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DISCUSSION PAPER

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Additional Award Criteria in Public Procurement Tenders and Firms' Innovation Performance Heterogeneity

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Additional Award Criteria in Public Procurement Tenders and Firms' Innovation Performance Heterogeneity

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Abstract

Public procurement is widely regarded as an important instrument to foster innovation. We examine how additional award criteria beyond price relate to firms' realized innovation performance by combining representative firm-level data from the German Innovation Survey with official tender-level data from Tenders Electronic Daily and estimating two-way fixed effects models. The results suggest that winning price-based tenders is associated with lower product and service innovation and higher turnover from established products and services, while criteria-based procurement shows an inverse U-shaped relationship between the average length of criteria lists in won tenders and firms' innovation outcomes. Overall, the findings indicate that the innovation effects of public procurement depend not only on whether additional award criteria are used, but also on how extensively they are applied.

Keywords Public procurement – Firm innovation – Demand side
JEL Code O31 - O32 - O38 - H57

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1. Introduction

Public procurement - the purchase of goods and services by the public sector - accounts for 15 to 20 percent of global GDP (European Council, 2022) and has increased across OECD countries by 10.8 percent from 2007 to 2021 (OECD, 2023). Moreover, the potential of innovative public procurement - public procurement tenders requiring innovation within their awardee selection - to foster firm innovation has been repeatedly confirmed over the last decade (e.g., Guerzoni and Raiteri, 2015; Czarnitzki et al. 2020; Stojčić et al., 2020; Belenzon and Cioaca., 2026). However, the potential negative effects of public procurement on firm innovation have rarely been analyzed conceptually or empirically (Kundu et al., 2020; Chiappinelli et al., 2025; Decarolis and Shroj, 2026).

We are the first to investigate the heterogenous relationships of winning public tenders with different amounts of additional award criteria next to the price on i) firms' turnovers from product and service innovations, as well as on ii) firms' turnovers from established products and services. Thus, we contribute first direct empirical evidence on the barriers to innovation through public procurement, next to Georghiou et al. (2014), who draw on survey evidence from a questionnaire administered to public sector suppliers. While Georghiou et al. (2014) identify a number of barriers to innovation based on suppliers' perceptions, we provide evidence on how a central element of tender design - the use of additional award criteria beyond price (Georghiou et al., 2014) - relates to firms' realized innovation performance by combining objective public tender-level data from the European Commission with representative firm-level survey data from the German Innovation survey covering both winners and non-winners of public procurement tenders.

Conceptually, we largely build on the work of Geroski (1990), Edler and Georghiou (2007), and Edquist and Zabala-Iturriagagoitia (2020) and deepen the discussion on public innovation procurement by distinguishing between price-based and criteria-based public procurement (e.g., Stake, 2017; Camboni et al., 2025; Awaya et al., 2025; Krieger et al., 2026). In short, tenders without additional award criteria beyond price encourage firms to offer established products

and services and discourage them from offering innovative products and services, as quality is not considered in the award decision. By contrast, tenders with additional award criteria allow firms to compete on dimensions beyond price and can therefore strengthen incentives to develop innovative products and services. However, this effect is not linear. While a moderate number of award criteria can promote innovation, too many criteria increase tender complexity, bidding costs, and uncertainty, which may weaken firms' incentives to innovate. Consequently, criteria-based procurement is expected to be more innovation-friendly than price-based procurement, but only up to a certain number of additional criteria.

Empirically, we test our hypotheses by building on the work of Czarnitzki et al. (2020) and Krieger and Zipperer (2022). First, we combine the Mannheim Innovation Panel, a representative survey of the German enterprise sector (Peters and Rammer, 2023), and the Tenders Electronic Daily database, provided by the European Commission covering all public procurement tenders in the European Economic Area whose monetary value exceeds the legal thresholds for securing a transparent and competitive procurement process across borders (Krieger and Zipperer, 2022). Second, we use two-way fixed-effects estimators to analyze the relationship between winning tenders with different amounts of award criteria and firms' introduction of and turnovers from newly introduced products and services, as well as their turnovers from established products and services.

The results show that firms winning public procurement tenders without additional criteria within the last three years have, on average, 11.7 percent lower turnover from new or improved products and services, alongside 4.7 percent higher turnover from established products and services. Consistently, the probability of introducing new or improved products is 7.0 percentage points lower. At the same time, for tenders that include additional award criteria, we document an inverse U-shaped relationship between the average length of criteria lists in awarded contracts and firms' product and service innovation outcomes. Thus, our results indicate that while the inclusion of award criteria can foster innovation, an excessive number of criteria may hinder innovation efforts, potentially because an overly complex set of requirements makes contract fulfillment more difficult. Notably, between 18.5 and 27.4 percent

of firms in our sample that win criteria-based tenders encounter an average criteria length associated with a negative marginal innovation effect.

Consequently, our research advances the discussion on public procurement and firm innovation by analyzing how additional award criteria in public procurement tenders relate to firms' product and service innovation outcomes (Chiappinelli et al., 2025; Kundu et al., 2020). Specifically, we show that additional award criteria can initially strengthen firms' incentives to develop innovative products and services, but that this positive relationship weakens and may turn negative as the number of criteria increases. These findings indicate potential negative implications for long-term competitiveness resulting from price- and criteria-based public procurement. Thus, in addition to contributing to the scientific dialogue, our results aim to raise awareness of the potential innovation-reducing effects of public procurement among public authorities, policymakers, and firm managers, while underscoring the importance of balancing criteria in tenders to support innovation.[1]

2. Conceptual Framework

Public procurement is the procedure through which public authorities, such as government departments and local authorities, acquire goods and services from private firms. Besides its primary goal - fulfilling the needs and demands of public administration - the significant buying power of the public authorities can be used to stimulate innovation activities in the enterprise sector (Edler and Georghiou, 2007; Obwegeser and Müller, 2018; Chiappinelli et al., 2025; Decarolis and Shroj, 2026). The existing empirical literature has extensively affirmed the positive effects of public procurement in driving innovation (e.g., Lichtenberg, 1988; Aschhoff and Sofka, 2009; Guerzoni and Raiteri, 2015; Slavtchev and Wiederhold, 2016; Stojčić et al., 2020; Czarnitzki et al., 2020; Caravella and Crespi, 2021; Krieger and Zipperer, 2022; Belenzon and Cioaca, 2025). From a theoretical point of view, the idea of using public procurement to promote innovation has been conceptualized in studies by Geroski (1990), Edler and

[1] The share of public procurement tenders solely awarded based on the price criterion in the entire Tenders Electronic Daily database was 60.66 percent in 2019. The share of firms located in Germany winning public procurement tenders solely based on the price criterion was 69.59 percent in 2019.

Georghiou (2007) and Edquist and Zabala-Iturriagagoitia (2020). Our conceptual framework builds on these foundations in three ways:

First, we extend existing concepts on the potential innovation-enhancing effects of public procurement, manifested by Geroski (1990) and Edler and Georghiou (2007), and address the limitations of public procurement as an innovation policy tool or even mechanisms of public procurement to actively prevent innovation. The theoretical foundation of public procurement and how it can stimulate innovation was built by Geroski (1990), who conceptualized government demand and public procurement as an instrument for industrial policy and pointed to its potential in the development and diffusion of innovations. Following upon a new emerging wave of interest in public procurement among policymakers during the early 2000s, Edler and Georghiou (2007) conceptually discuss public procurement as an innovation policy tool, elaborating on the underlying mechanisms with which public procurement can promote innovation. According to Edler and Georghiou (2007) public procurement can promote innovation by i) providing a critical market size for firms to scale up their production capacities, ii) enhancing rates of return while minimizing the risk associated with innovation investments, and iii) mitigating information asymmetries between suppliers and purchasers of innovative solutions. In this study, we build on this framework and extend it by suggesting alternative mechanisms which can have negative effects on innovation.

Second, we build on Edquist and Zabala-Iturriagagoitia (2020) who point to the role of the product description in a procurement tender and its effect on firm innovation. They differentiate between two forms of procurement: Functional procurement means procurement contracts in which problems to be solved or functions to be fulfilled are described, leaving flexibility to the supplier to potentially come up with innovative solutions. In contrast, product procurement refers to procurement tenders that describe a very specific, existing product which has to be bought and thus can even prevent suppliers from delivering innovation. Consequently, the authors conclude that more innovation can be achieved by shifting from product procurement towards functional procurement. In our conceptual framework, we highlight an additional and equally important component of the procurement tender, namely

the role of award criteria. We follow previous work focused on scoring rules and the price–quality trade-off in procurement, such as Camboni et al. (2025) and Awaya et al. (2025), and use the concept of price-based public procurement - public procurement tenders with no additional award criteria beyond the price - as opposed to criteria-based public procurement - public procurement tenders with additional award criteria beyond the price, and relate it to the innovativeness of suppliers.

The public procurement procedure is a multi-stage process, in which each stage has the potential to affect the innovation outcome of firms individually. At the beginning of the public procurement procedure, the procuring agency puts out a call for tender, in which it informs about the requirements of the procured product or service. Moreover, at this stage, the procuring agency publishes criteria for their awardee selection. In a second step, the procuring agency solicits bids from potential suppliers. Third, it evaluates the submitted bids by awarding points based on the published award criteria (e.g., Stake, 2017; Krieger et al., 2026). Finally, the procuring agency awards the tender to the supplier who best meets the specified criteria.

This procedure makes award criteria a major component of the public procurement process. As described, award criteria are a major component in public procurement procedures and the European public procurement directives specifically encourage procurement agencies to include them in the selection process. For instance, public authorities have the option to establish award criteria including qualitative, environmental, social, or innovative aspects when determining their awardee. Firms that demonstrate better performance in the established criteria in their bids receive an increased likelihood of winning the tender (Krieger and Zipperer, 2022). We refer to these tenders as criteria-based procurement tenders.

We build upon arguments from Zabala- Iturriagagoitia (2020), who argues that a functionally oriented product description in a call for tender can promote firm innovation. In contrast, this study focuses on the role of award criteria instead of the tender description. We argue that the inclusion of award criteria increases firms' incentives to innovate to a certain extent as it gives

flexibility to firms to come up with own suggestions and approaches to provide a non-prescribed product or service, which might outperform conventional, established solutions to a problem. This channel promotes firm innovation. However, a too extensive use of award criteria may deter firms from competing for the tender, as too many award criteria reflect high complexity of the contract. Too many criteria raises bid preparation costs, increases uncertainty about how bids will be evaluated, and shifts firms' attention from developing innovative solutions towards satisfying a broad set of formal requirements. This can disincentive firms from competing for the tender and weaken innovation incentives. Accordingly, the relationship between the use of award criteria and firm innovation is expected to follow an inverted U-shaped pattern.

H1: The inclusion of additional award criteria increases firms' probability of introducing new/improved products and services and the turnover generated from them, but only to a certain extent: Too many award criteria in tender reflect high complexity and thus decreases firms' probability of introducing new/improved products and services and the turnover generated from them.

However, publishing and evaluating a tender based on additional award criteria requires time, know-how, and effort from the procurer. In contrast, an evaluation purely based on price is easier and faster to implement (Sigma, 2016). For instance, in a recent survey of over 700 public procurers in Germany, participants reported that a lack of expertise, alongside difficulties in verifying compliance with environmental requirements, was a major obstacle to the use of environmental award criteria (Chiappinelli et al., 2019). As a result, for a substantial share of public procurement tenders, no additional award criteria beyond the price are accounted for. In Germany between 2012 and 2019, the share of firms winning price-based procurement tenders amounted to 63.1 percent, compared to 56.6 percent in the European Economic Area.[2] Consequently, these tenders are granted to the firm offering the lowest price for a specified

[2] Based on own calculations using procurement tender information on the most economically advantageous tender criteria. 3,006,674 out of 5,311,928 public procurement tenders in the Tenders Electronic Daily database from 2012 to 2019 were solely awarded based on their price. 226,696 out of 359,268 procurement tenders were solely awarded to firms located in Germany based on their price.

product or service, and no additional factors are considered. We refer to these tenders as price-based procurement tenders.

First, the absence of award criteria in the tender implies that the procured product or service is precisely described, and likely to be an already-existing solution. In this case, the award is granted to the firm that can supply the exact product or service as described, at the lowest price. This disincentives firms to develop and propose innovative solutions, as potentially qualitatively superior products and services are routinely excluded, or at least not rewarded in the procurement process. Instead, firms are incentivized to select an already existing product or service 'off the shelf' (Edquist and Zabala-Iturriagagoitia, 2020). In a survey of hundreds of suppliers to the public sector in the United Kingdom, approximately 90 percent of all surveyed firms perceived the emphasis on price as award criterion as a significant barrier to innovation, making it the most important (out of 13 possible) obstacle in public procurement for innovation (Georghiou et al., 2014). Therefore, we hypothesize that winning price-based public procurement tenders reduces firms' probability of introducing new/improved products and services and the turnover generated from them.

H2: Winning price-based procurement tenders decreases firms' probability of introducing new/improved products and services and the turnover generated with them.

Second, using the price as the sole selection criterion creates incentives for firms to reduce their costs to submit the lowest possible bid among all potential suppliers. In order to save costs, firms can i) focus their production on their established products and services, and ii) introduce more efficient production processes. Introducing new/improved products and services requires resources for investments in R&D and is therefore costly. Moreover, new supply chains and distribution networks need to be developed. In contrast, focusing on established products and services is less costly, as no R&D is required, and production processes, as well as logistical networks already exist (Bessen, 2002). Hence, concentrating on established products and services can lower firms' costs compared to concentrating on innovative products and services. Thus, we hypothesize that winning price-based public procurement

tenders decreases firms' turnover share from innovative products and services while increasing firms' turnover from established products and services.

H3: Winning price-based procurement tenders increases firms' turnover from established products and services and decreases firms' turnover share with new/improved products and services.

3. Data

3.1. Databases

The data are based on the Mannheim Innovation Panel, the Tenders Electronic Daily database, and PATSTAT. The databases are matched by the ZEW - Leibniz Centre for European Economic Research based on firms' name and address histories (Doherr, 2023).

Mannheim Innovation Panel - The Mannheim Innovation Panel is an annual representative survey organized by the ZEW on behalf of the German Federal Ministry of Education and Research. It is the German part of the European Community Innovation Survey, whereas it stands out by being annually, and using rotational panel sampling. The database covers firms with five or more employees in the German business sector and provides information about a variety of firms' innovation activities. Moreover, in addition to detailed information about firm innovations, it contains information about firms' structure, such as their turnovers, their exports, and their employee numbers. (Peters et al., 2013; Peters and Rammer, 2023)

Tenders Electronic Daily database - The Tenders Electronic Daily database is provided by the European Commission and covers all public procurement tenders awarded in the European Economic Area whose monetary value exceeds the legal thresholds for securing a transparent and competitive procurement process across borders (Krieger and Zipperer, 2022). Nevertheless, it is considered good practice to publish information about awards with a monetary value below the specified thresholds (TED, 2020). The data stems directly from standard procurement forms completed by the procuring authorities, and contain, most

importantly for our analysis, the awardee, the award date, and the award selection criteria of each tender.

PATSTAT - Information on the number of firm patent applications is taken from the PATSTAT database of the European Patent Office.

3.2. Variable Construction

Firm innovation **-** We create four variables on firm innovation based on the Mannheim Innovation Panel. First, we take a dichotomous variable equal to one if a firm introduced new/improved products or services within the last three years, and zero otherwise. Second, we use firms' turnover shares from new/improved products and services. Third, we create firms' total turnovers from new/improved products and services by multiplying the mentioned turnover shares and firms' total turnovers.[3] Fourth, the other way around, we measure firms' turnovers from established products or services by multiplying the reciprocal turnover share from new/improved products and services with firms' total turnovers.

Public procurement **-** Based on the merger of the Mannheim Innovation Panel and the Tenders Electronic Daily database, we generate four variables on firms' won public procurement tenders. First, we create two dichotomous variables equal to one if a firm won at least one price-based or criteria-based procurement tender within the last three years, and zero otherwise. In addition, as a measure for winning public procurement tenders in general, we create a dichotomous variable equal to one, if a firm won at least one public procurement tender within the last three years. Finally, we measure the average word count of the criteria lists in the criteria-based tenders a firm won within the last three years. In the Tenders Electronic Daily database, these lists summarize the award criteria applied under the most economically advantageous tender principle, covering both broad categories such as price, quality, and environmental aspects and more specific subcategories such as emissions,

[3] The turnover shares relate to the turnover shares in the current year generated with new/improved products or services introduced within the last three years.

durability, or delivery time (Stake, 2017; Krieger and Zipperer, 2022). To limit the influence of outliers, we winsorize the average criteria length at the 95th percentile.

Control variables - Following the work of Krieger and Zipperer (2022) and Czarnitzki et al. (2020), we use various control variables to tackle omitted variable bias within our estimations.

Firm structure - To control for the structure of a firm, we extract its number of employees, as well as the membership of a firm within a national/international company group measured by two dichotomous variables equal to one, if a firm is a member of a national/international company group, and zero otherwise. Moreover, we create a firm's capital and labor intensity measured by dividing a firm's personnel costs and fixed assets by its total turnover. Also, we consider its exporter status with a dichotomous variable equal to one if a firm has positive export turnovers, and zero otherwise. Finally, we use firm fixed effects to consider all time-constant differences between firms.

Innovation capabilities - We use various information on firms' innovation inputs from the Mannheim Innovation Panel and the PATSTAT database. More precisely, we use the share of employees with a university degree from the Mannheim Innovation Panel, and we create two dichotomous variables, the first being equal to one if a firm engages in continuous internal R&D, and zero otherwise, and the second being equal to one if a firm engages in occasional internal R&D, and zero otherwise. Furthermore, we measure a firm's innovation intensity by dividing its innovation expenditures by its turnovers. Finally, using the PATSTAT database, we estimate the patent application stock of each firm using a depreciation rate of 15 percent.

Market environment - We create industry-year fixed effects from the Mannheim Innovation Panel based on 21 industries aggregated from the NACE Rev. 2 classification (e.g., Czarnitzki et al., 2020) to control for aggregate trends being the same for all firms within an industry. Moreover, we generate a dichotomous variable equal to one if a firm is located in East Germany and zero otherwise.

3.3. Descriptive statistics

The combined dataset comprises 15,623 firm-year observations from 4,675 firms over the period 2012 to 2019. Descriptive statistics of our constructed variables are demonstrated in Table 1. Regarding the innovation outcome variables described in Section 3.2, 29.9 percent of our firm-year observations involve firms that introduced new/improved products or services within the last three years. These firms generate, on average, EUR 20.3 million in turnover from innovative products and services in the current year. By comparison, average turnover from established products and services amounts to EUR 69 million, implying an average share of innovative turnover of 7.5 percent.

With respect to public procurement, 6.6 percent of our sample firm-year observations won at least one price-based public procurement tender within the last three years, and 4.7 percent of firm-year observations won at least one criteria-based procurement tender. Overall, 8.7 percent of the sample won at least one public procurement contract, either price-based or criteria-based, within the same period. The fact that this share is smaller than the sum of the two tender types indicates that some firms participate in both types of procurement. The average length of award criteria amounts to 0.195, reflecting that this variable is defined as the average number of words in criteria-based tenders won within the last three years and takes the value zero for firm-year observations without such tenders. Accordingly, the low mean primarily reflects the large share of firms that do not participate in criteria-based procurement, while among participating firms the effective criteria length is higher.

Table 1 - Descriptive statistics

Variable	Mean	Std. dev.	Min	Max
Innovation variables				
New/Improved products/services within last three years (0/1)	0.299	0.458	0	1
Turnover with new/improved products/services (EUR million)	20.292	603.569	0	48,995
Turnover with established products/services (EUR million)	69.192	852.456	0	34,230
Turnover share with new/improved products/services (0-1)	0.075	0.173	0	1
Public procurement variables				
Winning price-based public procurement tender within last three years (0/1)	0.066	0.248	0	1
Winning criteria-based public procurement tender within last three years (0/1)	0.047	0.212	0	1
Winning any public procurement tender within last three years (0/1)	0.087	0.282	0	1
Average number of words in the award criteria list of all won criteria-based tenders within last three years	0.160	.976	0	14
Control variables				
Number of employees	296.363	4,721.54	0.500	379,000
Share of employees with university degrees (0-1)	0.223	0.264	0	1
Continuous R&D activities (0/1)	0.224	0.417	0	1
Occasional R&D activities (0/1)	0.083	0.276	0	1
Innovation expenditures/turnovers	0.042	0.145	0	3.400
Personnel costs/turnovers	0.367	0.268	0	8.500
Tangible assets/turnovers	0.632	1.934	0	38.300
Patent stock	1.649	22.329	0	900.200
Export turnovers (0/1)	0.457	0.498	0	1
Located in East Germany (0/1)	0.385	0.487	0	1
National company group member (0/1)	0.134	0.341	0	1
International company group member (0/1)	0.147	0.355	0	1

Note: The variable "Average number of words in award criteria" is averaged over criteria-based tenders won within the last three years and equals zero for firm-years observations without criteria-based procurement. The number of observations equals 15,623.

In total, we observe 1,364 firm-year observations with at least one public procurement contract win within the last three years. Of these 733 observations (53.7 percent), correspond to firms that won only price-based tenders within the previous three-year period and therefore have an average criteria word count of zero. The remaining 631 firm-year observations correspond to firms that won at least one criteria-based tender within the same period. Figure 1 focuses on this subsample of 631 firm-year observations. The distribution of the average criteria length is right-skewed, with most observations concentrated at relatively low values, while higher average word counts become increasingly rare, with values reaching up to 14 words.

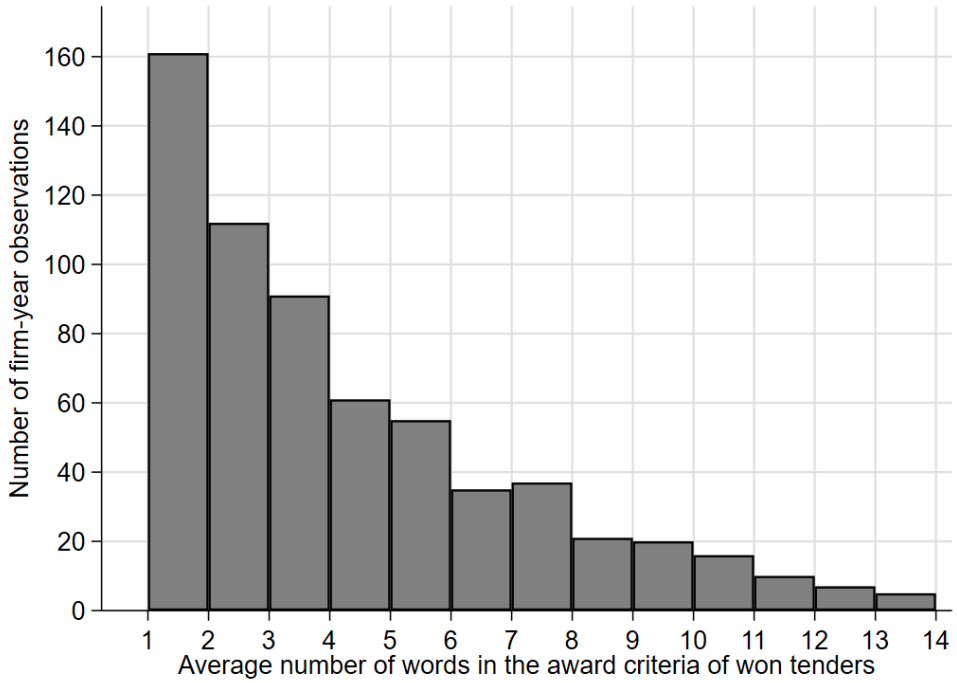

Figure 1 - Distribution of the average word count of criteria list

Note: The figure is based on 631 firm-year observations with at least one win in a public tender including additional award criteria within the last three years. It shows the distribution of the average word count across the criteria lists of all criteria-based tenders a firm won within the last three years.

4. Empirical strategy

The empirical strategy identifies the association of winning public procurement within the last three years with our hypothesized outcomes. More specifically, we estimate the relation between winning procurement tenders with different amounts of additional award criteria on

i) the introduction of new/improved products and services, and their associated turnover, and ii) the turnover from established products and services, and iii) the turnover share of new/improved products and services.

The combination of the Mannheim Innovation Panel and the Tenders Electronic Daily database allows to i) differentiate between firms that won public procurement tenders during the last three years, and firms which did not win a public procurement tender during the last three years, and ii) to observe firms in both groups over time, i.e. we observe firms before and after they won a public procurement tender within the last three years. Thus, we are able to implement a two-way fixed effects estimator to test our hypotheses.[4] Formally, we estimate:

$$Y_{it} = \beta_0 + \beta_1 PP_{it} + \beta_2 PPCL_{it} + \beta_3 PPCL_{it}^2 + \boldsymbol{X}_{it}\beta_4 + \theta_i + \tau_{it} + \varepsilon_{it}, \quad (1)$$

where Y_{it}represents the respective outcome of firm i in year t. PP_{it} is a dichotomous variable equal to one if a firm won at least one public procurement tender during the last three years, and zero otherwise. $PPCL_{it}$ measures the average number of words in the award criteria across all criteria-based tenders won by firm i during the last three years, while $PPCL_{it}^2$ is its squared term. This specification covers both price-based and criteria-based public procurement within a unified framework. In particular, firms that won only price-based tenders have $PPCL_{it} = 0$, such that β_1 captures the association between winning price-based public procurement and Y_{it}. By contrast, firms that won tenders with additional award criteria have $PPCL_{it} > 0$. For these firms, the association between procurement wins and the outcome is given by $\beta_1 + \beta_2 PPCL_{it} + \beta_3 PPCL_{it}^2$, such that β_2 and β_3 capture how the association changes with the extent of criteria-based procurement. Accordingly, β_2 captures the initial change in the outcome as

[4] We employ a two-way fixed effects specification as our empirical strategy because it is best suited to our setting. It allows us to exploit within-firm variation over time while jointly estimating multiple parameters of interest, including the potentially non-linear association between additional award criteria and firm outcomes. In comparison, a difference-in-differences design is less appropriate as our analysis requires the estimation of several parameters simultaneously, including a continuous treatment dimension and its quadratic term, which would likely lead to a violation of its identification assumptions. An instrumental-variable approach is likewise less appropriate, as it would require valid and sufficiently strong instruments not only for public procurement wins, but also for the extent of additional award criteria and its squared term. The required exclusion restrictions would likewise be difficult to justify empirically.

the average number of criteria increases, while β_3 captures the curvature of this relationship. The vector $\boldsymbol{X}_{it}$ includes our set of firm-level control variables. Finally, θ_i and τ_{it} represent firm fixed effects and industry-year fixed effects respectively and thus allow us to control for unobservable time-constant firm characteristics and macroeconomic trends per industry and year. ε_{it} is the error term.

5. Results

5.1. Baseline results

Table 2 reports our baseline results from the two-way fixed-effects regression specified in Equation (1).

The coefficient on winning a public procurement contract (PP) captures the association between winning a price-based public procurement tender and firms' innovation outcomes. In line with H2, Columns (1) and (2) show that winning price-based public procurement tenders is associated with less favorable product and service innovation outcomes. More specifically, winning such tenders is associated with a 7.0 percentage point lower probability of introducing new or improved products and services and with an 11.7 percent lower turnover generated from these products and services. These results suggest that tenders awarded solely on the basis of price are related to lower innovation performance among winning firms.

Moreover, in line with H3, Columns (3) and (4) show that winning price-based public procurement tenders is associated with a stronger focus on established products and services. Winning such tenders is associated with a 4.7 percent higher turnover from established products and services and with a 2.0 percentage point lower turnover share of new or improved products and services. Taken together, these results indicate that price-based procurement is associated not only with weaker innovation outcomes, but also with a relative shift towards established products and services. Turning to H1, the coefficients on PPCL and

its squared term $PPCL^2$ are positive for the linear term and negative for the squared term when product and service innovation measures are used as dependent variables in Columns (1), (2), and (4). This pattern is consistent with an inverse U-shaped relationship between the average criteria length in won criteria-based tenders and firms' innovation outcomes. Thus, the inclusion of additional award criteria is positively associated with firms' innovation performance up to a certain point, while a more extensive use of criteria is associated with less favorable innovation outcomes thereafter. By contrast, Column (3) shows the opposite pattern for turnover from established products and services.

Figure 2 illustrates these relationships by presenting predicted values and 95 percent confidence intervals for different average criteria lengths, while holding all remaining variables at their means. Figures 2.A, 2.B, and 2.D show the inverse U-shaped relationship between the average criteria length and firms' product and service innovation outcomes. They further indicate that a significant share of firms winning criteria-based tenders lies beyond the turning point, where the marginal association becomes negative: 27.42 percent for the dichotomous innovation indicator, 18.54 percent for turnover from new or improved products and services, and 19.49 percent for the turnover share of new or improved products and services. In line with this, Figure 2.C shows a U-shaped relationship between the average criteria length and turnover from established products and services. An alternative illustration of these results is provided as Figure B.1 in Appendix B, which illustrates the changes in the marginal effects of winning public procurement tenders depending on the average length of criteria lists.

Table 2 - Baseline results

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover (0-1)
[a]PP (0/1)	-.070***	-.124***	.046**	-.020**
	(.019)	(.035)	(.018)	(.009)
[b]PPCL - Criteria length	.025**	.037**	-.024**	.009*
	(.011)	(.017)	(.009)	(.004)
[b]PPCL - Criteria Length^2	-.002**	-.003*	.002***	-.001*
	(.001)	(.002)	(.001)	(.000)
Ln(employees)	.026**	.073***	.346***	.003
	(.013)	(.015)	(.035)	(.006)
University degree (0-1)	.061	.082**	.061*	.021
	(.037)	(.035)	(.036)	(.016)
Regular R&D (0/1)	.225***	.233***	-.049***	.057***
	(.022)	(.031)	(.016)	(.008)
Occasional R&D (0/1)	.154***	.091***	-.030***	.032***
	(.019)	(.021)	(.012)	(.007)
Innovat. exp./turnovers	.195***	.038	-.030	.098***
	(.041)	(.034)	(.063)	(.025)
Pers. costs/turnovers	-.029**	-.093***	-.374***	-.010
	(.015)	(.025)	(.084)	(.006)
Tang. assets/turnovers	-.002	.000	-.004	.000
	(.003)	(.002)	(.003)	(.002)
Ln(patent stock+1)	.012	.030	.055	-.038*
	(.038)	(.083)	(.054)	(.021)
Exporter (0/1)	-.002	-.002	-.001	.002
	(.018)	(.019)	(.015)	(.007)
East Germany (0/1)	-.169	-.287	-.021	.009
	(.120)	(.327)	(.349)	(.153)
National group (0/1)	-.010	-.023	-.010	-.002
	(.016)	(.021)	(.011)	(.006)
Intern. group (0/1)	-.029	-.033	-.035	.004
	(.027)	(.053)	(.024)	(.010)
Constant	.208***	.149	.763***	.046
	(.066)	(.138)	(.180)	(.061)
Observations	15623	15623	15623	15623
R-squared	.759	.879	.985	.731

*Note: All Estimates are based on OLS. Firm and industry-year fixed effects are included in all columns. Clustered firm-level standard errors are in parentheses. P-values correspond to: *** p<.01, ** p<.05, * p<.1.*

[a]PP (0/1) refers to winning price-based or public procurement tenders in general, including price- and award-based tenders within the last three years.

[b]PPCL refers to the average number of words within the selection criteria of all criteria based public tenders won by a firm over the past three years

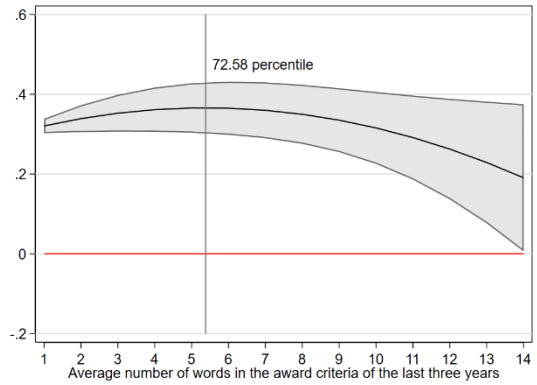

Figure 2A – Introducing new/improved products and services (0/1)

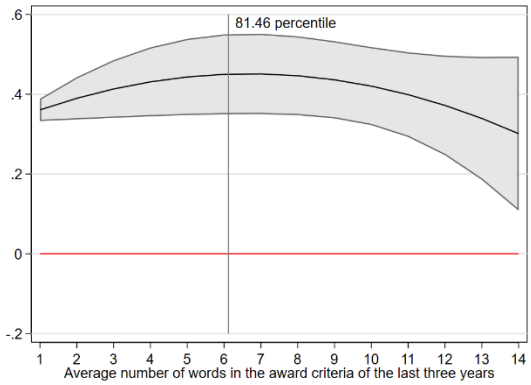

Figure 2B - Ln(turnover with new/ improved products and services + 1)

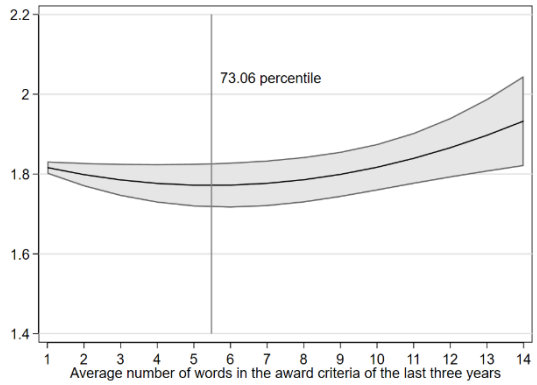

Figure 2C – Ln(turnover with established products and services +1)

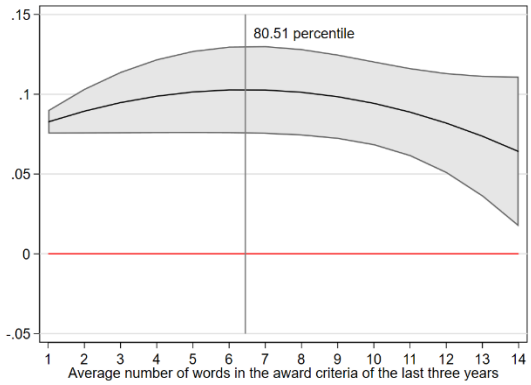

Figure 2D – Turnover shares with new/ improved products and services (0-1)

Figure 2 – (Inverse) U-shaped effects of criteria based public procurement

Note: The average number of words in the award criteria of tenders won over the past three years is calculated as the total number of words across all won tenders with additional award criteria during this period, divided by the total number of such tenders. The figures illustrate the following: i) Predicted values for our four dependent variables at the sample mean, across varying levels of the average number of words. ii) The 95% confidence intervals for these predicted values. iii) The percentile rank of the average word count at the minimum and maximum predicted values for firms winning criteria-based tenders in the past three years.

5.2. Robustness tests

To rule out the possibility of our results being driven by procurer, product, or service types related to firms' won tenders, we exclude various procurer, product, and service types from our regressions in a leave-one-out analysis. Moreover, we test the robustness of our results to the exclusion of our control variables to tackle the risk of using bad controls.

Public procurer types – A primary concern is that our results may stem from a correlation between public procurer types and the absence of award criteria in public tenders. Specifically, it could be that certain types of public procurers i) include additional criteria less or more frequently in their tenders, and ii) possess unobserved characteristics that drive our results. In this case, our estimates could be affected by omitted variable bias.

In the Tenders Electronic Daily database, each tender is assigned to one of ten procurer types. To address this concern, we use this classification and re-run the three main coefficients (PP, PPCL and $PPCL^2$) from our primary estimation (Table 2) on ten subsamples, each excluding firms that have won a tender from a particular procurer type within the last three years. The results of this robustness test are summarized in Figure B2-B5 in Appendix B. Overall, our previous findings remain robust, though their statistical significance decreases slightly, likely due to the reduction in observations.

Product and service types - A similar source of omitted variable bias might stem from differences in the product and service types of public tenders. Certain types of products and services may i) include additional criteria less frequently in their tenders, and ii) have unobserved characteristics that could influence our results.

To address this concern, we use the product and service classification available in the Tenders Electronic Daily database, similar to the procurer type classification previously. The products and services covered within a tender are classified according to the Common Procurement Vocabulary. We use its two-digit level, covering 45 different classes as displayed in Table B.1

in Appendix B, and re-run the three main coefficients of our baseline estimations on subsamples, excluding each class separately.[5] As shown in Figures B6 – B9 in Appendix B, our results remain largely robust, though they slightly lose statistical significance, again.

Bad controls - To tackle the risk of including bad controls within our estimations, we re-estimate our baseline analysis without using our control variables. As demonstrated in Table B2 our previous results are robust.

6. Conclusion

Discussion - The examination of winning public procurement tenders with different amounts of additional award criteria reveals significant heterogeneous associations with firms' innovativeness.

Price-based public procurement - We find that firms winning price-based public procurement tenders - tenders awarded solely based on price - show lower product and service innovativeness: they are less likely to introduce new or improved products and services and generate lower turnover from them. In contrast, their turnover from established products and services is higher.

Criteria-based public procurement - Winning criteria-based public procurement tenders - tenders awarded based on additional criteria next to price - is associated with an inverse U-shaped relationship between the average length of criteria lists in won tenders and firms' innovation probabilities, innovation-related turnovers, and turnover shares. This suggests that the use of additional award criteria may initially strengthen firms' innovativeness, but that this relationship weakens and can turn negative when criteria become too extensive.

Taken together, the results suggest that public procurement design matters not only in terms of whether additional criteria next to the price are used, but also in terms of how extensively

[5] A list of all classes is provided as Table B1 in Appendix B

they are applied. For public procurers and policymakers, this implies that reducing exclusive reliance on price may be relevant for supporting innovation, while an overly extensive use of award criteria may limit such effects. Accordingly, the findings point to the importance of a balanced use of award criteria.

Limitations - A limitation of our analysis is its focus on large public procurement tenders covered by the Tenders Electronic Daily database. It is possible that our results do not hold or may be weaker for smaller tenders. Moreover, the additional award criteria covered by the Tenders Electronic Daily database focus on the award phase. Thus, additional criteria established as part of the technical specifications of a public procurement tender are not covered by our empirical investigation (Igarashi et al., 2015). Furthermore, we cannot claim causality based on our findings due to our empirical strategy being limited to two-way fixed effects estimates given the complexity of our analyzed mechanisms covering two separate procurement types of interest and non-linear relations. Finally, our analysis concentrates on the effects of public procurement on firms, while abstracting from the public procurer. Thus, it does not consider, for example, the additional costs for public procurers resulting from including additional award criteria.

Future research – Building on these limitations, a naturally emerging extension would be an estimation of the costs of including different kinds of additional criteria in public procurement tenders from the side of the procurer. Also, further considering potentially heterogeneous effects of winning public procurement tenders from different public authorities seems promising in the light of recent research (Patsali, 2024). Lastly, discovering reliable identification strategies to isolate causal effects – potentially within specific procurement regimes, product categories, or regional settings – could contribute by verifying our results.

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Appendix A - Example of criteria-based public procurement tender

To understand the role of award criteria in the public procurement process in practice, the diffusion of electrical ferries in Norway is a suitable example of a successful public procurement tender with additional award criteria: Norway is the largest ferry nation in Europe, and thus ferries emit a substantial share of Norwegian's emissions (Siemens Energy & Bellona, 2022). In 2010, the Norwegian public authorities decided to call for tenders for an energy-efficient and low-emission car ferry, intended to replace the conventional diesel-powered ferry. The conventional procurement approach would have entailed describing a specific, pre-existing ferry, prompting firms to compete solely on prices. In contrast, the new procurement strategy involved incorporating a variety of additional award criteria targeted at achieving the desired functionality of the ferry: Emphasizing energy efficiency as an essential criterion, the final tender competition aimed to select the ferry service operator through a weighted combination of two key factors: The evaluation considered 40 percent weightage for the ferry's energy and environmental efficiency along with the innovativeness of the solution, and the remaining 60 percent weightage for the lowest total price of operating the ferry connection. This approach ensured a holistic consideration of eco-friendliness, innovativeness, and cost-effectiveness in determining the winning proposal. The procurement process resulted in the worldwide first provision of a fully electric large ferry, which started operating in 2015. It successfully saves one million liters of diesel every year, while offsetting 570 tons of carbon dioxide and 15 tons of nitrogen oxide emissions in comparison to a conventional ferry operating on the same route. Furthermore, this tender sparked the creation of a lead market for low-emission ferries and was the starting point for a significant diffusion of innovative, energy-efficient ferries in Norway. Since 2015, 60 additional electric or hybrid-electric ferries started operating in Norway (Baron, 2016; Rostad Sæther and Moe, 2021; Krieger and Zipperer, 2022). This example demonstrates the significant impact that the consideration of additional award criteria in public procurement contracts can exert on their innovation outcomes.

Appendix B

B.1. Additional figures

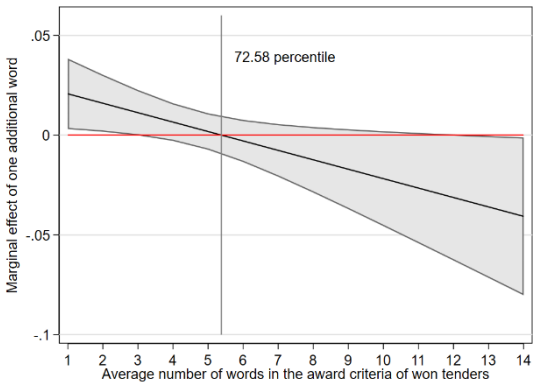

Figure B1 A – Introducing new/improved products and services (0/1)

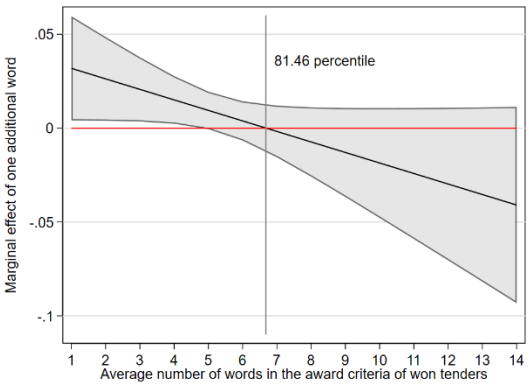

Figure B1 B - Ln(turnover with new/ improved products and services + 1)

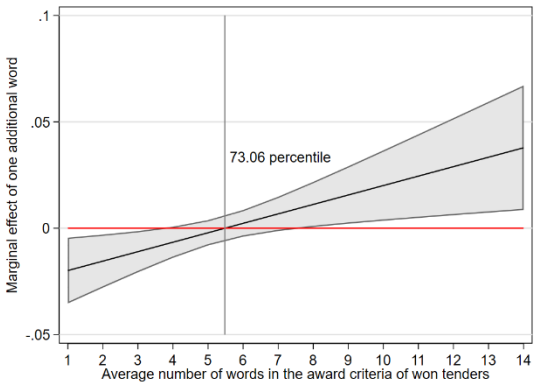

Figure B1 C – Ln(turnover with established products and services +1)

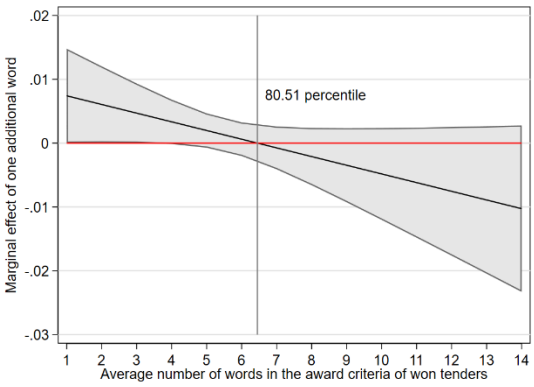

Figure B1 D – Turnover shares with new/ improved products and services (0-1)

Figure B1 – Marginal effect of additional words included in the award criteria list

Note: The average number of words in the award criteria of tenders won over the past three years is calculated as the total number of words across all won tenders with additional award criteria during this period, divided by the total number of such tenders. The figures illustrate the following: i) Marginal effect for our four dependent variables at the sample mean, across varying levels of the average number of words. ii) The 95% confidence intervals for these marginal effects. iii) The percentile rank of the average word count at the minimum and maximum predicted values for firms winning criteria-based tenders in the past three years.

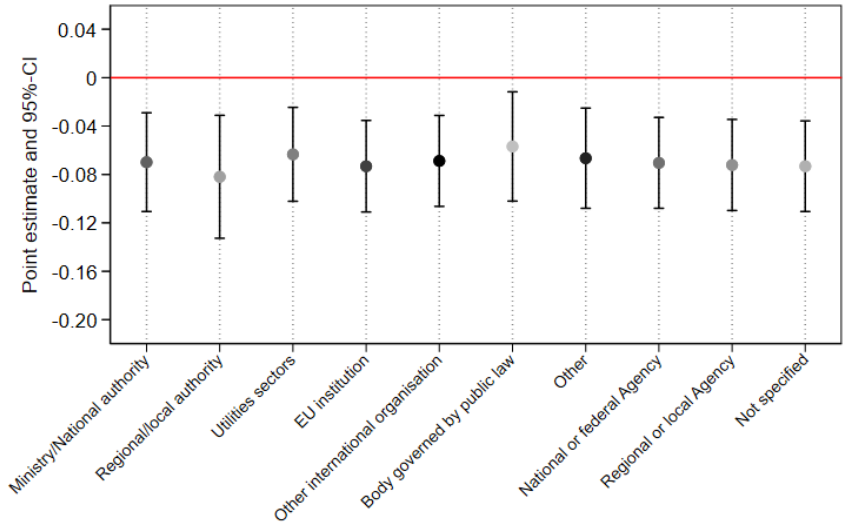

Figure B2 A – Point estimates PP (0/1) for introducing new/improved products and services (0/1) excluding public authority types

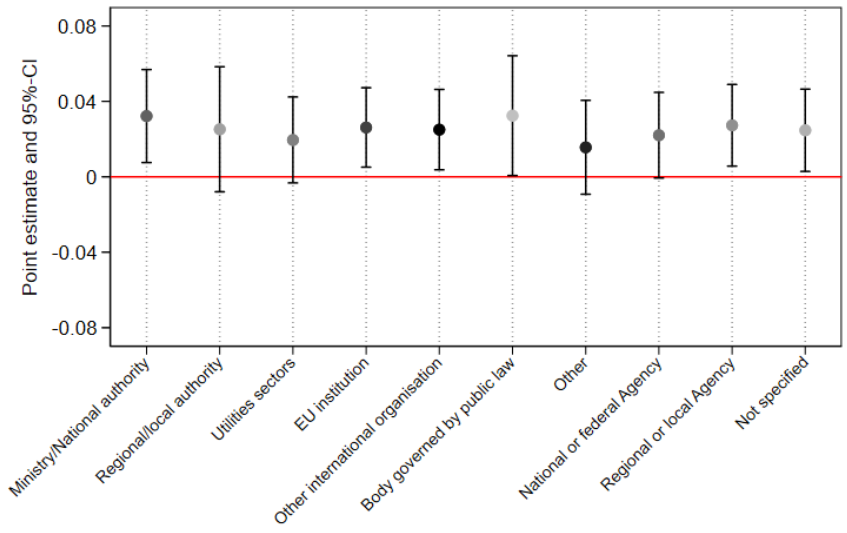

Figure B2 B – Point estimates (PPCL – Criteria Length) for introducing new/improved products and services (0/1) excluding public authority types

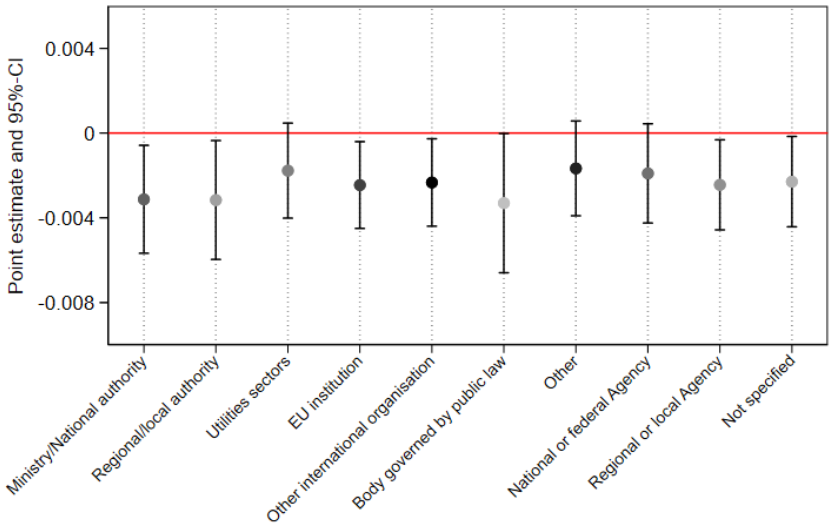

Figure B2 C – Point estimates (PPCL – Criteria Length²) for introducing new/improved products and services (0/1) excluding public authority types

Figure B2 – Baseline estimates for introducing new/improved products and services (0/1) excluding tenders of each public authority type

Note: Each point estimate represents the results for three main coefficients from the baseline estimation, re-run on ten subsamples, each excluding observations from the baseline sample that won at least one procurement tender by one of the ten public authority types in the last three years. Confidence intervals are provided on the 95% level.

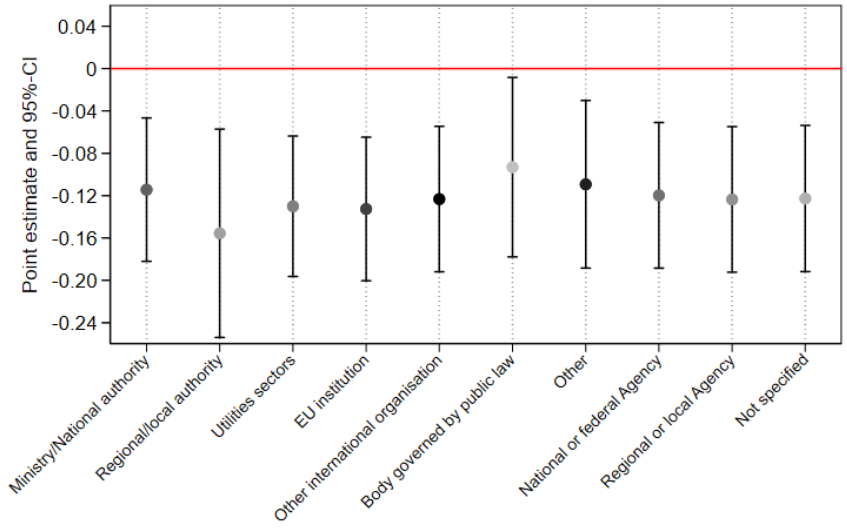

Figure B3 A – Point estimates PP (0/1) for ln(turnover with new/improved products and services +1) excluding public authority types

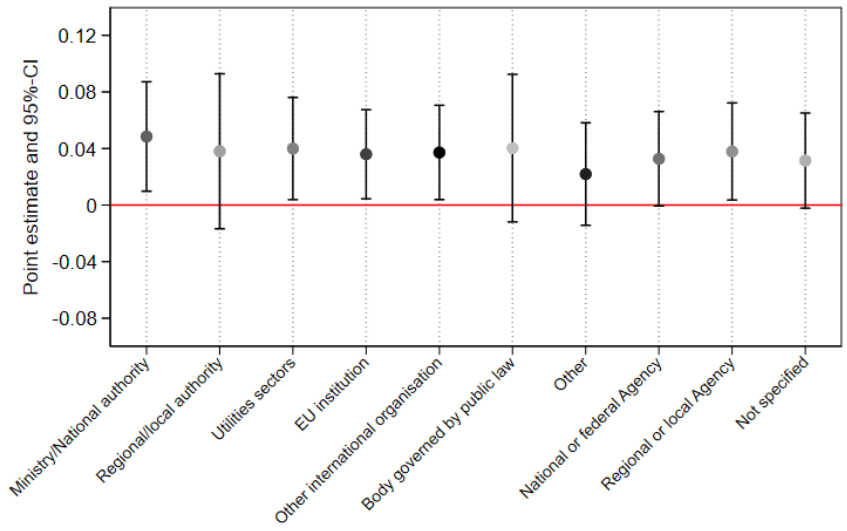

Figure B3 B – Point estimates (PPCL – Criteria Length) for ln(turnover with new/improved products and services +1) excluding public authority types

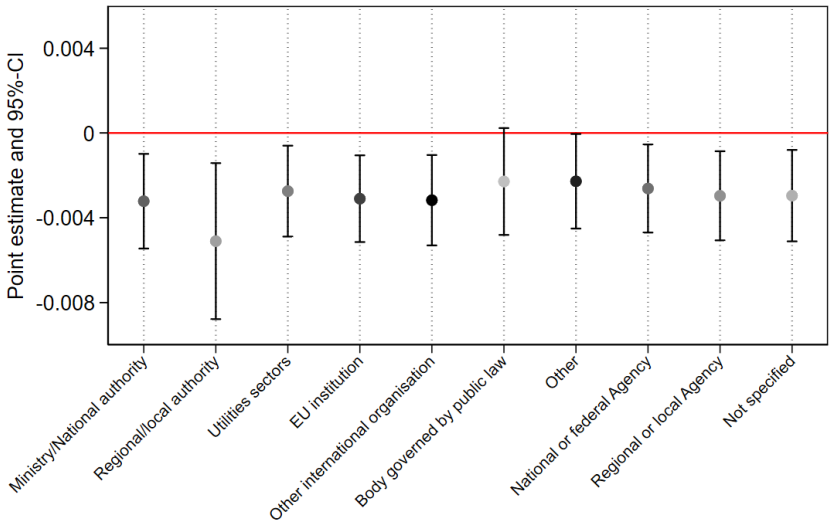

Figure B3 C – Point estimates (PPCL – Criteria Length²) for ln(turnover with new/improved products and services +1) excluding public authority types

Figure B3 – Baseline estimates for ln(turnover with new/improved products and services +1) excluding tenders of each public authority type

Note: Each point estimate represents the results for three main coefficients from the baseline estimation, re-run on ten subsamples, each excluding observations from the baseline sample that won at least one procurement tender by one of the ten public authority types in the last three years. Confidence intervals are provided on the 95% level.

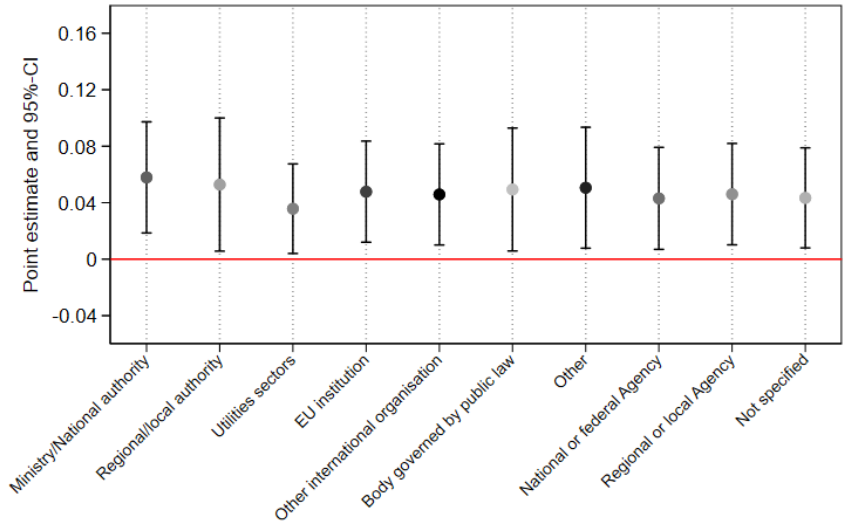

Figure B4 A – Point estimates PP (0/1) for ln(turnovers with established products +1) excluding public authority types

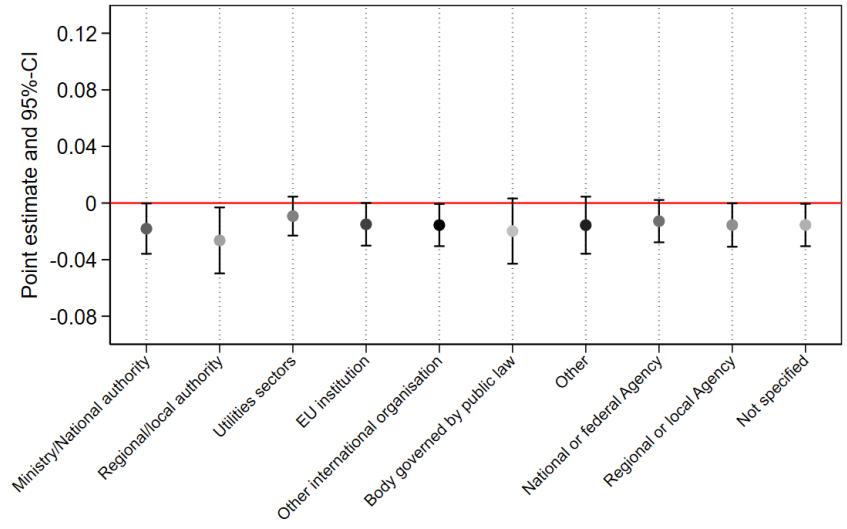

Figure B4 B – Point estimates (PPCL – Criteria Length) for ln(turnovers with established products +1) excluding public authority types

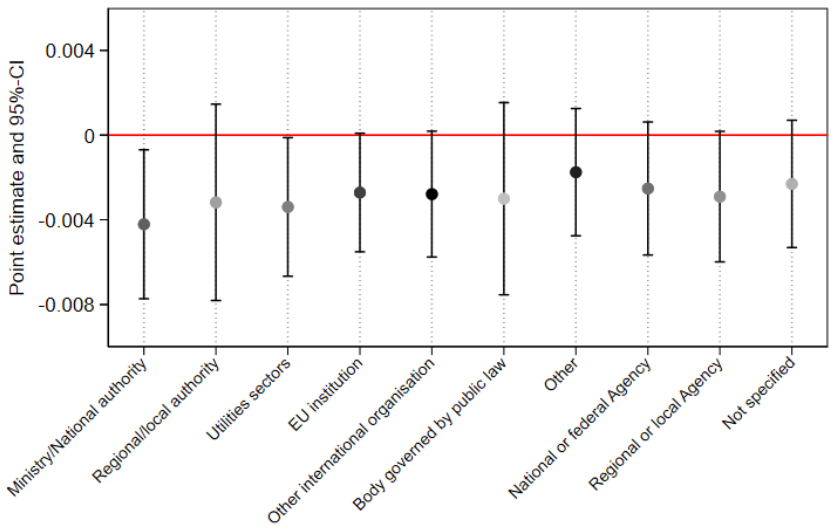

Figure B4 C – Point estimates (PPCL – Criteria Length²) for ln(turnovers with established products +1) excluding public authority types

Figure B4 – Baseline estimates for ln(turnovers with established products +1) excluding tenders of each public authority type

Note: Each point estimate represents the results for three main coefficients from the baseline estimation, re-run on ten subsamples, each excluding observations from the baseline sample that won at least one procurement tender by one of the ten public authority types in the last three years. Confidence intervals are provided on the 95% level.

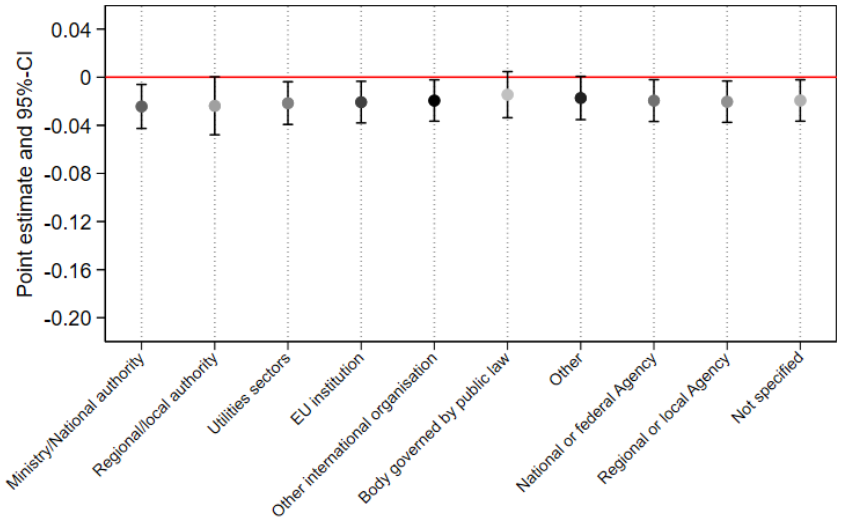

Figure B5 A – Point estimates PP (0/1) for turnover shares with new/improved products and services excluding public authority types

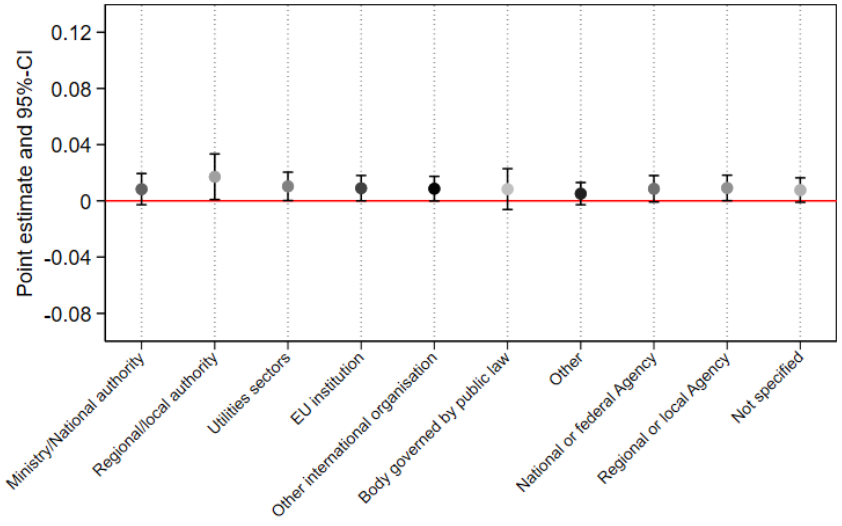

Figure B5 B – Point estimates (PPCL – Criteria Length) for turnover shares with new/improved products and services excluding public authority types

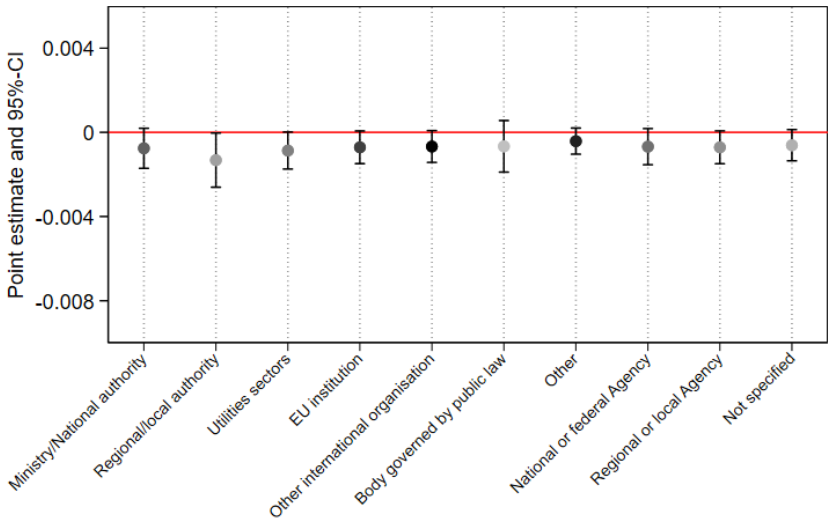

Figure B5 C – Point estimates (PPCL – Criteria Length²) for turnover shares with new/improved products and services excluding public authority types

Figure B5 – Baseline estimates for turnover shares with new/improved products and services excluding tenders of each public authority type

Note: Each point estimate represents the results for three main coefficients from the baseline estimation, re-run on ten subsamples, each excluding observations from the baseline sample that won at least one procurement tender by one of the ten public authority types in the last three years. Confidence intervals are provided on the 95% level.

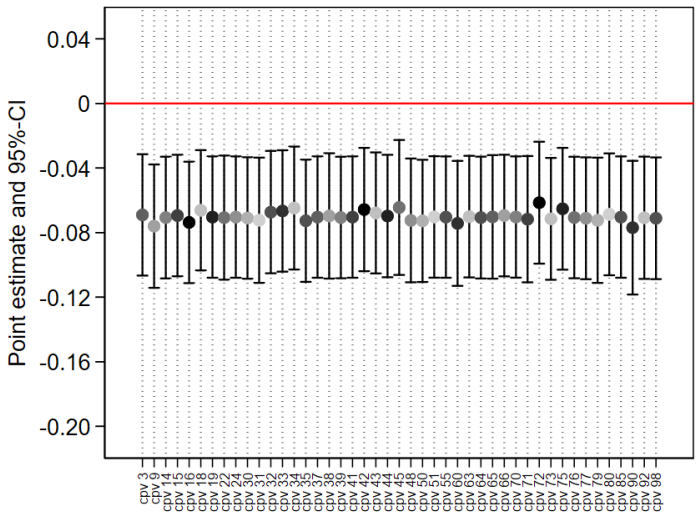

Figure B6 A – Point estimates (PP(0/1)) for introducing new/improved products and services (0/1) excluding tenders for each product/service type

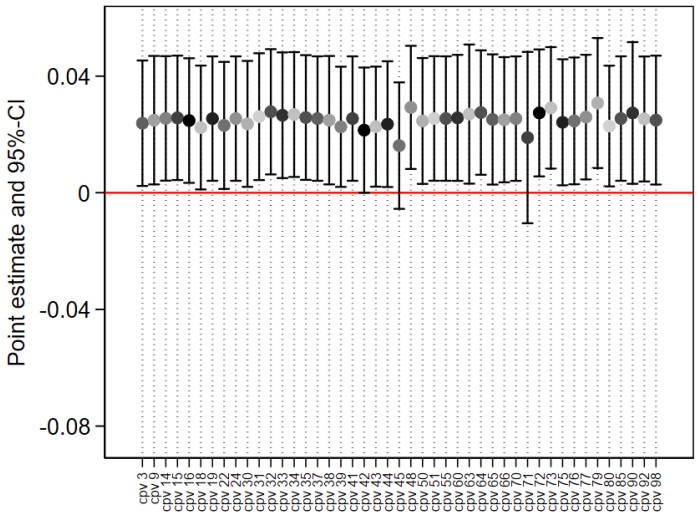

Figure B6 B – Point estimates (PPCL – Criteria Length) for introducing new/improved products and services (0/1) excluding tenders for each product/service type

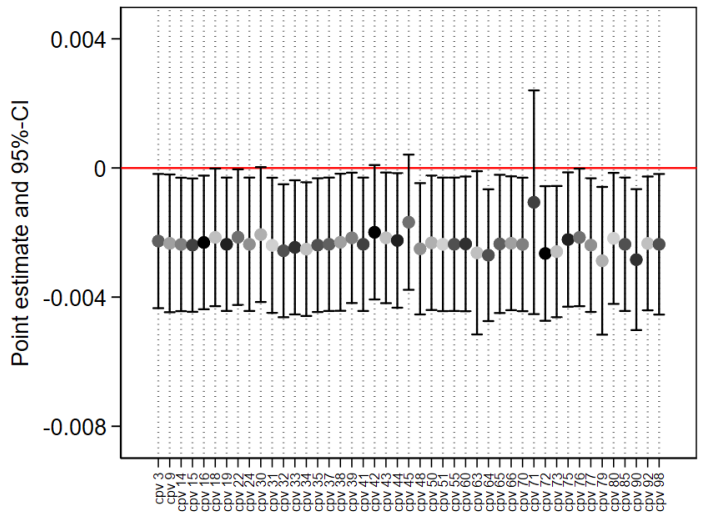

Figure B6 C – Point estimates (PPCL – Criteria Length²) for introducing new/improved products and services (0/1) excluding tenders for each product/service type

Figure B6 – Baseline estimates for introducing new/improved products and services (0/1) excluding tenders for each product and service type

Note: Each point estimate represents the results for three main coefficients from the baseline estimation, re-run on 45 subsamples each excluding observations from the baseline sample that won at least one tender procuring one of the 45 product/service types in the last three years. Confidence intervals are provided on the 95% level. The description of the product and service types of the contract can be found in Table B1 in Appendix B.

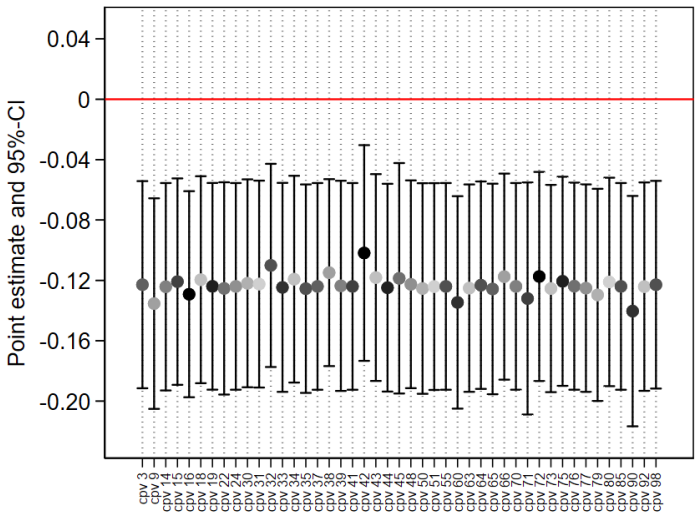

Figure B7 A – Point estimates (PP(0/1)) for ln(turnover with new/improved products and services +1) excluding tenders for each product/service type

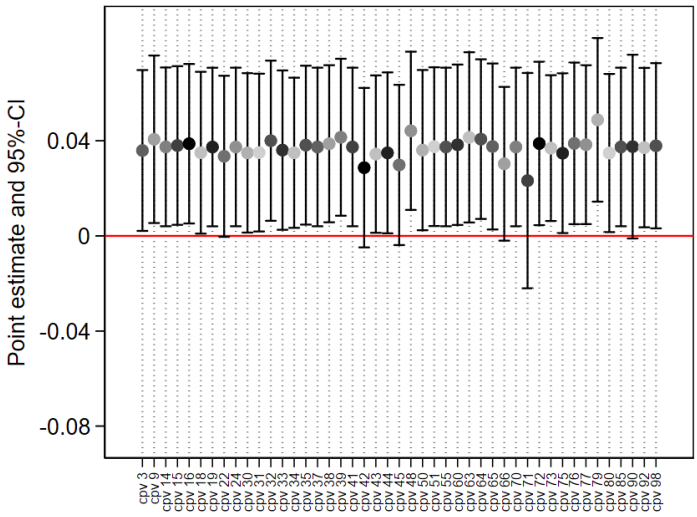

Figure B7 B – Point estimates (PPCL – Criteria Length) for ln(turnover with new/improved products and services +1) excluding tenders for each product/service type

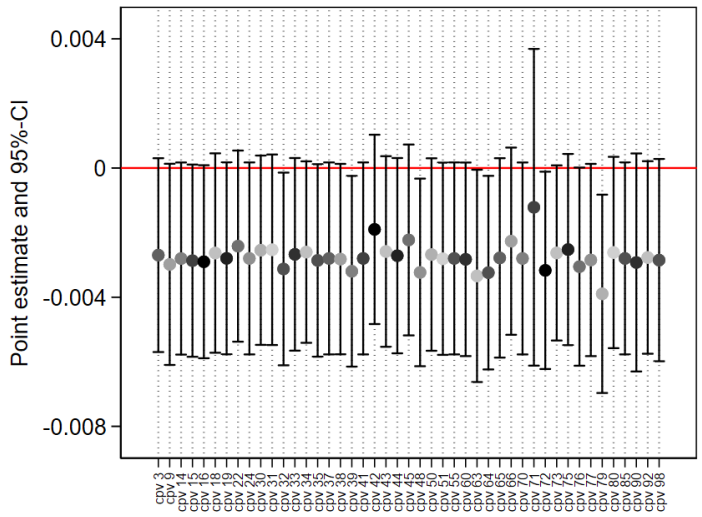

Figure B7 C – Point estimates (PPCL – Criteria Length²) for ln(turnover with new/improved products and services +1) excluding tenders for each product/service type

Figure B7 – Baseline estimates for ln(turnover with new/improved products and services +1) excluding tenders for each product and service type

Note: Each point estimate represents the results for three main coefficients from the baseline estimation, re-run on 45 subsamples each excluding observations from the baseline sample that won at least one tender procuring one of the 45 product/service types in the last three years. Confidence intervals are provided on the 95% level. The description of the product and service types of the contract can be found in Table B1 in Appendix B.

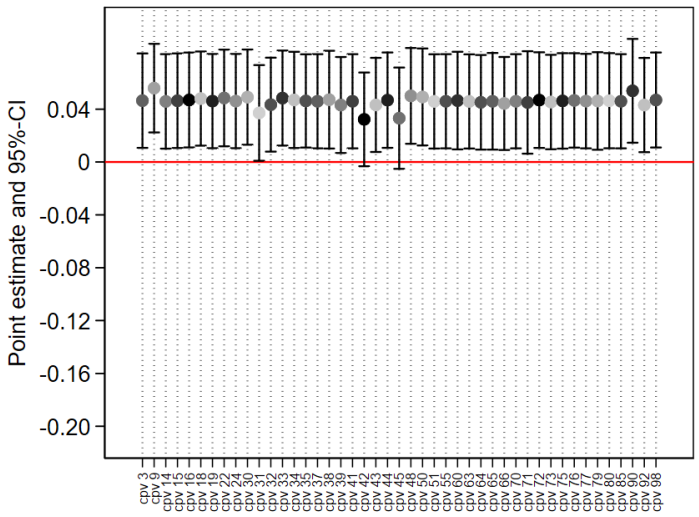

Figure B8 A – Point estimates (PP(0/1)) for ln(turnovers with established products +1) excluding tenders for each product/service type

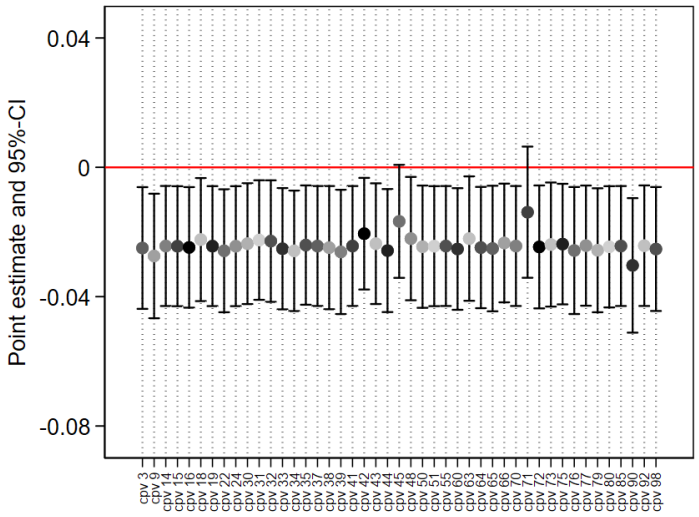

Figure B8 B – Point estimates (PPCL – Criteria Length) for ln(turnovers with established products +1) excluding tenders for each product/service type

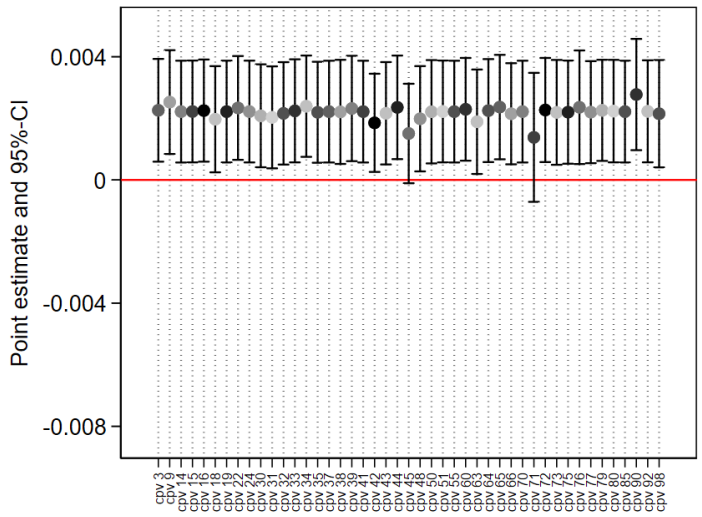

Figure B8 C – Point estimates (PPCL – Criteria Length²) for ln(turnovers with established products +1) excluding tenders for each product/service type

Figure B8 – Baseline estimates for ln(turnovers with established products +1) excluding tenders for each product and service type

Note: Each point estimate represents the results for three main coefficients from the baseline estimation, re-run on 45 subsamples each excluding observations from the baseline sample that won at least one tender procuring one of the 45 product/service types in the last three years. Confidence intervals are provided on the 95% level. The description of the product and service types of the contract can be found in Table B1 in Appendix B.

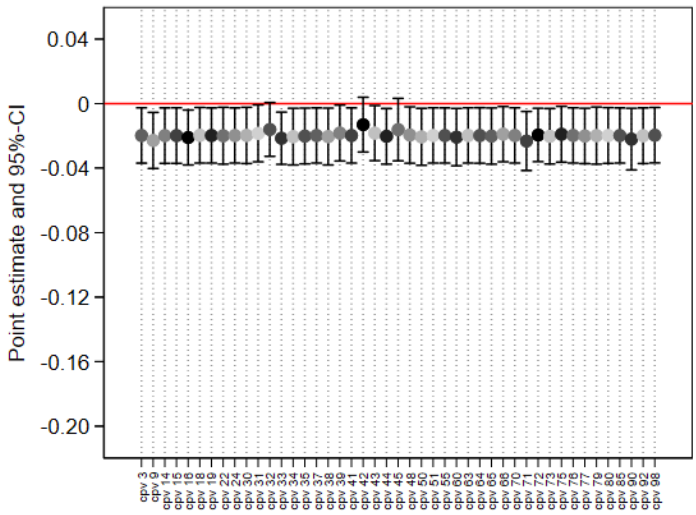

Figure B9 A – Point estimates (PP(0/1)) for turnover shares with new/improved products and services (0-1) excluding tenders for each product/service type

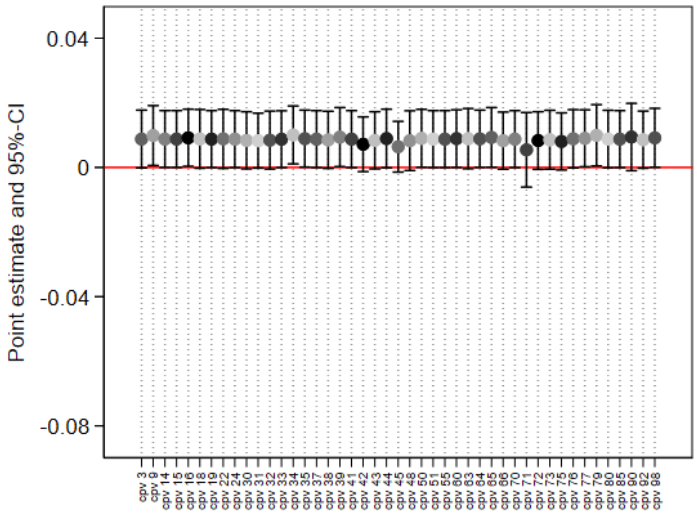

Figure B9 B – Point estimates (PPCL – Criteria Length) for turnover shares with new/improved products and services (0-1) excluding tenders for each product/service type

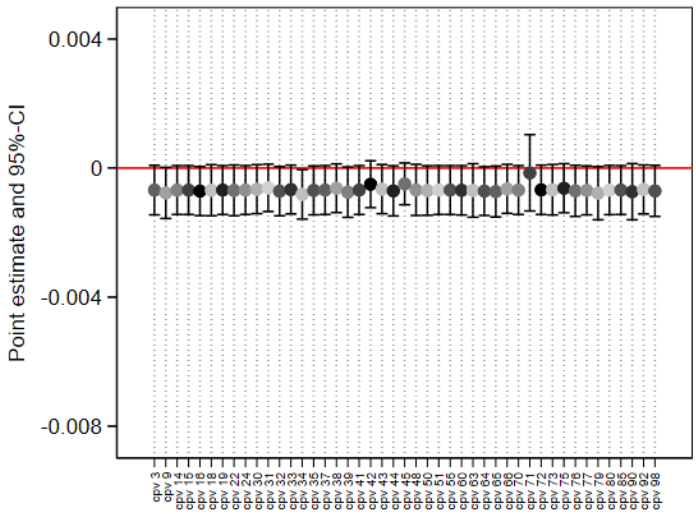

Figure B9 C – Point estimates (PPCL – Criteria Length²) for turnover shares with new/improved products and services (0-1) excluding tenders for each product/service type

Figure B9 – Baseline estimates for turnover shares with new/improved products and services (0-1) excluding tenders for each product and service type

Note: Each point estimate represents the results for three main coefficients from the baseline estimation, re-run on 45 subsamples each excluding observations from the baseline sample that won at least one tender procuring one of the 45 product/service types in the last three years. Confidence intervals are provided on the 95% level. The description of the product and service types of the contract can be found in Table B1 in Appendix B.

Table B1 – Two-digit common procurement vocabulary classes available in the Tenders Electronic Daily database

CPV class	CPV Name
3	Agricultural products from plant cultivation and animal husbandry, as well as fisheries, forestry, and related products
9	Petroleum products, fuel, electricity, and other energy sources
14	Mining, basic metals, and related products
15	Food, beverages, tobacco, and related products
16	Agricultural machinery
18	Clothing, footwear, luggage items, and accessories
19	Leather and textile products, plastic and rubber materials
22	Printed matter and related products
24	Chemical products
30	Machines, materials, and accessories for office and computer, except furniture and software packages
31	Electrical machinery, equipment, supplies, and consumables; lighting
32	Radio and television sets, communication and telecommunication equipment and accessories
33	Medical equipment, pharmaceuticals, and personal care products
34	Means of transport and products for transportation purposes
35	Equipment for security purposes, fire fighting, police, and defense
37	Musical instruments, sports equipment, games, toys, handicrafts, and art supplies and accessories
38	Laboratory equipment, optical devices, and precision instruments (except glasses)
39	Furniture (including office furniture), accessories, household appliances (excluding lighting), and cleaning supplies
41	Raw water and treated water
42	Industrial machinery
43	Machinery and equipment for mining and stone crushing, construction machinery
44	Building structures and materials; construction auxiliary products (excluding electrical appliances)
45	Construction work
48	Software package and information systems
50	Repair and maintenance services
51	Installation (except software)
55	Services of the hotel and restaurant industry and retail trade
60	Transport and conveyance services (excluding waste transport)
63	Auxiliary and related activities in the field of transportation; travel agency services
64	Postal and telecommunication services
65	Utility companies

66	Financial and insurance services
70	Real estate services
71	Services of architecture, construction, and engineering offices and testing laboratories
72	IT services: consulting, software development, internet, and support
73	Research and development services and related consulting
75	Services of public administration, defense, and social security
76	Services related to oil and gas extraction
77	Services in agriculture, forestry, horticulture, aquaculture, and beekeeping
79	Business services: law, marketing, consulting, recruitment, printing, and security
80	General and vocational education
85	Health and social services
90	Wastewater and waste disposal, cleaning, and environmental protection services
92	Services in the areas of recreation, culture, and sports
98	Other community, social, and personal services

Table B2 - Baseline results without covariates

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover (0-1)
[a]PP (0/1)	-.065***	-.117***	.058***	-.019**
	(.02)	(.035)	(.02)	(.009)
[b]PPCL - Criteria length	.021*	.035**	-.024**	.008*
	(.012)	(.017)	(.012)	(.005)
[b]PPCL - Criteria Length^2	-.002*	-.003*	.002**	-.001
	(.001)	(.002)	(.001)	(.000)
Constant	.303***	.337***	1.833***	.076***
	(.002)	(.003)	(.002)	(.001)
Observations	15623	15623	15623	15623
R-squared	.752	.877	.982	.726

*Note: All Estimates are based on OLS. Firm and industry-year fixed effects are included in all columns. Clustered firm-level standard errors are in parentheses. P-values correspond to: *** p<.01, ** p<.05, * p<.1.*

[a]PP (0/1) refers to winning price-based or public procurement tenders in general, including price- and award-based tenders within the last three years.

[b]PPCL refers to the average number of words within the selection criteria of all criteria-based public tenders won by a firm over the past three years

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