46)	(3.89)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	766	442	392	338	766	442	392	338

Table 1: Fixed-effects regression results examining the impact of CO_2PL adoption and firm certification on mean municipal emissions in construction tenders with controls

*Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

	(1)	(2)	(3)	(4)
	CO_2PL & Level 5 winner value share			
	Lag 0	Lag 1	Lag 2	Lag 3
Coefficient	-2.287*	-1.384	-1.098	-0.928
T-statistic	(-2.11)	(-1.66)	(-1.42)	(-1.07)
Constant	14766.1***	22510.2***	18325.6***	17433.3***
T-statistic	(5.38)	(4.25)	(3.45)	(3.91)
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	766	442	392	338

Table 2: Fixed-effects regression results examining the impact of CO_2PL adoption and firm certification on mean municipal emissions in construction tenders with controls

*Note: * $p < 0.05$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

3 Additional analyses and robustness checks

To assess the robustness and generalizability of the main results, this section presents a set of additional analyses. Specifically, we (1) consider all certification levels rather than focusing solely on level 5, (2) broaden the scope to include all types of public contracts beyond construction, (3) test an alternative sustainability indicator based on CO_2-related references, (4) explore heterogeneous effects based on municipal characteristics, and (5) provide a complementary validation using verified emissions from the EU ETS. These tests help assess the robustness and generalizability of the relationship between CO_2PL-related procurement practices and municipal emissions.

3.1 Incorporating all contract types

Thus far, the analysis has focused exclusively on works contracts, given their direct and measurable link to local emissions. However, public procurement encompasses a broader range of contract types, including services and supplies, which may exhibit different sustainability dynamics. To investigate whether the previously observed associations between CO_2PL adoption, firm certification, and emissions hold across all procurement categories, this section broadens the scope to include works, services, and supply contracts.

Because the geographic location of service and supply assignments is often less clearly defined than for works contracts, we use the contracting authority's location as a proxy for the project location in these cases. The extended sample comprises 70,758 contracts, of which 3,229 applied the CO_2PL. Full regression results are reported in Appendix 1.2.

A key observation from this extended sample is that only 4.6% of contracts applied CO_2PL criteria, compared to 22.2% within the construction sector. When all contract types are included, the previously observed negative relationship between CO_2PL adoption and emissions is no longer statistically significant across specifications.

This result highlights the sector-specific nature of CO_2PL's environmental impact. The certification may be associated with emission reductions within the construction sector, where activities such as on-site operations, material transport, and energy use lead to immediate and localized emissions. In contrast, for service and supply contracts, where emissions are often diffuse, indirect, or occur outside the municipality, the environmental benefits of CO_2PL are less visible or absent.

These findings suggest that the environmental benefits of sustainable procurement initiatives like the CO_2PL are most readily observed in sectors with substantial and traceable emissions footprints.

Different methodological approaches may be required to accurately assess environmental impacts across diverse sectors.

3.2 Including all CO_2PL certification levels

We rerun the regression using all certified firms, not just those certified at level 5, to examine whether certification level influences the relationship between procurement variables and emissions outcomes. This alternative specification is presented in 1.3.The results show that the effects are smaller in magnitude and less consistent.

Specifically, we find a statistically significant negative relationship only at lag 2 for the value share of contracts awarded to certified firms, and at lag 0 for contracts that both applied CO_2PL and were awarded to certified firms. In all other periods, the effects are statistically insignificant.

These findings suggest that the certification level may play an important role. Firms certified at level 5 appear to drive stronger emissions reductions, likely due to more ambitious sustainability practices. Lower certification levels may involve less stringent requirements or weaker implementation, resulting in smaller or negligible environmental impacts. This reinforces the interpretation that certification level reflects meaningful differences in firm behavior and sustainability commitment, rather than serving as a symbolic designation.

3.3 Alternative sustainable procurement indicator

To further evaluate the robustness of our results and isolate the unique contribution of CO_2PL, we compare it against more generic references to sustainability by including contracts that mention CO_2 reduction or emission reduction without adopting CO_2PL. In this specification, we introduce two additional variables: the share of total contract value for tenders that explicitly mention CO_2 or emission reduction but do not use CO_2PL, and the share of such tenders awarded to level 5-certified firms.

Among the 5,360 contracts in the work sector sample, 626 (11.7%) contain CO_2-related references. Across all 70,758 contracts in the full dataset, 6,271 (8.9%) reference CO_2 reduction or emission reduction. All models follow the main fixed-effects setup with municipality and year fixed effects, controls, and up to three annual lags.

Appendix 1.4 presents the regression results. Overall, coefficients are mostly positive and statistically insignificant, indicating no evidence that CO_2-referencing contracts, whether or not awarded to certified firms, reduce local emissions. In fact, for lag 2, the coefficient for CO_2-referencing contract value share is significantly positive: a one percentage point increase in this share is associated with a 1.98 ton/km^2 increase in emissions two years after award. When running the same regression not only on work sectors but on all contract types, we likewise find no negative relationship between CO_2-referencing contract value share and local emissions (results in Appendix 9).

These findings suggest that merely referencing environmental goals in procurement is not sufficient to drive emission reductions. Structured, verifiable schemes such as the CO_2PL may be more effective in producing measurable local environmental benefits.

3.4 Heterogeneous effects by municipal characteristics

To assess whether the environmental impacts of CO_2PL-related procurement depend on local conditions, we extend the baseline regressions by interacting the main procurement variables with two municipal characteristics: population density and baseline emission levels. This approach allows us to test whether the estimated effects differ across low-, medium-, and high-density areas, as well as between municipalities with above- and below-average emissions. The corresponding results are reported in Appendix 1.5.

For the population density analysis, municipalities are classified into three groups based on residents per km^2. The results show that statistically significant negative effects, particularly for the CO_2PL contract value share and for contracts that both applied CO_2PL and were awarded to Level 5-certified firms, are concentrated in high-density municipalities. This pattern suggests that emission-reducing procurement practices have a greater measurable impact where economic activities, including construction, are spatially concentrated.

For the baseline emissions analysis, municipalities are categorized according to whether their 2010 emissions were above or below the national average. Here too, significant negative effects of CO_2PL contract value share and the combined CO_2PL × Level 5 winner value share are found almost exclusively in above-average emission municipalities.

Taken together, these heterogeneous effect results indicate that CO_2PL-related procurement is most effective in dense, high-emission municipalities, where targeted contracting can yield immediate and measurable reductions in local emissions.

3.5 Validation with EU ETS data

While our primary analysis evaluates municipal-level emissions using satellite data, we complement this with a validation exercise using firm- and installation-level data from the EU Emissions Trading System (EU ETS), which covers major emitters across Europe. We link Dutch installations to firms active in public procurement and/or holding CO_2PL certification. The analysis, presented in Appendix 1.6, indicates that tender-winning firms are among the largest emitters in the EU ETS registry and tend to emit well above their allocated allowances. In contrast, CO_2PL-certified firms appear somewhat closer to compliance with their allocations, suggesting relatively greater emissions efficiency compared to non-certified peers. Although constrained by small sample sizes and sectoral heterogeneity, these findings should be viewed as preliminary and complementary to the municipal-level satellite analysis.

4 Conclusion and Recommendations

4.1 Conclusion

This report examines the role of the CO_2PL in reducing emissions through public procurement. At the municipal level, it combines satellite-based emissions data with detailed procurement records to assess how contract characteristics—particularly CO_2PL adoption and the certification status of winning firms—relate to local environmental outcomes. The municipal analysis focuses on the construction sector in 185 municipalities, excluding those where more than 40% of the land is designated as Natura 2000 protected habitats, which are subject to strict environmental regulations and generally have limited anthropogenic emissions.

We find that, in the main regressions without interaction terms, the contract value share awarded to Level 5-certified firms, the highest certification level, is more consistently and strongly associated with lower municipal emissions than CO_2PL adoption alone. Where statistically significant, the estimated associations persist for one to two years after contract award, consistent with typical construction timelines. The strength of this association varies by certification level. When all certification levels are included, the estimated effects weaken, whereas Level 5 contracts produce the most consistent and substantial reductions. In the heterogeneous effect regressions with interactions, the largest effects are observed for the value share of contracts that applied CO_2PL, especially when those contracts were awarded to Level 5-certified firms. These heterogeneous effects are most pronounced in dense, high-emission municipalities, suggesting that targeted procurement in such contexts can deliver the greatest environmental gains.

By contrast, contracts that merely reference CO_2 reduction without adopting CO_2PL show no consistent link to lower emissions. Similarly, expanding the scope beyond construction to include service and supply contracts produces no consistent negative effects and, in some cases, positive associations with emissions, highlighting the sector-specific nature of CO_2PL's effectiveness. While construction procurement tends to have a direct and localized emissions impact, other sectors often have more diffuse or indirect effects.

Although these findings provide meaningful insights, they do not establish causality. Emissions are influenced by broader economic, technological, and policy factors, and the study is constrained by data limitations, including the municipal emissions series ending in 2023 and limited EU ETS coverage for firm-level emissions.

If the estimated associations hold, a 10 percentage-point increase in the value share of construction contracts awarded to Level 5-certified firms corresponds to an estimated reduction of approximately 0.31 million tons of CO_2 in the award year, 0.37 million tons in the following year, and 0.34 million tons in the second year after the award. Given that total CO_2 emissions in the Netherlands in 2022 were 121.5 million tons, these reductions represent roughly 0.25-0.30% of national emissions. At the 2023 average EU ETS auction price of €73.27 per ton (nea, 2025), this translates into potential market benefits of about €23-27 million per year[1]. Because not all emissions are likely local, and emissions occurring outside the municipality are not captured in our measurements, the actual benefits are probably larger.

Overall, the findings indicate that prioritizing highly certified contractors, particularly Level 5, and applying CO_2PL in dense, high-emission municipalities can be an effective strategy for achieving measurable, local environmental gains. Future research should extend the time frame, refine sector-specific emissions measures, and explore causal mechanisms to strengthen the evidence base for sustainable procurement policy.

---

[1] *These estimates are based on the regression coefficients reported in Table 1, scaled to reflect a 10 percentage-point increase in the contract value share awarded to Level 5-certified winners, and multiplied by the total land area of the 185 municipalities included in our sample ($A = 21{,}387.25$ km^2). Formally,*

$$\Delta\text{Emissions}_{t+k} = A \times 10 \times \hat{\beta}_k.$$

For the Level 5 winner value share specification ($\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2$ = -1.441, -1.714, -1.613), the implied annual changes are:

$$\Delta\text{Emissions}_{t} = -308{,}190 \text{ tCO}_2$$
$$\Delta\text{Emissions}_{t+1} = -366{,}577 \text{ tCO}_2$$
$$\Delta\text{Emissions}_{t+2} = -344{,}976 \text{ tCO}_2$$

4.1.1 Recommendations

To build on the findings and maximize the impact of the CO_2PL, the following recommendations are proposed:

1) **Prioritize higher certification levels in procurement decisions**
   Evidence shows that contracts awarded to firms certified at Level 5 are more consistently and strongly associated with local emission reductions than CO_2PL adoption alone. Procurement policies should encourage or incentivize higher certification levels, particularly for projects in high-impact sectors such as construction.

2) **Target procurement efforts in high-emission, densely populated municipalities**
   The largest local emission reductions were observed in municipalities with high baseline emissions and greater population density. Directing CO_2PL-based procurement toward these areas could maximize local environmental benefits.

3) **Integrate lag effects into policy evaluation and planning**
   Significant effects on emissions often emerged one to two years after contract award, reflecting typical construction timelines. Policy monitoring frameworks should incorporate these lags when assessing the effectiveness of the CO_2PL or similar instruments.

4) **Continuous monitoring and cost–benefit assessment:** Implement longitudinal evaluations to systematically compare emission reductions achieved under CO_2PL-certified contracts with those of other CO_2-related procurement practices. Complement these with *ex ante* cost–benefit analyses that quantify expected emission reductions alongside compliance costs, administrative burdens, and potential effects on price and competition. Such assessments help determine whether environmental benefits outweigh the additional costs and provide guidance on how to optimize the design and application of the CO_2PL.

Bibliography

Chen, J., Zhao, F., Zeng, N., and Oda, T. (2020). Comparing a global high-resolution downscaled fossil fuel co2 emission dataset to local inventory-based estimates over 14 global cities. *Carbon Balance and Management*, 15(1):9.

EU ETS INFO (2024). Eu ets data download. Available at: https://www.euets.info/download.

Government of the Netherlands (2019). Circular construction economy: Transition agenda. Available at: https://www.government.nl/topics/circular-economy/accelerating-the-transition-to-a-circular-economy.

Hildebrandt, J., Brende, B., and Sicars, S. (2022). Green public procurement: Catalysing the net zero economy. In *World Economic Forum*.

nea (2025). Tarieven co-heffing industrie. Available at: https://www.emissieautoriteit.nl/onderwerpen/co2-heffing/tarieven-co2-heffing.

Oda, T. and Maksyutov, S. (2025). Odiac fossil fuel co emissions dataset (odiac2024). Center for Global Environmental Research, National Institute for Environmental Studies (NIES), Japan. Available at: https://db.cger.nies.go.jp/dataset/ODIAC/DL_odiac2023.html.

Oda, T., Maksyutov, S., and Andres, R. J. (2018). The open-source data inventory for anthropogenic co 2, version 2016 (odiac2016): a global monthly fossil fuel co 2 gridded emissions data product for tracer transport simulations and surface flux inversions. *Earth System Science Data*, 10(1):87–107.

1 Appendix

1.1 Regression results without controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CO_2PL contract value share				Level 5 winner value share			
	Lag 0	Lag 1	Lag 2	Lag 3	Lag 0	Lag 1	Lag 2	Lag 3
Coefficient	-2.112	-1.052	-1.710	-3.183	-1.434*	-1.451	-1.776*	-2.274*
T-statistic	(-1.79)	(-0.66)	(-1.44)	(-1.91)	(-2.37)	(-1.81)	(-2.33)	(-2.07)
Constant	7819.9***	8924.9***	8313.7***	7771.5***	8020.2***	9027.3***	8367.0***	7781.3***
T-statistic	(148.70)	(20.77)	(16.74)	(34.88)	(147.81)	(19.83)	(15.94)	(35.06)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	No	No	No	No	No	No	No
Observations	831	481	426	360	831	481	426	360

Table 3: Fixed-effects regression results examining the impact of CO_2PL adoption and firm certification on mean municipal emissions in construction tenders

*Note: * $p < 0.05$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

	(1)	(2)	(3)	(4)
	CO_2PL & Level 5 winner value share			
	Lag 0	Lag 1	Lag 2	Lag 3
Coefficient	-2.572*	-0.558	-1.403	-4.020*
T-statistic	(-2.19)	(-0.65)	(-1.47)	(-2.15)
Constant	7793.2***	8914.3***	8308.5***	7764.3***
T-statistic	(141.80)	(20.92)	(16.80)	(34.15)
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Controls	No	No	No	No
Observations	831	481	426	360

Table 4: Fixed-effects regression results examining the impact of CO_2PL adoption and firm certification on mean municipal emissions in construction tenders

*Note: * $p < 0.05$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

1.2 Regression results for all types of contracts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CO_2PL contract value share				Level 5 winner value share			
	Lag 0	Lag 1	Lag 2	Lag 3	Lag 0	Lag 1	Lag 2	Lag 3
Coefficient	-1.163	-0.963	-1.700	-0.441	-0.404	0.072	-0.882	-0.253
T-statistic	(-1.42)	(-1.40)	(-1.68)	(-0.90)	(-0.93)	(0.22)	(-1.71)	(-0.65)
Constant	11581.6***	10833.8***	11282.7***	12199.5***	11632.6***	10830.9***	11296.9***	12193.4***
T-statistic	(6.12)	(6.31)	(6.00)	(5.25)	(6.15)	(6.30)	(5.99)	(5.24)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1380	1127	978	851	1380	1127	978	851

Table 5: Fixed-effects regression results examining the impact of CO_2PL adoption and firm certification on mean municipal emissions in all types of tenders with controls

*Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

	(1)	(2)	(3)	(4)
	CO_2PL & Level 5 winner value share			
	Lag 0	Lag 1	Lag 2	Lag 3
Coefficient	-1.446	-0.595	-1.874	-0.339
T-statistic	(-1.32)	(-0.89)	(-1.61)	(-0.64)
Constant	11597.3***	10836.6***	11305.8***	12200.4***
T-statistic	(6.12)	(6.30)	(6.02)	(5.24)
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	1380	1127	978	851

Table 6: Fixed-effects regression results examining the impact of CO_2PL adoption and firm certification on mean municipal emissions in all types of tenders with controls

*Note: * $p < 0.05$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

1.3 Regression results using all certified firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Certified winner value share				CO_2PL & Certified winner value share			
	Lag 0	Lag 1	Lag 2	Lag 3	Lag 0	Lag 1	Lag 2	Lag 3
Coefficient	-1.134	-1.511	-1.541*	-0.791	-2.0561*	-1.378	-1.063	-1.510
T-statistic	(-1.75)	(-1.95)	(-2.02)	(-1.20)	(-2.06)	(-1.62)	(-1.42)	(-1.48)
Constant	15013.5***	22521.8***	18201.2***	17452.1***	14780.5***	22502.8***	18320.7***	17403.2***
T-statistic	(5.37)	(4.23)	(3.44)	(3.90)	(5.36)	(4.25)	(3.45)	(3.93)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	766	442	392	338	766	442	392	338

Table 7: Fixed-effects regression results examining the impact of CO_2PL adoption and firm certification at all levels on mean municipal emissions in construction tenders with controls

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. *T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

1.4 Regression results comparing CO_2PL contracts and other CO_2-referencing contracts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CO_2-referencing contract value share				CO_2 referencing contract & Level 5 winner value share			
	Lag 0	Lag 1	Lag 2	Lag 3	Lag 0	Lag 1	Lag 2	Lag 3
Coefficient	0.202	0.198	1.982*	-0.903	0.428	-0.167	2.321	0.175
T-statistic	(0.22)	(0.16)	(2.24)	(-0.55)	(0.46)	(-0.15)	(1.42)	(0.10)
Constant	14889.0***	22420.3***	18342.9***	17390.9***	14887.4***	22414.3***	18378.9***	17421.8***
T-statistic	(5.31)	(4.23)	(3.45)	(3.87)	(5.31)	(4.24)	(3.45)	(3.88)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	766	442	392	338	766	442	392	338

Table 8: Fixed-effects regression results examining the impact of CO_2-referencing contracts and firm certification on mean municipal emissions in construction tenders with controls

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. *T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CO_2-referencing contract value share				CO_2-referencing contract & Level 5 winner value share			
	Lag 0	Lag 1	Lag 2	Lag 3	Lag 0	Lag 1	Lag 2	Lag 3
Coefficient	0.945	1.188*	0.486	0.0704	1.164	1.160	-0.625	-0.844
T-statistic	(1.29)	(2.06)	(0.97)	(0.15)	(1.94)	(1.68)	(-1.01)	(-1.33)
Constant	11613.1***	10841.0***	11281.4***	12185.0***	11588.1***	10831.2***	11287.2***	12189.5***
T-statistic	(6.14)	(6.32)	(5.97)	(5.24)	(6.11)	(6.30)	(5.97)	(5.24)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1380	1127	978	851	1380	1127	978	851

Table 9: Fixed-effects regression results examining the impact of CO_2-referencing contracts and firm certification on mean municipal emissions in all types of tenders with controls

*Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

1.5 Regression results for heterogeneous effects

1.5.1 CO_2PL contract value share × Population density

	(1)	(2)	(3)	(4)
	CO_2PL contract value share × population density			
	Lag 0	Lag 1	Lag 2	Lag 3
Sparse × CO_2PL value share	0.520	2.607	1.339	2.448
T-statistic	(0.71)	(1.68)	(0.98)	(1.95)
Mid dense × CO_2PL share	-1.339	-2.214	-0.989	-3.154
T-statistic	(-1.30)	(-1.28)	(-0.65)	(-1.91)
Dense × CO_2PL share	-10.11*	-12.53*	-10.22**	-10.66*
T-statistic	(-2.11)	(-2.06)	(-2.76)	(-2.20)
Constant	5067.0***	7382.3***	6196.2***	5924.2***
T-statistic	(6.34)	(10.69)	(8.09)	(7.18)
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	766	442	392	338

Table 10: Fixed-effects regression results for the effect of CO_2PL adoption on mean municipal emissions, with interactions for population density in construction tenders with controls

*Note: * $p < 0.05$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

1.5.2 *Level 5 winner value share × Population density*

	(1)	(2)	(3)	(4)
	Level 5 winner value share × population density			
	Lag 0	Lag 1	Lag 2	Lag 3
Sparse × Level 5 winner value share	-0.683	-0.638	-0.110	2.743*
T-statistic	(-1.00)	(-0.41)	(-0.06)	(2.27)
Mid dense × Level 5 winner value share	0.038	1.073	-0.759	-3.400*
T-statistic	(0.04)	(0.56)	(-0.41)	(-2.39)
Dense × Level 5 winner value share	-1.860	-2.653	-4.581	-5.187*
T-statistic	(-0.93)	(-1.16)	(-1.67)	(-2.58)
Constant	5852.2***	7402.9***	6401.8***	5732.9***
T-statistic	(10.20)	(10.17)	(7.25)	(6.82)
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	766	442	392	338

Table 11: Fixed-effects regression results for the effect of Level 5 winner value share on mean municipal emissions, with interactions for population density in construction tenders with controls

*Note: * $p < 0.05$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

1.5.3 CO_2PL & Level 5 × population density

	(1)	(2)	(3)	(4)
	CO_2PL & Level 5 × population density			
	Lag 0	Lag 1	Lag 2	Lag 3
Sparse × CO_2PL & Level 5	0.234	1.171	1.225	2.903*
T-statistic	(0.29)	(0.70)	(0.76)	(2.15)
Mid dense × CO_2PL & Level 5	-1.332	-0.297	-1.022	-3.579*
T-statistic	(-1.20)	(-0.15)	(-0.57)	(-2.02)
Dense × CO_2PL & Level 5	-8.415	-6.805*	-6.952*	-8.171*
T-statistic	(-1.94)	(-2.00)	(-2.54)	(-2.00)
Constant	5194.9***	7336.1***	6164.8***	6020.3***
T-statistic	(6.96)	(10.25)	(7.76)	(7.03)
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	766	442	392	338

Table 12: Fixed-effects regression results for the effect of CO_2PL × Level 5 value share on mean municipal emissions, with interactions for population density in construction tenders with controls

*Note: * $p < 0.05$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

1.5.4 *CO_2PL contract value share × above emission*

	(1)	(2)	(3)	(4)
	CO_2PL contract value share × above emission			
	Lag 0	Lag 1	Lag 2	Lag 3
Below-average × CO_2PL share	-0.339	0.347	1.094*	0.126
T-statistic	(-0.97)	(0.70)	(2.22)	(0.25)
Above-average × CO_2PL share	-10.36*	-14.29	-13.46**	-8.329
T-statistic	(-2.33)	(-1.86)	(-3.28)	(-1.70)
Constant	13852.6***	22122.9***	18056.7***	17157.6***
T-statistic	(5.95)	(4.65)	(3.46)	(4.06)
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	766	442	392	338

Table 13: Fixed-effects regression results for the effect of CO_2PL contract value share on mean municipal emissions, comparing above- and below-average emission municipalities, in construction tenders with controls

*Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

1.5.5 *Level 5 winner value share × above emission*

	(1)	(2)	(3)	(4)
	Level 5 winner value share × above emission			
	Lag 0	Lag 1	Lag 2	Lag 3
Below-average × Level 5 winner share	-0.526	-0.335	0.425	0.660
T-statistic	(-1.88)	(-0.76)	(0.78)	(1.38)
Above-average × Level 5 winner share	-4.275	-4.801	-7.216*	-3.470
T-statistic	(-1.70)	(-1.91)	(-2.58)	(-1.93)
Constant	15122.8***	22795.4***	18390.0***	17405.3***
T-statistic	(5.41)	(4.20)	(3.58)	(3.92)
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	766	442	392	338

Table 14: Fixed-effects regression results for the effect of Level 5 winner value share on mean municipal emissions, comparing above- and below-average emission municipalities, in construction tenders with controls

*Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

1.5.6 CO_2PL & Level 5 × above emission

	(1)	(2)	(3)	(4)
	CO_2PL & Level 5 × above emission			
	Lag 0	Lag 1	Lag 2	Lag 3
Below-average × CO_2PL & Level 5	-0.474	0.220	1.206*	0.151
T-statistic	(-1.28)	(0.44)	(2.18)	(0.26)
Above-average × CO_2PL & Level 5	-9.851*	-8.715*	-10.87***	-5.153
T-statistic	(-2.14)	(-2.00)	(-3.46)	(-1.47)
Constant	14098.2***	22620.7***	18431.4***	17493.0***
T-statistic	(5.62)	(4.31)	(3.55)	(4.01)
Year FE	Yes	Yes	Yes	Yes
Municipality FE	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	766	442	392	338

Table 15: Fixed-effects regression results for the effect of CO_2PL × Level 5 winner value share on mean municipal emissions, comparing above- and below-average emission municipalities, in construction tenders with controls

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. *T-statistics in parentheses. Dependent variable: mean CO_2 emissions/km^2 (winsorized at 99%).*

1.6 Emission Analysis From EU ETS Data

To assess the impact of the CO_2PL on emissions at the firm/installation level, we utilize emissions data from the EU Emissions Trading System (EU ETS). The dataset used in this study is available online EU ETS INFO (2024). The EU ETS provides verified CO_2 emissions data for installations regulated under the EU's cap-and-trade system, making it one of the most comprehensive datasets for tracking industrial GHG emissions. The system covers a wide range of sectors, including power plants, aviation, and manufacturing, across EU member states. Additionally, the dataset includes firm-level identifiers, allowing for an analysis of emissions at the corporate level.

1.6.1 Data preparation and merging

To analyze the impact of CO_2PL certification on emissions, this study integrates EU ETS emissions data with public procurement records. Using firm-level account information from the EU ETS dataset, we matched installations to firms that have either participated in public procurement tenders, acquired CO_2PL certification, or both.

Since emission data is reported at the installation level, we aggregated emissions at the firm level to facilitate direct comparisons between companies. Specifically, for each firm, we calculated its total verified emissions by summing the emissions from all installations associated with that firm. This approach allows us to measure emissions at the corporate level, ensuring consistency in comparisons across firms that may own multiple installations.

Due to the limited number of installations in the dataset and the relatively small number of firms transacting with these installations, it was not feasible to categorize firms by sector. Instead, this study includes all types of firms, regardless of industry affiliation, to ensure a sufficient sample size for analysis. While the remainder of the study focuses on public construction work tenders, this analysis is not strictly limited to the construction sector.

To facilitate a structured comparison of emissions performance, firms were classified into four distinct categories based on their procurement and certification status:

- **Ever won tender firms**: Firms that have won public procurement tenders but have never obtained CO_2PL certification. Since the dataset only records contract winners rather than all participants, we can only confirm that these firms have successfully secured at least one contract (**37 firms**).
- **Ever certified firms**: Firms that have obtained CO_2PL certification but have never won public procurement tenders. Notably, all but one of these firms were certified at level 5 (**17 firms**).
- **Ever won tender and ever certified firms**: Firms that have both won public procurement tenders and obtained CO_2PL certification. This firm was also certified at level 5 (**4 firm**).
- **Non-participants**: Firms that have neither won public procurement tenders nor obtained CO_2PL certification (**361 firms**).

1.6.2 Calculating emission trends

To account for variations in installation size, where larger installations inherently emit more regardless of certification status, we developed a metric called *over-emissions* ratio. This metric adjusts for installation size and emissions efficiency, providing a fair basis for comparison across firms.

The *over-emissions* metric is defined as the ratio of the verified emissions (the actual reported emissions) to the allocated emissions (the emissions cap or allowance granted to an installation). For example, if a company is allocated 100,000 tCO_2e but its verified emissions amount to 150,000 tCO_2e, the over-emissions ratio would be 1.5. This ratio reflects the operational efficiency of installations relative to their allowance:

- A ratio greater than 1 indicates that an installation emits **more** than its allocated allowance, suggesting inefficiency.
- A ratio less than 1 indicates that an installation emits **less** than its allocated allowance, suggesting efficiency.

1.6.3 Summary statistics and emissions trends

The summary statistics for firms across the four categories are presented in Table 16. These statistics provide an overview of key variables, including the number of firms (N), total allocated emissions, verified emissions, total assets, operating revenue, and *over-emissions* ratio. All emissions-related figures are expressed in metric tons of CO_2 equivalent (tCO_2e), while financial variables are expressed in thousands of euros (€000s).

Certified Won tender	No Yes	Yes No	Yes Yes	No No
Allocated total (tCO_2e)	448,052	2,407	2,565	140,883
Verified (tCO_2e)	717,046	3,828	4,483	205,681
Total assets (€000s)	1,198,131	9,489	18,480	318,014
Operating revenue (€000s)	1,739,405	29,976	68,002	359,147
over-emissions	2.25	1.60	1.83	1.56
N	37	17	4	361

Table 16: Summary statistics for firms across four categories

From Table 16, it is evident that firms categorized as *Won tender but not certified* exhibit the highest *over-emissions* ratio at 2.25, meaning they emit more than twice their allocated emissions allowances on average. These firms also display the highest levels of allocated emissions and financial metrics, suggesting that firms involved in public procurement tend to be larger in size. In comparison, firms in the *Certified but never won tender* (1.60) and *Won tender and certified* (1.83) categories exhibit relatively lower over-emission ratios, indicating comparatively greater emissions efficiency.

Interestingly, firms in the *Neither certified nor won tender* group that neither participated in public procurement nor obtained certification have the lowest *over-emissions* ratio at 1.56. This observation raises two possible explanations. First, firms engaged in public procurement may inherently operate in high-emission industries. However, the sectoral composition across groups complicates this explanation. In the *Won tender but not certified* group, the dominant sectors are manufacturing (32%), electricity and gas (18%), and social work services (16%). The *Certified but never won tender* group is even more concentrated in manufacturing (70%), while the *Certified and won tender* group includes firms predominantly in construction (75%). Meanwhile, the *Neither certified nor won tender* group includes a share of firms in manufacturing (39%), agriculture, forestry, and fishing (16%), and financial and insurance activities (12%). Given this distribution, it is not evident that the higher *over-emissions* ratios among firms engaged in procurement are driven solely by sectoral composition, as high-emission industries are also well represented among non-certified firms. Nevertheless, given the small sample sizes, it is difficult to determine whether the observed differences are driven by certification, winning tenders, or other characteristics of the firms involved.

Another possible explanation is that firms participating in public procurement may operate less energy efficiently than those that do not. However, certified firms, which are more likely to engage in public procurement, demonstrate better emissions efficiency, suggesting that certification may help mitigate excessive emissions. Alternatively, energy-efficient firms may self-select into certification because they are already more efficient. Given current data limitations, it remains unclear whether the elevated emissions observed among tender-winning firms are primarily a result of sectoral composition or operational inefficiencies. Disentangling these drivers requires further investigation. Nonetheless, the analysis highlights the relevance of green public procurement—and particularly the use of instruments like the CO_2 Performance Ladder—as firms that win tenders are among the highest emitters within the EU ETS registry.

Future research should aim to expand the dataset and explore more detailed sectoral breakdowns to better understand how certification interacts with procurement participation in influencing emissions. Additionally, investigating causal mechanisms and controlling for firm-level characteristics would help clarify whether CO_2PL certification directly improves emissions efficiency. While the trends in this analysis provide some preliminary insights, they should not be interpreted as definitive evidence of certification effectiveness.