Environmental criteria and clauses in public procurement: theory and evidence on their effects on bidder participation

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Preliminary version, please do not quote

Abstract

Many governments worldwide use public procurement as an environmental policy instrument through the inclusion of green clauses and award criteria. Green clauses consist of mandatory standards governing contract performance, which set a minimum level of environmental quality that bidders must meet. By contrast, green award criteria incorporate sustainability into bid evaluation, thereby introducing a trade-off between price and quality. At first glance, green clauses and criteria may reduce firm participation in procurement procedures by requiring specific technologies and increasing participation costs. This concern echoes a broader issue regarding the declining attractiveness of public procurement and the resulting weak competition. The purpose of this article is to evaluate the impact of green clauses and green award criteria on firm participation in public procurement from both theoretical and empirical perspectives. From a theoretical standpoint, we show that green clauses and criteria have a dual effect on participation: while they may exclude some firms and raise participation costs, they also increase the expected profit margin of the winning bidder. We test the predictions of our theoretical model using a dataset of 50,000 award procedures in France. Our empirical results reveal a moderate but positive effect of both green clauses and green criteria on participation, despite substantial sectoral heterogeneity. Therefore, the growing integration of sustainability considerations into public procurement is unlikely to be responsible for the observed decline in competition for public contracts.

Keywords: public procurement; green public procurement; competition; participation; auctions

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1 Introduction

Public procurement refers to all the contracts through which public institutions purchase supplies, services, and works from private suppliers. Due to its significant weight on GDPs and public spending, governments and international organizations pay close attention to competition in the award of public contracts. Low competition in public procurement can result in higher prices, poor quality, and corruption, thus degrading public services. The issue of the level of effective competition in public procurement procedures in Europe recently came to the fore. The special report 28/2023 of the European Court of Auditors points out that over the last decade, competition for public contracts has decreased. It concludes:

> "[...] key goals of the EU's 2014 reform to ensure competition [...] have not been met and that some of the objectives may even reduce competition. We recommend clarify and prioritize public procurement objectives, close the gaps in the public procurement data collected, improve its monitoring tools to allow better analysis, deepen the root cause analysis and put forward an action plan to overcome key obstacles to competition in public procurement."

This issue echoes a similar assessment in the US (Kang and Miller, 2022). Identifying the underlying causes of this observed decline in firm participation is crucial. It may be due to stronger corruption practices (Fazekas et al., 2016) or an increased complexity of award procedures that follow diverse public policy goals. Indeed, contracting authorities often have multiple objectives to pursue. They are responsible for achieving various strategic goals while efficiently managing public funds. In particular, public procurement must be aligned with sustainable development practices, with environmental considerations of utmost importance.

In France, green procurement practices are gaining momentum. Following the *Climat et Résilience* law of 2021, by August 2026, all public procurement contracts will be required to consider environmental issues by integrating at least one green clause *and* one green award criterion. Green clauses can be defined as mandatory provisions related to environmental issues in contract performance. For example, when purchasing cars, contracting authorities can require vehicles to be electric. In contrast, green award criteria partly base the scoring of each bid on the environmental characteristics of the latter. For example, 20% of the score assigned to each offer can be based on the carbon emissions of the vehicles. In this second situation, offering electric vehicles is not mandatory, but it will be rewarded in the scoring of the bid, as electric cars have a better carbon footprint. Therefore, green clauses consist of a minimum environmental quality that bids must satisfy, while green criteria reward the environmental characteristics of the bids through a trade-off between price and quality.

The implementation of environmental clauses and criteria is probably not neutral with respect to firm participation. Indeed, they can increase participation costs and tend to select firms based on their environmental innovation. Most empirical studies identify moderate negative impacts of green clauses and criteria on participation, in particular Vigren (2018) for bus contracts in Sweden and Carreras (2023) for Spanish public procurement contracts. In France, Arve and Desrieux (2024) find a negative effect of green award criteria on participation when focusing on municipal procurement. Other works identify ambivalent – but limited – impacts of green criteria and clauses on supplier behavior. Based on 337 procurement auctions for cleaning services in Sweden, Lundberg et al. (2015) and Drake et al. (2024) do not find a clear effect of green clauses on participation.

In this paper, we reexamine the links between participation and green clauses and criteria for two reasons. First, although some firms may not participate due to specific requirements on green technologies and higher participation costs, we show under an endogenous entry perspective that green clauses and criteria can have a stimulating impact on the effective number of bidders. The actual effect of green clauses and criteria on participation therefore depends on the respective magnitude of these two opposite effects. Second, we can test this theoretical prediction with data covering 50,000 award procedures in France between 2022 and 2023. Compared to previous empirical analysis, this dataset is more recent (in contrast to Lundberg et al., 2012; Carreras, 2023), larger (as it covers all types of contracting authorities and industries, unlike Vigren, 2018; Arve and Desrieux, 2024), and more comprehensive, since it includes both clauses and criteria (contrary to Carreras, 2023; Arve and Desrieux, 2024).

We find robust evidence of an overall – but moderate – stimulating effect of green clauses on firm participation in French public procurement. Green award criteria also have a stimulating impact on

the number of bidders when their weight is less than 30%. However, we identify sectoral heterogeneity in the effect of green clauses and criteria on participation. Although green clauses seem to have a detrimental effect on participation in medical supplies, environmental criteria can reduce the number of bidders in construction works for extreme weights. Green clauses also have a stimulating impact on participation in environmental services. Interestingly, environmental clauses and criteria do not have the same effects as those related to social, delay, and technical aspects of the bids.

The remainder of the paper is structured as follows. In Section 2, we present a theoretical framework that analyzes participation with multi-dimensional bids and endogenous entry. In Section 3, we describe the empirical economic method of this paper and the sample we use to test the theoretical model. Section 4 describes the empirical results. We discuss the latter and their potential implications of the results for public policies in Section 5.

2 Theoretical insights

The literature has determined the optimal procedures for awarding procurement contracts when price and quality matter (Che, 1993; Asker and Cantillon, 2010). It has essentially considered environments in which, on the one hand, quality is observable and verifiable, and on the other hand the buyer is able to describe her preferences in terms of price-quality trade-offs. In this context, comparing the commonly used procedures, Asker and Cantillon (2008) show that scoring auctions dominate price-only auctions with minimum quality thresholds. Che (1993) shows that even a "naive"scoring auction, where the scoring of quality dimension reveals the buyer's preferences – although it is not optimal –, performs no worse than price-only auction where quality is fixed.

However, the superiority of scoring auctions is based on assumptions that are rarely verified in practice. First, public buyers do not necessarily fully reveal their preferences, as they typically announce the criteria and their weights only. For instance, in France, the fully specified scoring rule – how the quality measure and the price are transformed into a single score – is often not disclosed. Second, price and quality are not always (perfectly) substitutable, depending on the nature and technical complexity of public contracts (Estache and Iimi, 2009). As stressed by Bergman and Lundberg (2013), the downside of the flexibility of a scoring auction is that the quality level is not known ex ante. Therefore, if it is of critical importance to reach a minimum quality, it is better to use a first-price auction with a minimum quality threshold. Third, the comparison of procedures is carried out under the assumption that the number of participating firms is exogenous. However, a firm's decision to submit a bid can vary from one procedure to another, depending, for example, on the cost of participation (e.g. preparing a bid) and/or on the presence of a clause imposing a specific level of quality that only a few firms can provide (Estache and Iimi, 2009).

In order to analyze the impact of – endogenous – participation of firms on the expected cost of a contract, the literature has first considered contracts in which the price is the sole award criterion. Then, two extreme cases have been considered: one in which bidders have perfect information about their costs before deciding to enter (Samuelson, 1985; Menezes and Monteiro, 2000), and the other in which bidders learn their cost after they have made the decision to enter the auction (Levin and Smith, 1994). One key result of this literature (Samuelson, 1985) is that – contrary to models with an exogenous number of bidders – expected costs do not necessarily decline when the number of bidders increases. In other words, this means that increasing firm participation does not always benefit the public purchaser. The intuition behind this result is as follows: when firms incur participation costs (e.g. to prepare their bids), the number of firms that actually submit a bid decreases. However, only the most efficient firms submit a bid, and knowing this, they submit more aggressive bids than they would have done in the absence of participation costs. Consequently, the effect of the reduction in the number of bids may – or may not – be offset by the more aggressive nature of these bids.

The literature has also recently analyzed the endogenous entry of firms when a procurement contract is awarded on price and quality criteria. As pointed out by Estache and Iimi (2009), there are two reasons for a firm not to participate: the cost of entry (or participation cost, e.g. the cost of preparing a bid) and the minimum quality threshold that can be used by the public buyer as an instrument to modulate the level of participation. In the context of our study, participation costs and quality thresholds do not concern green clauses and criteria identically. First, green criteria significantly increase participation costs, since firms must detail the technology they want to implement. They sometimes have to carry out assessments and produce original information, for example, to provide a

carbon footprint. In contrast, firms must comply with green clauses when implementing the contract to avoid penalties, but they require little effort from firms at the application stage. Second, no firm is directly prevented from participating due to environmental criteria. Clauses are mandatory and not incentivizing, thus possibly reducing the pool of eligible candidates among potential applicants, while criteria keep the number of potential applicants unchanged. Although these remarks may imply that green clauses and criteria are bound to have a detrimental effect on participation, in an endogenous entry perspective, environmental quality can also affect the margin of the awarded firm, therefore potentially raising participation.

To clarify the potential relationship between the number of bidders and the potential use of green clauses and criteria, we consider – as Menezes and Monteiro (2000) – that companies possess private knowledge of the cost of carrying out the contract before participation. This assumption seems appropriate for most public procurement contracts. Then, they decide to participate in the contract, weighting the cost of participation against the expected benefits.

As Che (1993), let us denote $V(q)$ as the surplus generated by the fact that the contract is carried out with a level of environmental quality q. This quality is assumed to be observable and verifiable. We assume that $V'(.) > 0, V''(.) < 0$, $\lim_{q\to 0} V'(q) = +\infty$, and $\lim_{q\to+\infty} V'(q) = 0$. The last two assumptions ensure an interior solution. Then, when the public buyer pays a price p, its utility derived from a contract (q, p) equals $V(q) - p$. Let us consider that n risk neutral firms $i = 1, ..., n$ are potentially bidding for the contract. According to the assumption of independent private value, the bidder i knows her own efficiency parameter θ_i but only knows the distribution $F(\theta_j), \forall j \neq i$, of the other bidder's efficiency. It is assumed that these parameters are drawn independently from the continuous distribution F with support $[\underline{\theta}, \overline{\theta}]$ and density $f = F' > 0$. For a given level of environmental quality q, the production cost of the firm i for the contract is $c(\theta_i, q)$, where $c_{\theta_i} > 0$ and $c_q > 0$. $\kappa > 0$ refers[1] to the participation cost. Given its efficiency parameter and the production and participation costs, each firm decides whether or not to submit a bid (it pays κ if it does) without knowing how many firms will submit bids.

In what follows, we will successively analyze procedures that include environmental clauses and those that include environmental criteria. In the first case, the clause is modeled as a minimum level of environmental performance that all bidders must provide. In the second case, companies submit two-dimensional bids (price and level of environmental performance) and a scoring function is used to compare these offers.

2.1 Public procurement with environmental clause

In a procurement contract with an environmental clause, the public buyer defines a minimum level of environmental performance that all candidate companies must provide. Since public contract performance typically occurs shortly after the award decision, firms do not have time to innovate, so they cannot extend the range of technologies they can implement. Therefore, some firms may not be eligible for the award of the contract if they cannot implement the level of environmental performance required by the green clause. In the presence of a green clause, the pool of eligible candidates can therefore be smaller than the pool of potential candidates in the absence of such a clause.

Given this requirement, we can derive the optimal bidding strategy, $b(.)$, of eligible firms, following a reasoning similar to Menezes and Monteiro (2000) when they derive the optimal bidding strategy in a first-price sealed-bid auction where the only criterion is the price and where the winner is the highest bidder. To do so, let us suppose a cutoff value $\tilde{\theta}$ such that bidder j participates if and only if $\theta_j \leq \tilde{\theta}$. If bidder i bids b_i and bidder j bids $b_j = b(\theta_j)$, $\forall j \neq i$, then i does not win if and only if there is a bidder j with $\theta_j < b^{-1}(b_i)$. Thus, the expected profit of the firm i, with efficiency parameter θ_i, bidding b_i when all other firms use a bidding function b, can be written as

$$E\pi(\theta_i) = (b_i - c(\theta_i, q)) \left[1 - F\left(\min\left(b^{-1}(b_i), \tilde{\theta}\right)\right)\right]^{n-1} - \kappa. \tag{1}$$

Let us consider symmetric strategies. Let us assume that $E\pi(\tilde{\theta}) = 0$. Following standard manipulations, we can show[2] that the optimal bidding strategy of firm i is

[1] We assume that $\kappa > 0$ is not too large to guarantee the participation of at least one bidder. This assumption will be clarified later.

[2] See Appendix A.1 for a proof.

$$b(\theta_i) = c(\theta_i, q) + \frac{\kappa}{(1-F(\theta_i))^{n-1}} + \frac{\int_{\theta_i}^{\tilde{\theta}} \left(\frac{\partial c(\theta,q)}{\partial \theta}\right)(1-F(\theta))^{n-1} d\theta}{(1-F(\theta_i))^{n-1}} \quad \text{if} \quad \theta_i < \tilde{\theta}. \tag{2}$$

If $\theta_i > \tilde{\theta}$, then the firm i does not participate.

Following Menezes and Monteiro (2000), the threshold value $\tilde{\theta}$ is implicitly defined as the solution of $E\pi(\tilde{\theta}) = 0$, since a firm with parameter $\tilde{\theta}$ is indifferent between participating or not. Then, we have

$$\big(b(\tilde{\theta}) - c(\tilde{\theta}, q)\big)\big(1 - F(\tilde{\theta})\big)^{n-1} - \kappa = 0. \tag{3}$$

Note that a firm with the parameter $\tilde{\theta}$ can only win the contract if it is the sole supplier. Then, it is optimal for this firm to submit a bid equal to the maximum acceptable one, which is equal to $c(\overline{\theta}, q)$. Substituting this value into (3) yields

$$\big(c(\overline{\theta}, q) - c(\tilde{\theta}, q)\big)\big(1 - F(\tilde{\theta})\big)^{n-1} - \kappa = 0. \tag{4}$$

In order to derive an explicit formula, let us consider in the sequel that $c(\theta_i, q) = \theta_i q^2$ and F are uniform on $[1, 2]$. Under these assumptions, it can be easily shown that

$$\tilde{\theta} = 2 - \left(\frac{\kappa}{q^2}\right)^{\frac{1}{n}}. \tag{5}$$

Note that in our example, to have $\tilde{\theta} \in [1, 2]$, we must have $\kappa < q^2$. Otherwise, no firms will participate.

Focusing first on the influence of participation costs on effective participation (denoted $\tilde{\theta}$), we can compute

$$\frac{\partial \tilde{\theta}}{\partial \kappa} = -\frac{\left(\frac{\kappa}{q^2}\right)^{\frac{1}{n}}}{n\kappa} < 0.$$

Thus, the more expensive it is to prepare a bid in an award procedure, the lower the expected level of participation, which is quite intuitive.

Analyzing now the impact of the level of potential competition (i.e. n) on the level of effective competition, we have

$$\frac{\partial \tilde{\theta}}{\partial n} = \frac{\left(\frac{\kappa}{q^2}\right)^{\frac{1}{n}} \log(\frac{\kappa}{q^2})}{n^2} < 0 \text{ since } \kappa < q^2.$$

Thus, increasing the level of potential bidders, e.g. via a longer advertising period, decreases the level of effective competition. This result, which is the same as Menezes and Monteiro (2000), can be easily interpreted. When n increases, the margin of a bidder in the event of a win decreases, making the entry less profitable. However, the public buyer may be better off with this decline in participation. Indeed, the remaining bidders are the most cost-effective. Knowing that they are competing with other cost-effective bidders, it is optimal for them to reduce their margin to win. Therefore, the exclusion of some potential candidates through a green clause increases the propensity of the candidates to participate, irrespective of the level of environmental quality.

When evaluating the impact of an increase in the requested environmental quality level on effective participation, we have

$$\frac{\partial \tilde{\theta}}{\partial q} = \frac{2}{nq}\left(\frac{\kappa}{q^2}\right)^{\frac{1}{n}} > 0.$$

Thus, under our specifications, we have the following prediction:

Prediction 1. *For a given number of eligible candidates, requiring a higher level of quality via an environmental clause in a public procurement contract increases the level of participation.*

Intuitively, the result of Prediction 1 may seem counterintuitive since some firms are preventing from participating due to environmental requirements. However, we show that the margin of the awarded firm can be higher, making the entry more profitable. Therefore, the implementation of a green clause increases the actual number of participants if the incentive to participate among eligible firms through a higher expected margin is stronger than the reduction of the number of potential candidates.

2.2 Public procurement with environmental criteria

When the contract includes an environmental criterion, the difference from the clause case is that each firm now chooses the quality level when submitting its bid. There is no minimum quality level to reach. As analyzed by Che (1993), we consider that the public buyer uses a first score auction in which each competing firm (which pays κ) transmits a bid (q, p) and gets a score $S(q, p) = V(q) - p$. Following Che (1993), the firm i chooses a level of quality $q(\theta_i) = \arg max\, V(q) - c(\theta_i, q)$.

Using the same developments as for the previous case allows us to determine the level of firm participation. That is, a firm with parameter $\hat{\theta}$, is indifferent to participating (with a bid $b(\hat{\theta})$) or not if

$$\big(b(\hat{\theta}) - c(\hat{\theta}, q(\hat{\theta}))\big)\big(1 - F(\hat{\theta})\big)^{n-1} - \kappa = 0. \tag{6}$$

Note that a company with the parameter $\hat{\theta}$ can only win the contract if it is the sole supplier. Then, it is optimal for this firm to transmit a bid equal to the maximal acceptable one. The question arises of determining the maximal acceptable bid. Following the same reasoning as for the environmental clause, the highest possible cost would be $c(\overline{\theta}, q(\hat{\theta}))$.

Substituting this bid into (6) yields

$$\big(c(\overline{\theta}, q(\hat{\theta}) - c(\hat{\theta}, q(\hat{\theta}))\big)\big(1 - F(\hat{\theta})\big)^{n-1} - \kappa = 0. \tag{7}$$

Following the same developments as for the previous section, the optimal bidding strategy of firm i under an environmental criterion is

$$b(\theta_i) = c(\theta_i, q(\theta_i)) + \frac{\kappa}{(1 - F(\theta_i))^{n-1}} + \frac{\int_{\theta_i}^{\hat{\theta}} \left(\frac{\partial c(\theta, q(\theta))}{\partial \theta}\right)(1 - F(\theta))^{n-1} d\theta}{(1 - F(\theta_i))^{n-1}} \quad \text{if} \quad \theta_i < \hat{\theta}, \tag{8}$$

where $\hat{\theta}$ solves equation (7). If $\theta_i > \hat{\theta}$, then the firm i does not participate.

Under the environmental criterion, recall that each firm i chooses a level of quality $q(\theta_i) = \arg max\, V(q) - c(\theta_i, q)$. If $V(q) = \lambda q$, we can compute $q(\theta_i) = \frac{\lambda}{2\theta_i}$ and, from (7), $\hat{\theta}$ is the solution of

$$\frac{\lambda^2}{4\hat{\theta}^2}(2 - \hat{\theta})^n - \kappa = 0. \tag{9}$$

The relationship between the level of potential participation and the level of effective participation is also the same as for the clause since we can show[3] that $\frac{\partial \hat{\theta}}{\partial n} < 0$.

Finally, focusing on the influence on the quality weighting, we can show[4] that $\frac{\partial \hat{\theta}}{\lambda} > 0$. In this scenario, environmental criteria necessarily have a positive effect on the effective participation, as they increase the margin of the awarded firm while letting any candidate participate, unlike green clauses. However, as under green clauses, we can show[5] that $\frac{\partial \hat{\theta}}{\partial \kappa} < 0$. In other words, the more expensive it is to participate in a public procurement contract with an environmental criterion, the lower the expected level of participation. Concurrently, green criteria can increase participation costs by requiring companies to provide buyers with certain information about their technologies, which can be costly to obtain and report. Prediction 2 therefore stresses the stimulating effect of green criteria on participation only if the entry cost remains unchanged.

Prediction 2. *For a given level of participation costs, the higher the quality weighting, the greater the effective participation.*

In practice, the implementation of a green criterion actually increases the level of participation if the positive effect of green criteria on the expected margin offsets the negative impact of additional entry costs on participation.

3 Empirical analysis

In this section, we describe the empirical framework of this paper. After detailing the econometric method – based on a robust count model –, we introduce the sample and the variable it contains.

[3] See Appendix A.2 for a proof.
[4] See Appendix A.2 for a proof.
[5] See Appendix A.2 for a proof.

3.1 Econometric issues

As this paper focuses on participation, we use the number of bids as an outcome variable. We therefore need a count model that is robust to zero-truncation, uneven representation of contracting authorities, sectoral diversity, and treatment endogeneity.

The outcome variable – the number of participants in an award procedure – is a count variable. Consequently, we cannot use an ordinary least method to assess the determinants of the level of participation. Linear models cannot be used as they consider that any value is possible, even decimal numbers.

Although Poisson regression is the traditional way to deal with count variables, it rests on the assumption that $E[Y \mid X] = \mu$ and $Var(Y \mid X) = \mu$. The data may breach this condition by being overdispered – i.e. $E[Y \mid X] < Var(Y \mid X)$ –, so we use negative binomial regressions. They act as a generalization of Poisson regressions by considering that $Var(Y \mid X) = \mu + \alpha\mu^2$. If we find that α is significantly different from 0, then the data features overdispersion, and opting for a negative binomial regression rather than a simple Poisson regression is relevant.

Finally, since we only observe awarded contracts, the sample cannot contain null outcome values by definition. The estimators may be biased if we estimate $P(Y = y \mid Y \geq 0, X)$ rather than $P(Y = y \mid Y > 0, X) = \frac{P(Y=y|X)}{1-P(Y=0|X)}$. Thus, we will use a truncated negative binomial regression.

Let Y_i denote the number of offers for contract i. The expected count is modeled as:

$$\begin{aligned} \mathbb{E}[Y_i \mid Y_i > 0, \mathbf{X}_i] \;&=\; \frac{\exp(\eta_i)}{1 - \Pr(Y_i = 0 \mid \mathbf{X}_i)}, \\ \eta_i &= \beta_0 + \beta_1 \text{Clause}_i + \beta_2 \text{Criterion}_i + \mathbf{X}_i'\boldsymbol{\gamma}, \end{aligned} \tag{10}$$

where $\mathbf{X}_i$ is a vector of contract characteristics.

As the size of the contracting authorities is heterogeneous, some may be overrepresented in the sample. Since we do not want the estimates to reflect the features of the most represented public buyers at the expense of smaller ones, we weight each observation by the inverse of the occurrence frequency of the corresponding contracting authority.

Public procurement encompasses miscellaneous sectors in construction works, services, and supplies. One may think that sectoral fixed effects are sufficient to address the diversity of industries found in the sample. However, there are too many sectors to implement precise sectoral fixed effects. Considering the large number of industries found in the sample and the potential heterogeneity in the competitive impact of green clauses and criteria across sectors, we use multilevel truncated negative binomial regressions.

Let $s[i]$ denote the industry to which observation i belongs. We allow the conditional mean of the number of bids to shift by a sector-specific term, following a random effect $b_{s[i]}$:

$$\begin{aligned} Y_i \mid Y_i > 0, \mathbf{X}_i, b_{s[i]} &\sim \text{TruncNegBin}\big(\mu_{i|s},\, \alpha\big)\,, \\ \mu_{i|s} &= \frac{\exp\big(\eta_i + b_{s[i]}\big)}{1 - \Pr(Y_i = 0 \mid \mathbf{X}_i, b_{s[i]})}, \\ \eta_i &= \beta_0 + \beta_1\, \text{Clause}_i + \beta_2\, \text{Criterion}_i + \mathbf{X}_i'\boldsymbol{\gamma}, \\ b_s &\sim \mathcal{N}(0, \sigma_b^2). \end{aligned} \tag{11}$$

To further address potential endogeneity in the adoption of green clauses and criteria, we complement the analysis with *double-robust* (D.R.) estimators (Robins et al., 1994). In our setting, the inclusion of a green clause and the inclusion of a green award criterion are the two treatments. Since public buyers who adopt these instruments may systematically differ from those who do not, simple comparisons of average outcomes can be biased. The inclusion of green clauses and criteria probably does not act as a random event.

The D.R. approach combines two strategies for bias correction. First, we estimate the probability of treatment conditional on contract characteristics (i.e. propensity scores) using a multinomial logit model. These probabilities are used to reweight the sample using inverse probability weighting, so that the distribution of covariates is balanced across treatment groups. Second, we model the outcome conditional on treatments and covariates. The D.R. estimator then integrates the two components,

generating consistent estimates of treatment effects if the propensity score model *or* the outcome model is correctly specified.

Formally, let $D_i \in \{0, 1, 2, 3\}$ denote the treatment status of contract i, where 0 indicates no green consideration, 1 a green clause only, 2 a green criterion only, and 3 both. Let

$$m^d(X_i) = \mathbb{E}\big[Y_i \mid D_i = d, X_i, Y_i > 0\big]$$

denote the (conditional, truncated) expected number of offers under treatment d given characteristics X_i, and let $\hat{m}^d(X_i)$ be its estimate from a truncated negative binomial regression. Let $\hat{p}_d(X_i) = \widehat{\Pr}(D_i = d \mid X_i)$ denote the estimated (multinomial) propensity scores. The doubly-robust estimator for the average potential outcome under treatment d is

$$\hat{\mu}_d = \frac{1}{n} \sum_{i=1}^{n} \left[\frac{\mathbb{T}\{D_i = d\}}{\hat{p}_d(X_i)} \big(Y_i - \hat{m}^d(X_i)\big) + \hat{m}^d(X_i) \right],$$

with

$$\mathbb{T}\{D_i = d\} = \begin{cases} 1, & \text{if } D_i = d, \\ 0, & \text{otherwise.} \end{cases}$$

Subject to standard identification assumptions (consistency, unconfoundedness given X, and positivity $p_d(X) > 0$).

We then multiply the inverse-probability weights by the sampling weights (Pfeffermann, 1993; Ridgeway et al., 2015) and normalize the sum to the sample size. This construction ensures "double-robustness": consistency requires only one of the two models (the treatment model or the outcome model) to be correctly specified. In practice, this offers additional protection against misspecification when estimating the impact of green clauses and criteria.

3.2 Data

The empirical analysis will be based on the dataset *BeauAMP* (Deschamps and Potin, 2025), which centralizes and enhances the content of the award notices published in the official journal for public procurement in France (*BOAMP*). We analyze 52,510 observations from 20,341 public contracts awarded in mainland France between January 2022 and December 2023. Each observation corresponds to a contract lot (or a non-allotted contract). On average, a contract is therefore roughly subdivided into 2.6 lots.

The sample focuses on public contracts that were open to competition under the open procedure. We focus on this procedure because it is the most common by far, and other procedures allow the contracting authority to choose the number and the identity of the candidates, which does not match with our theoretical framework. We only keep the lots for which the required information is available to conduct the empirical approach as described in the previous subsection. We exclude the few lots for which more than ten offers are mentioned. Although some lots actually attract more than ten offers, we believe it is preferable to exclude them to avoid outliers resulting from input mistakes. In addition, participation is not a sensitive issue for contracts that already receive such a high number of bids.

47% of the observations in the sample correspond to services, while 37% are supplies, and 15% are works contracts. As the distinction between works, services, and supplies is not precise enough, we use the categorical variable *Sector*, which refers to the Common Procurement Vocabulary (CPV) code of the lot. The CPV is a 9-digit code that standardizes the matter of public contracts in the European Union. It provides a very useful ventilation of sectors in public procurement. Table 10 in Appendix B describes the main features of each CPV division (i.e. the first two digits of the CPV code). Not surprisingly, construction works are the most frequent contracts, followed by environmental services, as they include waste water and garbage collection, and medical equipment.

Offers is a count variable that indicates the number of offers received by the contracting authority for a given lot. Figure 1 illustrates the distribution of the number of offers in the sample. As mentioned in Table 1, the average number of offers is around 3, but Table 10 in Appendix B highlights the variability of the number of offers depending on the sector. Engineering services seem to be the sector with the highest average number of offers (over 4), and mining products the one with the lowest number of offers (around 1.7).

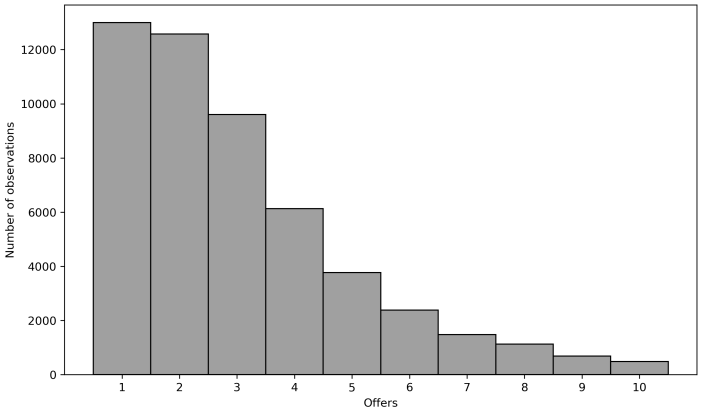

Figure 1: Distribution of the number of offers

	Offers	*G_weight*	*P_weight*
count	52510	52510	52510
mean	3.04	3.42	48.13
std	2.02	7.59	14.88
min	1	0	0
25%	1	0	40
50%	3	0	44.44
75%	4	5	60
max	10	90	100

Table 1: Description of continuous variables

The dummy variable *G_clause* indicates whether the considered lot includes an environmental clause (1) or not (0). As highlighted by Table 2, 28% of the lots in the sample include an environmental clause. Unfortunately, we do not have details on the content of the clauses, as the *BOAMP* website only mentions their presence.

	G_clause	*G_criterion*	*Allotment*	*Framework*
False	0.72	0.73	0.22	0.47
True	0.28	0.27	0.78	0.53

Table 2: Description of binary variables

Similarly, *G_criterion* is a dummy variable indicating the presence of an award criterion related to environmental matters in the award procedure[6]. 27% of the observations in the sample include a green award criterion. Figure 2 shows that there is little sectoral specialization between green clauses and green criteria: there is a quasi-linear relationship between the proportion of contracts with green clauses and green criteria in a given industry. If we omit the few observations for gas and oil, the sector where green clauses and criteria are integrated the most is the supply of agriculture and fishing products, while financial services and insurance seem to be the least favorable industry for implementing green public procurement.

We standardize award criteria weights from 0 to 100. A null value implies that the corresponding dimension is not integrated in the assessment of the offers, while a weight equal to 100 suggests that only this dimension is considered. *G_weight* refers to the weight assigned to the potential environmental criterion in the scoring of each received offer. If there is no green criterion, *G_weight* = 0. The

[6]We use the following keywords in the description of the original award criteria to characterize environmental criteria: “ENVIRONNEM”, “ENVIRONEM”, “ECOLO”, “ÉCOLO”, “ÉCOSYST”, “ECOSYST”, “ÉCO-SYST”, “ECO-SYST”, “RECYCL”, “RECICL”, “SOUTENABI”, “DURAB”, “CLIMAT”, “CARBO”, “DUREE DE VIE”, “DURÉE DE VIE”.

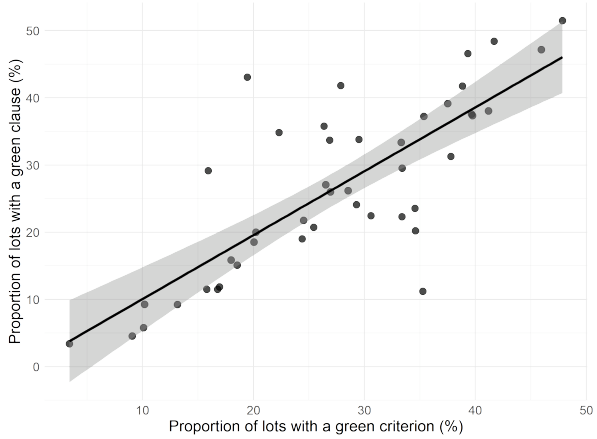

Figure 2: Scatter plot of green clauses and criteria by CPV division

average weight of environmental matters in the assessment of offers is 3,43%, which implies that when a green criterion is used, its average weight is approximately 12.25%. In contrast, *P_weight* refers to the weight of the bid value in the evaluation of the offers. This variable controls for the importance of quality-related criteria in general in the scoring of the bids. To avoid a correlation between *G_weight* and *P_weight*, we use the ratio of the weight assigned to the bid value and the sum of the weights assigned to all quality-related criteria, except those related to environmental matters. Figure 3 plots the distribution of the weight assigned to environmental and price-related award criteria. When implemented, the most frequent weight of environmental criteria is 10% of the score, while we observe a significant share of lots where environmental criteria account for 5% of the score. The bid value typically accounts for 30 to 70% of the score.

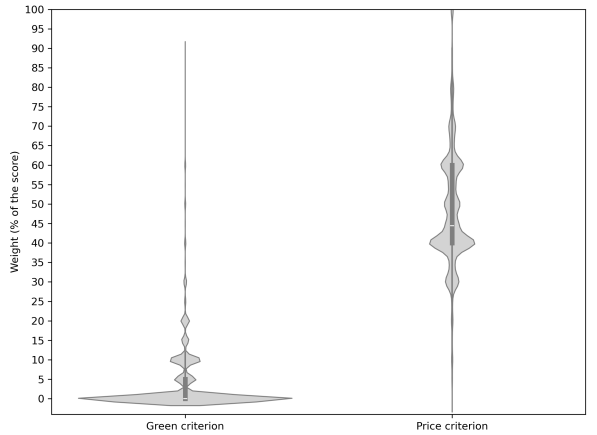

Figure 3: Distribution of award criteria weights

Allotment is a dummy variable that indicates whether the observation belongs to a subdivided contract or not. Allotment may increase the number of offers, as the different lots in a contract have strong similarities. It may generate economies of scale for potential candidates. However, allotment may also make the contract content more specialized, thus reducing the number of participants. 78% of the observations belong to allotted contracts.

Framework is a dummy variable that indicates whether the lot belongs to a framework agreement. Framework agreements are contracts that organize the execution of new contracts in the future with the awarded company. This kind of agreement represents half the contracts in the sample. They may be a strong incentive to participate as they lead to recurrent transactions.

We categorize the contracting authorities into six groups in the variable *Status*. As highlighted by Figure 5, municipalities are the most represented in the sample, before local agencies, municipal

federations, *departements*, *regions*, and state institutions. The latter implement green public procurement the most (58% of their lots include a green clause or criterion), while local agencies integrate green considerations in 37% of the observations. The status of contracting authorities can influence the number of offers through procurement resources, management, and proximity to local suppliers.

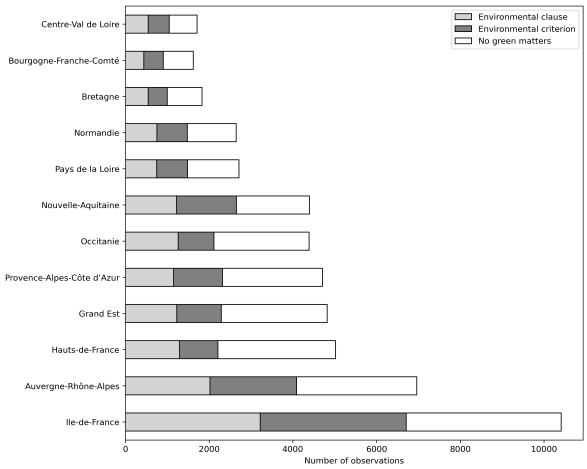

Figure 4: Procurement characteristics by region

Finally, we control for the location of the public buyer with the categorical variable *Region*. There are 12 regions in mainland France. Obviously, the *Ile de France* region is the most represented in the sample, as Paris is located there (Figure 4). Due to the strong administrative centralization of France, most national institutions are located in this region, which may explain why the average implementation of green clauses and criteria is the highest.

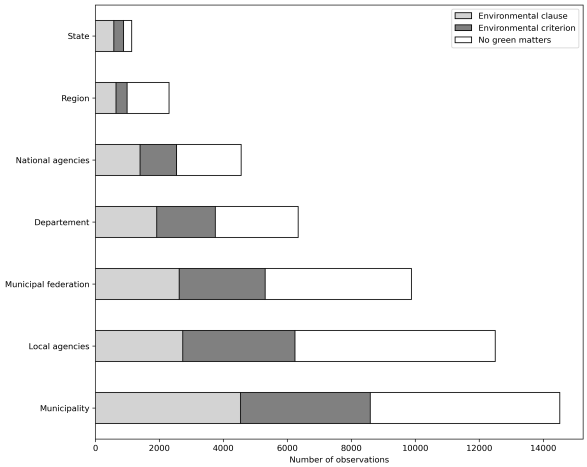

Figure 5: Procurement characteristics by type of contracting authority

Table 3 highlights that there is no clear correlation between participation and the inclusion of environmental award criteria or clauses. Obviously, the implementation of a green clause is strongly correlated with the implementation of a green criterion. Green clauses and criteria are not strongly correlated with contract features such as allotment and framework agreements, but we observe a clear positive association between the weight of the environmental criterion and the share of the score – irrespective of *G_weight* – that is related to the bid value. This can be explained by the fact that contracting authorities typically include one or two quality-related award criteria, so that the presence of a green criterion reduces the proportion of the score other quality-related criteria represent.

	Offers	*G_clause*	*G_weight*	*P_weight*	*Allotment*	*Framework*
Offers	1.00	0.03	-0.01	-0.05	-0.05	0.04
G_clause	0.03	1.00	0.26	0.08	0.04	0.07
G_weight	-0.01	0.26	1.00	0.36	0.04	0.07
P_weight	-0.05	0.08	0.36	1.00	0.04	0.02
Allotment	-0.05	0.04	0.04	0.04	1.00	0.01
Framework	0.04	0.07	0.07	0.02	0.01	1.00

Table 3: Correlation matrix

4 Results

In this section, we describe the empirical results we obtain by applying the econometric method described above. We first perform regressions with different specifications on the general sample, which reveals a positive influence of green clauses and criteria on participation, although the impact of green criteria on participation is inverted when the assigned score exceeds 30%. Despite this overall result, we then find sectoral heterogeneity when focusing on the three main industries in French public procurement. In addition, environmental issues seem to have a specific effect compared to other quality-related clauses and criteria. We finally show that the positive effect of green clauses and criteria on participation is robust by addressing issues such as within-contract correlation and endogeneity in the implementation of green public procurement.

4.1 Main results

We first look for a global effect of green clauses and criteria on participation by conducting regressions on all the sectors of public procurement with different settings, including quadratic effect of award criteria weight and interaction between clauses and criteria. We then show that although we identify an overall stimulating impact, there is sectoral variability in the effect of green clauses and criteria. Finally, we find that environmental quality and other qualitative aspects in the assessment of offers can have different impacts on participation.

In Table 4, we find consistent evidence of a positive effect of green clauses and criteria. In addition, since the coefficient α is significantly positive, note that negative binomial regressions seem preferable to Poisson models.

Despite their significance and consistency across model specifications, these effects are quite moderate. If we focus on the estimators of the linear multilevel regression, we find an overall effect of +3% for green clauses on participation (the 95% confidence interval of the effect ranges from 1.2% to 4.7%). Similarly, a one percentage point increase in the weight of the environmental criterion stimulates participation by 0.3%, so that a 10 point increase boosts the number of offers by 3% (the 95% confidence interval of a 10% increase in the environmental weight ranges from 1.4% to 3.6%).

Interestingly, when considering a potential quadratic influence of the weight of green criteria on participation, we find that the coefficient associated with the squared weight of the environmental criterion is significantly negative, so that the estimated influence of the environmental criterion on participation follows an bell-shaped curve. The stimulating effect of green criteria on participation seems to peak at 34. It implies that increasing the weight assigned to green criteria beyond 35% of the score tends to reduce participation. We do not identify a specific interaction between green clauses and green criteria.

We find evidence of a negative association between contract allotment and participation. This may seem surprising, as allotment is usually promoted to stimulate SME participation. However, it also indicates that the contract is more specialized, so that fewer firms are able to participate.

Finally, we identify a negative effect of the weight of the price criterion on participation. It echoes the fact that quality can attract more offers by increasing margins and that only a minority of firms can specialize in low cost business models. Recall that we computed *P_weight* after removing the potential environmental criterion, so that there is no direct correlation between the weight of the price criterion and the presence of a green criterion.

In Table 5, we check whether the general positive effect of green clauses and criteria holds at a sectoral level with negative binomial regressions that include sectoral fixed effects based on the first

	Truncated Poisson (Linear)	Truncated Neg. Bin. (Linear)	Multilevel Trunc. Neg. Bin. (Linear)	Multilevel Trunc. Neg. Bin. (Quadratic)	Multilevel Trunc. Neg. Bin. (Interaction)
G_clause	0.051***	0.073***	0.029***	0.024**	0.029**
G_weight	0.003***	0.002**	0.003***	0.005***	0.006***
G_weight^2	-	-	-	-7.46e-5*	-7.91e-5*
G_weight × *G_clause*	-	-	-	-	-0.001
Allotment	-0.038***	-0.023**	-0.053***	-0.053***	-0.054***
Framework	0.019**	0.097***	-0.004	-0.005	-0.005
P_weight	-0.004***	-0.004***	-0.003***	-0.003***	-0.003***
Constant	1.045***	0.954***	1.017***	1.010***	1.009***
Status	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes
Sector	F.E.	F.E.	Random	Random	Random
Standard errors	Robust	Robust	Robust	Robust	Robust
Sample weights	Yes	Yes	Yes	Yes	Yes
Observations	49,214	49,214	49,214	49,214	49,214
Levels	-	-	146	146	146
Pseudo-R^2	0.283	0.386	0.273	0.274	0.274
Dispersion (α)	-	5.11***	8.36***	8.38***	8.38***

Significance levels: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 4: Comparison of models with linear and quadratic effects of green criterion weight

three digits of the CPV codes. Interestingly, we find heterogeneous results when focusing on the three largest sectors in French public procurement in terms of the number of contracts: construction works (division 45 of the CPV classification), environmental services (division 90), and medical equipment (division 33).

We still identify a slight stimulating effect of green clauses on participation in construction works. However, although we find a quadratic influence of environmental criteria, it follows a U-shaped curve this time. The critical point is still comprised between 30% and 35% of the score. It implies that green criteria with a low to medium weight have a negative effect on participation, while the impact on participation is positive when the assigned weight is relatively high. Contrary to the results we obtain with the general sample, construction works contracts that prioritize cost concerns seem to be more attractive.

When focusing on environmental services – typically waste collection and water treatment – we also find a positive effect of green clauses on participation. However, we cannot find any significant association between participation and environmental award criteria.

When it comes to medical equipment, we find a negative effect of environmental clauses on participation. The approximate significance level of this estimate is 97%, so the 95% confidence interval of the negative effect ranges from −14% to nearly 0.

Although we find multiple signs of an overall positive effect of green clauses and criteria on firm participation, it is not certain whether this result is specific to the environmental dimension of these clauses and award criteria or if it is common to any award mechanism related to quality. We find that an increase in the weight of the price criterion has a detrimental effect on firm participation, irrespective of the weight assigned to environmental matters in the assessment of the offers, which suggests that other qualitative issues as a whole may also have a stimulating impact on participation. Fortunately, the data we utilize in this paper also mention social clauses, as well as award criteria related to the social, delay, and technical aspects of the offers. In Table 6, we perform three multilevel negative binomial regressions as in Table 4 to check whether we find similar results with other clauses and criteria related to the quality of the offer. Note that the weight of the price criterion is expressed with respect to all quality-related criteria except the one studied (as we do with the environmental criterion in the other tables not to create correlation among independent variables).

Interestingly, we find significant evidence of a moderate negative impact of social clauses on participation (about −3%), while we find a positive effect of green clauses in Table 4. However, we identify a quadratic association between the weight of the social criterion and participation that is similar to the

	Multilevel Trunc. Neg. Binomial (Construction works)	Multilevel Trunc. Neg. Binomial (Environmental services)	Multilevel Trunc. Neg. Binomial (Medical equipment)
G_clause	0.034*	0.072**	-0.072*
G_weight	-0.007***	0.005	-0.002
G_weight^2	1.34e-4***	-1.28e-4	-1.87e-5
Allotment	-0.050**	-0.094***	-0.111***
Framework	0.085***	-0.066**	0.078**
P_weight	0.003***	-0.005***	0.005***
Constant	1.093***	1.017***	1.071***
Status	Yes	Yes	Yes
Region	Yes	Yes	Yes
Sector	F.E.	F.E.	F.E.
Standard errors	Robust	Robust	Robust
Sample weights	Yes	Yes	Yes
Observations	7,420	4,281	3,476
Sectors	4	5	3
Pseudo-R^2	0.244	0.668	0.190
Dispersion (α)	13.11***	9.21***	6.00***

Significance levels: $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 5: Environmental criterion effects by sector group with fixed effects

one we find for environmental criteria. We estimate a comparable critical weight around 33%. We find no evidence of a significant relationship between the number of offers and the weight of award criteria related to the delay in contract performance. Finally, we notice evidence of a positive association between the weight assigned to technical award criteria and firm participation in award procedures. The extent of this effect may not be linear and seems to increase with the assigned weight.

	Multilevel Trunc. Neg. Binomial (Social)	Multilevel Trunc. Neg. Binomial (Delay)	Multilevel Trunc. Neg. Binomial (Technical)
Social_clause	-0.037**	-	-
Social_weight	0.008***	-	-
Social_weight^2	-1.21e-4***	-	-
Delay_weight	-	0.002	-
Delay_weight^2	-	-7.41e-5	-
Technical_weight	-	-	0.001*
Technical_weight^2	-	-	1.58e-5*
Allotment	-0.041***	-0.052***	-0.051***
Framework	-0.006	-0.002	-0.003
P_weight	-0.002***	-0.003***	-0.002***
Constant	1.074***	1.026***	0.968***
Status	Yes	Yes	Yes
Region	Yes	Yes	Yes
Sector	Random	Random	Random
Standard errors	Robust	Robust	Robust
Sample weights	Yes	Yes	Yes
Observations	49,227	49,217	49,214
Levels	146	146	146
Pseudo-R^2	0.297	0.273	0.272
Dispersion (α)	8.42***	8.35***	8.34***

Significance levels: $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 6: Social, delay and technical criterion effects with quadratic specification and sample weights

4.2 Robustness

In this subsection, we evaluate whether the general results estimated above are robust. We identify three main threats to the robustness of the results. First, the observations may not be considered independent as they can belong to the same contract. Second, the implementation of green public procurement may not act as a random event, so we need to address potential endogeneity in the models. Third, the award value – which is sometimes poorly reliable in the original data – may influence both the inclusion of green clauses and criteria and the number of offers, thus creating an omitted variable bias. Fortunately, these robustness tests tend to corroborate the initial results.

As explained in the previous section, the observations correspond to a contract lot or a non-allotted contract. Since there may be a strong within contract correlation, observations can hardly be assumed to be independent. Therefore, the positive effect we find for green clauses and criteria might result from this unaddressed correlation among observations. In order to ensure that the significance of the results is not affected by the similarity among the different lots of a given contract, we opt for a bootstrap approach. Table 7 describes the distribution of the estimates after performing the quadratic model in Table 4 on 100 samples composed of the random drawing of one observation per contract. Interestingly, selecting one observation per contract still results in very significant estimates, despite a much lower sample size (19,134 observations instead of 49,214). Therefore, the results to not seem to be biased by the potential correlation among observations.

	95% interval	99% interval	99,9% interval
G_clause	[0.022, 0.041]	[0.020, 0.043]	[0.019, 0.043]
G_weight	[0.004, 0.007]	[0.004, 0.007]	[0.004, 0.007]
G_weight^2	[-1.22e-4, -5.561e-5]	[-1.26e-4, -4.681e-5]	[-1.27e-4, -3.911e-5]

Table 7: Bootstrap results after 100 iterations

One may claim that the introduction of a green clause or criterion may not act as a random treatment. For example, some contracting authorities seem more likely to implement green public procurement. If some factors to the introduction of green clauses and criteria also influence firm participation, the estimates face an endogeneity risk. We resort to a double-robust (D.R.) approach to alleviate this endogeneity issue. Concretely, we proceed to a new weighting of the sample that integrates both the propensity of an observation to be treated and the uneven representation of contracting authorities in the sample. First, we consider the presence of green clauses and criteria as two binary treatments. Although it cannot analyze the influence of the variability of the environmental weight, it is the most common way to carry out the D.R. method. We compute propensity weights based on a multinomial logistic regression (as in Table 11 in Appendix C). We find that allotted contracts and framework agreements are favorable to the inclusion of environmental clauses and criteria. We then multiply these weights by the usual sampling weights that account for the uneven representation of contracting authorities in the sample. As highlighted in Table 8, the D.R. estimates obtained by considering green clauses and criteria as binary variables do not contradict the initial finding. They still have moderate positive impacts on participation. The rest of the control variables are also not affected. However, we can also consider the propensity to assign a certain weight to the environmental criterion. Indeed, the implementation of a low weight green criterion may not be driven by the same factors as the utilization of a highly weighted criterion. Therefore, we consider green criteria with a low ($G\_weight \leq 10\%$ of the score), medium ($10\% < G\_weight \leq 30\%$), and high ($G\_weight > 30\%$) as three different treatments, in addition to the implementation of a green clause. We then perform a similar multinomial logistic regression to obtain propensity weights, which we multiply by the sample weights. This alternative D.R. approach confirms in Table 8 that green clauses have a slight stimulating impact on participation. We still find evidence of a quadratic relationship between participation and the weight assigned to green criteria, although we estimate the critical weight to be approximately equal to 25% of the score, which is lower than in Table 4. Interestingly, we identify a very significant interaction between green criteria and green clauses that seems to increase participation.

One may wonder why we do not integrate the value of the contract as a control variable. Indeed, there is a potential risk of an omitted variable bias if the value of the contract influences both participation (since an increased expected profit probably increases participation) and the implementation of green clauses and criteria. We believe that it is better not to do so for several reasons. First, there

	Multilevel Neg. Binomial (Binary D.R.)	Multilevel Trunc. Neg. Binomial (Linear D.R.)	Multilevel Trunc. Neg. Binomial (Quadratic D.R.)	Multilevel Trunc. Neg. Binomial (Interaction D.R.)
G_clause	0.028***	0.049***	0.045***	0.021*
G_criterion	0.032***	-	-	-
G_weight	-	0.004***	0.006***	0.004**
G_weight^2	-	-	-8.50e-5*	-8.29e-5*
G_weight × *G_clause*	-	-	-	0.006***
Allotment	-0.048***	-0.053***	-0.053***	-0.054***
Framework	0.008	-0.003	-0.003	-0.005
P_weight	-0.002***	-0.003***	-0.003***	-0.003***
Constant	1.122***	1.018***	1.015***	1.019***
Status	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes
Sector	Random	Random	Random	Random
Standard errors	Robust	Robust	Robust	Robust
Sample weights	Yes	Yes	Yes	Yes
Observations	49,214	49,214	49,214	49,214
Levels	146	146	146	146
Pseudo-R^2	0.210	0.296	0.296	0.297
Dispersion (α)	194.68***	9.87***	9.89***	9.93***

Significance levels: $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 8: double-robust estimates

is a risk of endogeneity if we integrate the value of the contract into the estimates, as the award price is influenced by firm participation, although the order of magnitude of the contract value is probably not affected by the amount of participation. From a practical point of view, the information related to prices in the *BOAMP* notices is sometimes not reliable. We observe a significant number of prices equal to zero or one euro. We also believe that controlling for allotment and CPV sectors partly accounts for the value of the contract. Table 9 shows that the inclusion of prices in econometric models does not have a major influence on the results. We control for the value of the contract by computing the logarithm of the award price, which provides an order of magnitude of the contract size. As we only keep observations where the award price is greater than 1,000 euros to avoid abnormally low contract values, the resulting sample is slightly smaller than the initial one. We still find evidence of a positive impact of green clauses on participation, as well as a positive interaction between green clauses and green criteria. However, although we find a stimulating effect of green criteria on participation, this relationship seems to be linear only following these results. The estimates for the squared value of the weight assigned to the green criteria are not significant. This might be explained by the reduced number of observations and the inclusion of one more variable in the estimates, as the significance of this variable in the previous models was already comprised between 1% and 5%. The new *p-value* of the quadratic coefficient is slightly higher than 10%.

5 Discussion

5.1 Result interpretation

Our empirical results highlight consistent evidence of a slight positive effect of environmental clauses and award criteria on the number of bids French contracting authorities receive. On average, both the implementation of a green clause and a 10-point increase in the weight assigned to the environmental quality of the offers increase the number of bids by 3%. This tends to confirm Predictions 1 and 2 in Section 2. Indeed, these results can be interpreted as a sign of an increase in the expected gain of participation due to the higher margin in the case of award. Contrary to popular belief, green clauses and criteria are not bound to reduce firm participation in award procedures. In addition, we identify a negative association between participation and the importance given to bid value, therefore illustrating

	Multilevel Trunc. Neg. Binomial (Linear D.R.)	Multilevel Trunc. Neg. Binomial (Quadratic D.R.)	Multilevel Trunc. Neg. Binomial (Interaction D.R.)
G_clause	0.043***	0.041***	0.020*
G_weight	0.003***	0.005***	0.003*
G_weight^2	-	-6.57e-5	-7.47e-5
G_weight × *G_clause*	-	-	0.005***
Allotment	-0.027***	-0.027***	-0.028***
log(*Award_price*)	0.031***	0.031***	0.031***
Framework	-0.004	-0.004	-0.005
P_weight	-0.003***	-0.003***	-0.003***
Constant	0.608***	0.604***	0.609***
Status	Yes	Yes	Yes
Region	Yes	Yes	Yes
Sector	Random	Random	Random
Standard errors	Robust	Robust	Robust
Sample weights	Yes	Yes	Yes
Observations	47,812	47,812	47,812
Levels	146	146	146
Dispersion (α)	9.59***	9.60***	9.62***

Significance levels: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 9: double-robust models with the log of award price

the link between expected margin and participation.

Interestingly, the weight assigned to environmental quality in the offer scoring seems to have a quadratic effect on participation. We find that increasing the weight of the environmental criterion tends to stimulate competition until it represents between 25% and 30% of the score, although only 8% of observations with a green criterion have a weight greater than 25% in the data. At first glance, this result may not align with our theoretical model, which predicts a positive impact of an increase in the weight assigned to green criteria on participation. However, this prediction holds if participation costs remain unchanged. While there is no direct link between entry cost and the weight assigned to green criteria in theory, highly weighted green criteria probably increase participation cost in practice. Public buyers probably ask for more documents and information when environmental issues represent a large part of the evaluation of the offers they receive. Therefore, Above 30% of the score, the marginal effect of an increase in participation costs may be stronger than the marginal attractive effect linked to margins.

The negative effect of the green clauses we find in Table 5 when focusing on medical equipment can be explained by the fact that this industry follows objectives that seem distant from environmental issues, namely safety, reliability, and cost. Environmental requirements can be too demanding in this very peculiar sector, and many firms can be excluded by minimum quality thresholds. In this sector, the shrinking pool of eligible candidates may be stronger than the attractive effect on expected margins. Firms may also prefer to participate in other award procedures – including private markets – that do not include such clauses.

Finally, concerning the quadratic relationship – following a U-shaped curve – between the weight of the environmental criterion and participation when focusing on construction works, firms may be attracted when facing a criterion that is either poorly or highly significant, while intermediate weights can induce participation costs that deter non innovative firms to participate and do not stimulate innovative firms enough.

5.2 Limitations

Despite the relatively large sample used in this paper compared to previous works (Lundberg and Marklund, 2013; Drake et al., 2024), the content of the green clauses and award criteria remains uncertain. This is due to the source of the information we use – the *BOAMP* online notices –, which do not provide such details. To the best of our knowledge, there are no centralized data that precisely

describe the content of environmental clauses and award criteria in France. It would be highly relevant to reassess the results of this paper with more accurate information on environmental clauses and criteria.

Concerning award criteria related to the environmental quality of the offers, we use the assigned weight to estimate their possible impact on participation. However, Lundberg et al. (2012) and Bergman and Lundberg (2013) claim that weights should not be used for environmental quality criteria. Indeed, as stipulated weights are scale dependent, the stated weight can differ from social preferences. As a result, knowing a weight without the associated scoring rule does not actually reveal the real importance given to the environmental features of the tender. This lack of precision may explain why we find a slight – but consistent – effect of the weight assigned to environmental criteria, since this weight is only an approximation of the real rewarding of environmental quality.

Similarly, as we do not know the content of environmental clauses, we have to consider them as a binary variable. However, there is probably a significant amount of variability in the requirements of the environmental clauses. Some can be very demanding, while others could be shallow or reflect a greenwashing strategy from the contracting authority. The small extent of the estimated effect of green clauses may be explained by this uncertainty over the content of the latter. The estimated impact of +3% is somehow the average estimated effect. Some demanding clauses may have a much more significant influence on the number of bids the contracting authority receives.

In addition, this paper clearly reveals sectoral heterogeneity in the impact of green public procurement on participation. Since the purpose of this article is not to study specific industries, future empirical investigations may focus on specific industries, for example, using the same data source as in this paper (Deschamps and Potin, 2025). It would also be interesting to integrate the identity and characteristics of all the bidders – not only the awarded one –, but this information is not available in the *BOAMP* notices.

Carreras (2023) identifies a decisive endogeneity issue in the analysis of the impact of environmental and social criteria on firm participation in Spain. This paper first finds evidence of a positive effect of sustainable criteria on participation. However, the implementation of the latter may be subject to endogeneity. Typically, contracting authorities might implement sustainable criteria when they anticipate that the contract is attractive. The author then uses a legal reform that increased the adoption of sustainable criteria to eliminate endogeneity. This alternative method inverts the results and highlights a slight negative effect of social criteria on participation.

However, we believe that endogeneity does not significantly threaten the results of our paper. Most estimates are very significant and consistent despite robustness tests and diverse model specifications. Although we cannot find suitable events in France to conduct robust causality assessment – such as difference-in-differences or regression discontinuity designs –, we use a D.R. approach that integrates the propensity of an observation to be assigned a green clause or criterion. Note that the estimates are not biased if at least one of the two models at stake – either the propensity model or the outcome one – is correctly specified. Interestingly, this method does not affect the conclusions of this paper, so the factors that influence the implementation of green public procurement seem not to drastically affect participation. Moreover, the variability in the sectoral effects of green clauses and criteria indicates that the overall positive effect we find is probably not only explained by the anticipation of a high participation level. Similarly, the quadratic relationship between participation and the weight of the environmental criteria probably reflects a reaction from firms facing a very high demand for environmental quality. Otherwise, contracting authorities would implement highly weighted green criteria only when they anticipate high participation, and we would not observe such a quadratic effect. Finally, we identify a negative effect of social clauses so that quality-related mechanisms are not simply implemented for contracts that attract more bids.

Surprisingly, we find results different from Arve and Desrieux (2024) regarding environmental award criteria, as they estimate a negative effect of green criteria on participation in French municipal procurement. However, the econometric approach of our study is significantly different. First, our paper does not only consider municipal public contracts. Second, because of overdispersion, we use negative binomial regressions rather than Poisson regressions. Third, we control sectoral heterogeneity with a more accurate breakdown by using the first three digits of CPV codes rather than distinguishing between services, supplies, and works.

5.3 Policy recommendations

Despite the aforementioned limitations, our empirical results show that green clauses and criteria can have a stimulating impact on firm participation in award procedures. This paper shows that the increasing integration of environmental issues in public procurement is not a likely explanation for the observed decrease in its attractiveness.

Therefore, the *Climat et Résilience* law, which is about to generalize the implementation of green clauses and criteria in France, may not reduce competition in public procurement in general. Award procedures that include green specifications do not attract fewer bids on average. Although we find a quadratic relationship between the weight of the green criteria and participation, an increase in the weight of the green criteria up to 25-30% has a stimulating effect on participation. So far, environmental criterion weights less than 25% are by far the most common scenario. Therefore, contracting authorities who are not used to implementing green criteria can start introducing moderately weighted criteria without much concern for the number of bids they will receive.

However, the sectoral heterogeneity we observe questions the efficiency of the general scope of the *Climat et Résilience* law. The latter states that any public contract must include both a green clause and a criterion by August 2026, regardless of the industry and the contract size. Special attention should be paid to sectors such as medical equipment that may be penalized by this reform. Additionally, the generalization of green clauses and criteria required by the *Climat et Résilience* law may affect the average quality and clarity of green clauses and criteria. So far, green clauses and criteria have been implemented by voluntary contracting authorities which have enough skills and knowledge to use public procurement as a lever for environmental policy. Poorly written environmental specifications that result from forced compliance may deter firms from participating, typically by increasing participation costs. In addition, the *Climat et Résilience* law also affects small contracting authorities that are not included in this paper's sample, since it is based on advertised contract notices. Consequently, we would like to highlight the need for public buyer training to ensure that the mandatory generalization of green clauses and criteria does not deteriorate firm participation and competition for public contracts.

More generally, it should be noted that the relevance of green procurement policies cannot be analyzed only through the issue of participation. Even if green clauses and criteria had a negative effect on participation, effective green clauses and criteria can increase the protection of the environment. For example, Chiappinelli et al. (2019) estimate that public procurement accounts for 12% of German CO_2 emissions. While they claim that green public procurement is an underused instrument of environmental policies, it remains difficult to measure its impact because of contract diversity measure uncertainty. Rietbergen and Blok (2013) assess the implementation of the CO_2 Performance Ladder scheme in public procurement in the Netherlands. They find a potential 1% annual decrease in carbon emissions for the firms participating in the program, which could help the country respect its greenhouse gas emission goals. The implementation of green procurement strategies by contracting authorities can also stimulate corporate environmental innovation. Public procurement has long been considered an important source of innovation on the demand-side (Dalpé et al., 1992). Lindström et al. (2020) find a positive impact of the Swedish government's organic farming scheme on green public procurement on the conversion of national farmland to organic agriculture. Krieger and Zipperer (2022) measure the impact of being awarded a contract with environmental criteria on green innovation in Germany. They reveal a significant impact of winning a procedure that includes a green criterion on the propensity of SMEs to adopt green products. Schäfer et al. (2024) find that participation in public procurement increases the financial constraint of firms for green innovation.

However, the literature is skeptical of the cost-effectiveness of public procurement as a tool for environmental policies. First, public procurement is an instrument that follows multiple public policy objectives, which violates Tinbergen's rule (Tinbergen, 1952). The seminal work of Marron (1997) claims that green public purchase crowds out private purchase, so private consumers have an incentive to buy more polluting products, since green products have become more expensive due to an increase in public demand for green products. Additionally, green public procurement can increase total environmental damage if the production growth resulting from a higher procurement volume offsets the environmental gains due to greener practices. Finally, green products are more costly, so more distortionary taxes are required to finance their purchase. Similarly, Saussier and Tirole (2015) claim that public procurement should only pursue the best value for money and that environmental policies should be implemented through economic mechanisms such as carbon tax.

6 Conclusion

Public procurement is increasingly used as an instrument for multiple public policy objectives, such as sustainability. Concurrently, poor competition in public procurement resulting from lower participation in award procedures can deteriorate the use of public funds. This paper examines whether environmental clauses and award criteria influence bidder participation in public procurement. From a theoretical point of view, we show that within the framework of multi-dimensional bids with endogenous entry, green clauses and award criteria can increase the number of bidders by extending the margin in case of award, if they do not exclude too many potential candidates and excessively increase participation costs. From an empirical point of view, based on 50,000 award procedures in France between 2022 and 2023, we find that green clauses and criteria have a slight but consistent positive effect of the number of bids the contracting authority receives, despite sectoral differences. Although we find evidence of a quadratic relationship between participation and the weight assigned to environmental award criteria with a critical weight of around 25-30%, only a slight proportion of contracts include such a high weight. Green public procurement is therefore unlikely to explain the observed decrease in the attractiveness of public procurement.

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A Appendix

A.1 Derivation of the optimal bidding strategy of firm i under a contract with environmental clause

Under a first-price sealed-bid auction, firm i chooses $b_i(\theta_i)$ to maximize its expected profit, when other bidders use an increasing bidding function b. Then, using (1), the derivative of the expected profit with respect to θ_i is

$$\frac{dE\pi_i}{d\theta_i} = -\frac{\partial\left(c(\theta_i, q)\right)}{\partial\theta_i}(1 - F(b^{-1}(b_i)))^{n-1}. \tag{A1}$$

Since we are looking for a symmetric Nash equilibrium of the bidding function, we have $b_i = b\left(\theta_i\right)$ $\forall\theta_i$. Then, from (A1), we have

$$\frac{dE\pi_i}{d\theta_i} = -\frac{\partial\left(c(\theta_i, q)\right)}{\partial\theta_i}(1 - F(\theta_i))^{n-1}.$$

By integration, and with $E\pi(\tilde{\theta}) = 0$, we obtain

$$E\pi_i\left(\theta_i\right) = \int_{\theta_i}^{\tilde{\theta}} \left(\frac{\partial c(\theta, q)}{\partial\theta}\right)(1 - F(\theta))^{n-1} d\theta.$$

From this equation and (1), we obtain the optimal bidding strategy (2). Note that since we do not depart from the standard assumptions of the independent private value model, the uniqueness and existence of this equilibrium are guaranteed. *Q.E.D.*

A.2 Proofs under a contract with environmental criteria

Proof that $\frac{\partial\hat{\theta}}{\partial\kappa} < 0$. Let us denote the left-hand-side of (9) as A. We can compute

$$\frac{\partial A}{\partial\hat{\theta}} = -\frac{(2-\hat{\theta})^{-1+n}\left(4 + (-2+n)\hat{\theta}\right)\lambda^2}{4\hat{\theta}^3} < 0.$$

Thus, A is decreasing in $\hat{\theta}$. Obviously, A is also decreasing in κ since $\frac{\partial A}{\partial\kappa} = -1 < 0$. Then, if κ is increasing, then the term $\frac{\lambda^2}{4\hat{\theta}^2}(2-\hat{\theta})^n$ must be increasing (to satisfy (9)), and since it is deceasing in $\hat{\theta}$, $\hat{\theta}$ must be decreasing. Therefore, $\hat{\theta}$ is decreasing in κ. *Q.E.D.*

Proof that $\frac{\partial\tilde{\theta}}{\partial n} < 0$. A is decreasing in n since

$$\frac{\partial A}{\partial n} = -\frac{(2-\hat{\theta})^{-1+n}\left(4 + (-2+n)\hat{\theta}\right)\lambda^2}{4\hat{\theta}^3} < 0.$$

Therefore, since A is decreasing in $\hat{\theta}$, $\hat{\theta}$ must be decreasing to satisfy (9). We conclude that $\hat{\theta}$ is decreasing in n. *Q.E.D.*

Proof that $\frac{\partial\tilde{\theta}}{\lambda} < 0$. A is decreasing in λ since

$$\frac{\partial A}{\lambda} = \frac{(2-\hat{\theta})^n\lambda}{2\hat{\theta}^2}.$$

Therefore, since A is decreasing in $\hat{\theta}$, $\hat{\theta}$ must be decreasing to satisfy (9). We conclude that $\hat{\theta}$ is decreasing in λ. *Q.E.D.*

B Description of each CPV division

	CPV division	*Offers*	*G_clause*	*G_criterion*	*G_weight*	*P_weight*	*Allotment*	*Framework*	N obs	% obs
03	Agriculture & Fishing	2.74	0.42	0.48	19	50	0.92	0.72	596	1.16
09	Energy & Fuels	2.44	0.18	0.16	11	51	0.59	0.58	734	1.43
14	Minerals & Metals	1.78	0.19	0.43	15	67	0.81	0.78	144	0.28
15	Food & Beverage	2.62	0.39	0.47	16	44	0.94	0.65	2276	4.44
16	Agricultural Machinery	2.41	0.38	0.39	14	54	0.85	0.53	184	0.36
18	Clothing & Accessories	3.10	0.48	0.51	13	47	0.90	0.73	773	1.51
19	Leather, Textiles & Plastics	2.97	0.39	0.42	19	55	0.78	0.68	139	0.27
22	Printing	3.38	0.29	0.26	11	29	0.90	0.68	635	1.24
24	Chemicals	2.08	0.27	0.27	12	51	0.89	0.73	377	0.74
30	Computers	3.11	0.40	0.37	13	50	0.69	0.73	1125	2.20
31	Electricity & Lighting	2.69	0.29	0.24	10	49	0.72	0.64	575	1.12
32	Com & Telecom	2.79	0.20	0.19	9	45	0.58	0.62	391	0.76
33	Medical equipment	2.91	0.15	0.29	9	41	0.97	0.73	4029	7.86
34	Transport & Accessories	2.35	0.29	0.34	13	54	0.79	0.50	2234	4.36
35	Security & Defense	2.53	0.41	0.38	10	48	0.82	0.67	284	0.55
37	Music & Sport	2.60	0.26	0.36	10	48	0.93	0.61	383	0.75
38	Labs & Optics	2.22	0.20	0.20	8	40	0.63	0.42	448	0.87
39	Furniture & Household	3.07	0.46	0.47	14	50	0.86	0.63	2215	4.32
41	Treated Water	2.44	0.33	0.33	10	47	0.11	0.33	9	0.02
42	Industrial Machinery	2.78	0.27	0.26	9	49	0.75	0.42	526	1.03
43	Mining & Construction	2.76	0.35	0.24	11	49	0.62	0.30	136	0.27
44	Building materials	2.94	0.33	0.30	12	55	0.80	0.61	1638	3.20
45	Construction	3.60	0.33	0.22	14	52	0.88	0.30	7541	14.72
48	Software & Info	3.19	0.19	0.15	9	44	0.45	0.72	231	0.45
50	Maintenance	2.64	0.31	0.23	10	51	0.70	0.61	2758	5.38
51	Installation	2.21	0.35	0.20	9	47	0.53	0.52	104	0.20
55	Hotel & Retail	2.47	0.38	0.31	15	42	0.57	0.64	562	1.10
60	Transportation	2.51	0.26	0.34	12	60	0.86	0.59	1924	3.76
63	Transport & Travel Support	2.94	0.25	0.22	10	45	0.52	0.62	216	0.42
64	Post & Telecom	2.98	0.25	0.21	9	41	0.74	0.62	401	0.78
65	Utilities	2.51	0.17	0.12	6	34	0.22	0.49	59	0.12
66	Finance & Insurance	2.18	0.03	0.03	12	43	0.86	0.10	2769	5.41
70	Real Estate	2.86	0.13	0.09	7	39	0.43	0.54	76	0.15
71	Architecture & Engineering	4.24	0.16	0.12	11	44	0.49	0.50	3571	6.97
72	IT Consulting	3.21	0.17	0.12	7	40	0.37	0.70	773	1.51
73	R&D & Consulting	3.48	0.10	0.05	10	38	0.57	0.48	21	0.04
75	Admin. Public & Social	2.78	0.10	0.09	8	42	0.65	0.53	216	0.42
76	Oil & Gas	2	1	0.33	10	53	0.67	0.67	3	0.01
77	Agro & Forestry	3.01	0.40	0.38	14	55	0.86	0.55	1669	3.26
79	Corporate Services	3.82	0.24	0.19	13	43	0.59	0.63	2615	5.10
80	Education & Training	2.62	0.10	0.06	6	36	0.93	0.45	690	1.35
85	Health & Social	2.08	0.22	0.35	11	46	0.69	0.69	335	0.65
90	Sewage & Waste	2.99	0.36	0.37	14	54	0.79	0.51	4190	8.18
92	Recreation & Culture	2.73	0.35	0.11	16	37	0.73	0.43	410	0.80
98	Community Services	1.89	0.28	0.42	14	52	0.66	0.59	244	0.48

The content corresponds to the average value of each variable in the sample.
G_weight corresponds to the average weight of green award criteria when they are implemented in the award procedure.

Table 10: Description of each CPV division

C Full multinomial logistic regression

	Clause only	Criterion only	Both
Allotment	0.261^{***}	0.285^{***}	0.100^{***}
Framework	0.123^{***}	0.373^{***}	0.379^{***}
Price weight	-0.005^{***}	0.040^{***}	0.032^{***}
Constant	-1.500^{***}	-3.872^{***}	-2.296^{***}
Region Auvergne-Rhône-Alpes	Reference	Reference	Reference
Region Bourgogne-Franche-Comté	0.147	0.106	-0.156
Region Bretagne	0.158	0.127	-0.278***
Region Centre-Val de Loire	0.346***	0.182	-0.082
Region Grand Est	0.181***	0.014	-0.465***
Region Hauts-de-France	0.161**	-0.602***	-0.675***
Region Ile-de-France	0.231***	0.642***	0.127**
Region Normandie	0.024	-0.055	-0.222***
Region Nouvelle-Aquitaine	0.029	0.454***	-0.022
Region Occitanie	0.232***	-0.503***	-0.771***
Region Pays de la Loire	0.284***	0.349***	-0.313***
Region Provence-Alpes-Côte d'Azur	-0.224***	-0.254***	-0.705***
Status Departement	Reference	Reference	Reference
Status Local agencies	-0.042	0.443***	-0.377***
Status Municipal federation	0.240***	0.450***	-0.243***
Status Municipality	0.360***	0.314***	-0.117**
Status National agencies	0.476***	0.133	-0.012
Status Region	1.130***	0.247**	-1.591***
Status State	1.502***	-0.155	0.127
Sectors	Yes	Yes	Yes
Standard errors	Basic	Basic	Basic
Observations	49,214	49,214	49,214
Pseudo-R^2	0.122	0.122	0.122

Significance levels: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 11: Multinomial logit for green clause and criterion (reference: none)