// NO.24-009 | 12/2024

DISCUSSION PAPER

// BASTIAN KRIEGER, MALTE PRUEFER, AND LINUS STRECKE

Public Procurement Can Hinder Innovation

Leibniz Association

ZEW

Public procurement can hinder innovation

Bastian Krieger[a], Malte Pruefer[b], Linus Strecke[c]

First version: February 2024
This version: December 2024

Abstract

Public procurement accounts for 15 to 20 percent of global GDP and is considered an effective innovation policy. However, the negative effects of price-based public procurement - public procurement tenders awarded solely based on their price - on firm innovations have not been investigated, even though it represents the majority of all tenders. We contribute by i) developing a detailed theory on the effects of winning price-based public procurement tenders as a firm and ii) empirically testing our theory by combining representative German data with two-way fixed effect difference-in-differences estimations. In total, the estimations demonstrate winning price-based public procurement reduces firms' product and process innovations on the one hand, and increases firms' focus on their established products and services on the other hand. These results confirm our theory and empirically hold at the level of the individual firm and the German enterprise sector.

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

[a] ZEW – Leibniz Centre for European Economic Research, Technical University Munich
bastian.krieger@zew.de
[b] Faculty of Economics and Business, Center for R&D Monitoring (ECOOM), KU Leuven
malte.pruefer@kuleuven.be
[c] ZEW – Leibniz Centre for European Economic Research, Technical University Berlin
linus.strecke@zew.de

Acknowledgments: We thank Adam Jaffe, Jakob Edler, Stefano Baruffaldi, Uschi Backes-Gellner, Christian Rammer, Bettina Peters, Dirk Czarnitzki, Maikel Pellens, Lowie Cnockaert, Michael Rose and Lena Füner for their valuable comments. We are further thankful for the comments by the participants of the CISS Summer School 2023, the KITZ Workshop on Innovation and Entrepreneurship 2023, the 10th ZEW/MaCCI Conference on the Economics of Innovation and Patenting, the Munich Summer Institute 2024, the KOF-ECOOM Innovation Workshop 2024, the UZH Business Economics Research Seminar 2024, and the seminars at the ZEW Mannheim and the University of Mainz. Moreover, we are grateful for receiving a special mention at the KID2024 Summer School. Finally, we thank Thorsten Doherr from the ZEW Mannheim for providing the merger of the databases.

1. Introduction

Public procurement - the purchase of goods, or services by the public sector - accounts for 15 to 20 percent of global GDP (European Council, 2022), and has increased within the OECD 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 innovations was repeatedly confirmed within the last decade (e.g.; Czarnitzki et al. 2020; Guerzoni and Raiteri, 2015; Krieger and Zipperer, 2022; Patsali, 2024; Stojčić et al., 2020). However, the potential negative effects of price-based public procurement - public procurement tenders without additional criteria within their awardee selection next to the price - on firm innovations have not been analyzed (Chiappinelli et al., 2023). Thus, we develop a theoretical framework on the effects of winning price-based public procurement on heterogeneous firm innovation and test our hypotheses using two-way fixed effects difference-in-differences estimations on a representative survey of German firms.

The theoretical framework builds on and extends the work of Geroski (1990), Edler and Georghiou (2007), and Edquist and Zabala-Iturriagagoitia (2020). Most prominently, it shifts the focus from innovative public procurement towards price-based public procurement and extends previous theories by deriving individual hypotheses on the effects of winning price-based public procurement on firms' product, service, and process innovations, as well as their established products and services. In short, public procurement tenders without additional award criteria next to the price incentivize firms to offer established products and services at a lower price and disincentive them from offering innovative products and services at a higher price, as the quality of products and services is not taken into account by the tenders. Moreover, the tenders incentivize the introduction of innovative processes to reduce costs to offer at lower prices, while they reduce innovative processes implemented as parts of the introduction of innovative products and services.

The empirical analysis tests our hypotheses by extending the work by Czarnitzki et al. (2020) and Krieger and Zipperer (2022). It focuses on the effects of winning price-based procurement

tenders and introduces robustness tests considering the recent literature on the various assumptions of two-way fixed effects difference-in-differences estimations (e.g., Roth et al., 2023).[1] Moreover, by building our data on a combination of the Mannheim Innovation Panel, a representative survey of the German enterprise sector (Peters and Rammer, 2023), and the Tenders Electronic Daily database, data 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), allows us to translate our estimated effects on individual firms to the German enterprise sector.

We find winning price-based public procurement tenders within the last three years reduce firms' turnover with new/improved products and services by 10.6 percent. Moreover, it increases firms' turnover with established products and services by 3.2 percent. Furthermore, firms' cost reductions due to the introduction of new/improved processes decrease by 4.7 percent. The probability of firms introducing new/improved products and services, as well as introducing new/improved processes to lower costs decreases by 5.4, and 3.7 percentage points, too. At the level of the economy, the results are similar: turnovers with product innovations shrink by 7.0 to 9.8 percent, turnovers with established products rise by 6.6 to 9.2 percent, and cost reductions decrease between 1.6 to 2.3 percent.

In addition to these findings, we explore criteria-based public procurement - public tenders that include additional criteria in their awardee selection next to the price - as part of our robustness tests. Our analysis reveals a previously unestablished inverse U-shaped relationship between the average length of the criteria in won tenders and firms' product and service innovations. Thus, while the inclusion of award criteria can foster innovation by enabling firms to propose solutions that exceed established options, an excessive amount of criteria hinders innovation efforts, potentially due to an overly complex set of requirements that complicates contract fulfillment. Notably, between 22.5 and 24.2 percent of firms in our

[1] The focus of Czarnitzki et al. (2020) was on innovative public procurement and of Krieger and Zipperer (2022) on green public procurement. Moreover, mostly due to a limited amount of panel information, both studies were not able to implement a similar variety of robustness tests.

sample winning criteria-based tenders encounter a criteria length associated with a negative marginal innovation effect.

Most prominently, our research extends the scientific discussion on the effects of public procurement on firm innovations by providing a detailed analysis of the effect of price-based and criteria-based public procurement (Chiappinelli et al., 2023; Kundu et al., 2020; Obwegeser and Müller, 2018). We demonstrate significant reductions in firm innovations at both the individual firm level and across the German enterprise sector due to price-based public procurement, while also highlighting the nuanced effects of criteria-based procurement - where excessive criteria can diminish innovation. These findings indicate potential negative implications for long-term competitiveness resulting from both kinds of public procurement. Consequently, 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.[2]

2. Theoretical Framework

Public procurement is the procedure through which public authorities, such as government departments and local authorities, acquire goods or services from private firms. Beside its primary goal - fulfilling the needs and demands of public administration - the significant buying power of the government can be used to stimulate innovation activities in the enterprise sector (Edler and Georghiou, 2007; Obwegeser and Müller, 2018). 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, Srhoj and Coad, 2020; Czarnitzki et al., 2020; Caravella and Crespi, 2021; Krieger and Zipperer, 2022). From a theoretical point of view, the idea of using public procurement to promote innovation has been conceptualized in studies

[2] 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.

by Geroski (1990), Edler and Georghiou (2007) and Edquist and Zabala-Iturriagagoitia (2020). Our theoretical framework builds on and extends these theoretical foundations in three ways:

First, we extend existing theories about potential innovation-enhancing effects of public procurement, manifested by Geroski (1990) and Edler and Georghiou (2007), and address limitations of public procurement as an innovation policy tool or even threats 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 governmental demand and public procurement as an instrument for industrial policy and pointed towards its potential in the development and diffusion of new innovations. Following upon a new emerging wave of interest in public procurement among policy makers 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 theoretical framework and extend it by suggesting alternative mechanisms which can have negative effects on innovation.

Second, we built on Edquist and Zabala-Iturriagagoitia (2020) who point towards 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 which describe a very specific, existing product which has to be bought and thus can even prevent suppliers from delivering innovation. Consequently, the authors conclude more innovation can be achieved by shifting from product procurement towards more functional procurement. In our theoretical framework, we

highlight an additional and equally important component of the procurement tender, namely the role of award criteria. We introduce 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. As described in the next sections, specifying award criteria for the procurement tender is an essential part of the procurement process, and our theoretical framework sheds light on how both forms of public procurement – price-based and criteria-based public procurement - can affect different firm innovation outcomes. By doing so, we contribute to the theoretical foundations of public procurement of innovation by shedding light on how individual components of the public procurement procedure impact innovation positively or negatively (Chiappinelli et al., 2023).

Third, Geroski (1990) and Edler and Georghiou (2007) focus on public procurement and its effect on aggregate innovation outcomes, not taking into account different effects of this instrument on product and process innovations separately. However, process innovations are an essential part of firm's innovation activities and can have a significant impact on the returns a firm gains from innovation (Rammer, 2023). Therefore it is important for policy makers, academics and managers alike to understand the different effects public procurement as an innovation policy can exert on process innovations in comparison to product innovations. In our theoretical framework, we suggest that there are opposing effects of price-based public procurement on process innovation and therefore the effect of public procurement and process innovation is ambiguous from a theoretical point of view.

The public procurement procedure is a multi-stage process, whereas each stage has the potential to affect the innovative 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, within this step, 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. Finally, the procuring agency awards the tender to the supplier who best meets the specified criteria.

We focus on public procurement tenders without additional award criteria next to the price - price-based procurement tenders - and their impact on firm innovation. As described above, award criteria are a major component within 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 within their offers receive an increased likelihood of winning the tender (Krieger and Zipperer, 2022). We refer to these tenders as criteria-based procurement tenders. An example is provided in Appendix A.

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, next to difficulties in verifying compliance with environmental requirements, was a major obstacle in using 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.[3] Consequently, these tenders are granted to the firm offering the lowest price for a specified product, or service, and no additional factors are considered. This dominance of price-based procurement tenders prompts us to shift the focus of our analysis to the innovation-effects of

[3] 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.

this common practice of waiving additional award criteria. Specifically, we identify three effects of price-based public procurement tenders on firms' behavior:

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). Therefore, we hypothesize that winning price-based public procurement tenders reduces firms' probability of introducing new/improved products and services and the turnover generated with them.

H1: 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 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 into R&D and hence is costly. Moreover, new supply chains and distribution networks need to be developed. In contrast, focusing on established products and services creates fewer costs, 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 with innovative products and services while increasing firms' turnover with established products and services.

H2: Winning price-based procurement tenders increases firms' turnover with established products and services, and decreases firms' turnover share with new/improved products and services.

The introduction of more efficient production processes is another possibility for a firm to save costs. When firms invest in improving their production processes, they can optimize workflows, automate repetitive tasks (Acemoglu and Restrepo, 2019), and identify areas where time and resources are being underutilized (Bunduchi et al. 2011). As a result, this leads to increased productivity and, in turn, lower costs (Adner and Levinthal, 2001; Mairesse and Mohnen, 2010; Rammer, 2023). Additionally, process innovations often introduce new technologies or methodologies that enable faster, more accurate, and error-free production, further reducing the operational expenses of manufacturing (Bunduchi et al., 2011). Thus, we hypothesize that there is a positive effect of winning price-based procurement tenders on firms' introduction of cost-reducing process innovations.

However, in addition, there might be an indirect, opposing effect on process innovation at the same time: As firms introduce new/improved products and services, they often encounter operational challenges and inefficiencies that prompt them to seek better ways of production, leading them to introduce process innovations as a side product. In turn, process innovations can emerge from product innovations as a byproduct (Damanpour and Gopalakrishnan, 2001; Hullova et al., 2016; Rammer, 2023; Reichstein and Salter, 2006). Since firms theoretically introduce less product innovation due to winning price-based procurement tenders that could also decrease the probability of a firm coming up with a cost-reducing process innovation. Hence, the overall effect of winning price-based public procurement tenders on cost-reducing process innovations is ambiguous and depends on which of the aforementioned mechanisms is dominating.

H3: Winning price-based public procurement tenders increases firms' probability to introduce process innovations if the increase in process innovations in order to reduce costs dominates the decrease in process innovations as a byproduct of less product innovations (and vice versa).

3. Data

3.1. Databases

The data is based on the Mannheim Innovation Panel, the Tender 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 contains, 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 six 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 with new/improved products and services. Third, we create firms' total turnovers with new/improved products and services by multiplying the mentioned turnover shares and firms' total turnovers.[4] Fourth, the other way around, we measure firms' turnovers with established products or services by multiplying the reciprocal turnover shares with firms' total turnovers. Fifth, we take a dichotomous variable equal to one if a firm introduced a new/improved process that reduced their unit costs, and zero otherwise. Sixth, we approximate the total cost reduction due to the introduction of new/improved processes by multiplying the percentage decrease in unit costs due to process innovations with firms' total turnovers, thus, assuming turnovers are associated with total costs.

Public procurement **-** Based on the merger of the Mannheim Innovation Panel and the Tenders Electronic Daily database, we generate two variables on firms' success in winning public procurement tenders. First, as a measure for winning price-based public procurement tenders, we create a dichotomous variable equal to one, if a firm won at least one price-based public procurement tender within the last three years, and zero otherwise.[5] Second, we establish a dichotomous variable equal to one, if a firm won at least one criteria-based public procurement tender using additional award criteria next to the price during the last three years, and zero otherwise, as a proxy for winning public procurement tenders with innovation potential (Stake, 2017).

[4] 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.

[5] We consider a tender being awarded solely based on the price criterion if the tender does not cover any most economically advantageous tender criteria in the Tenders Electronic Daily database, or the only mentioned most economically advantageous tender criterion is the price.

Control variables - Following the work of Krieger and Zipperer (2022) and Czarnitzki et al. (2020), we use various control variables to tackle omitted variables 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 within 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 turnovers. 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 take 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 continuously engages in internal R&D, and zero otherwise, and the second being equal to one if a firm occasionally engages in internal R&D, and zero otherwise. Furthermore, we generate the innovation intensity of a firm measured 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 databases comprise 15,623 firm-year observations from 4,675 firms during the years 2012 to 2019. The descriptive statistics of our constructed variables are demonstrated in Table 1. 6.6 percent of our sample won at least one price-based public procurement tender within the last three years, and 4.7 percent of our sample won at least one criteria-based procurement tender. Furthermore, 29.9 percent introduced new/improved products or services within the last three years, generating turnovers on average of 20.3 million EUR in the current year. The average turnover from established products and services in a current year averages at 69 million EUR, resulting in a turnover share of new/improved products or services of on average 7.5 percent. Moreover, 11.2 percent of observations reduced their costs due to the implementation of new/improved processes within the last three years, whereas the average total cost reduction due to those innovations in the current year amounts to 1.53 million EUR. Lastly, our control variables largely follow values presented in the previous literature (e.g., Krieger and Zipperer, 2022).

4. Identification strategy

The empirical strategy identifies the effect of winning price-based public procurement within the last three years on our hypothesized outcomes. More specifically, we estimate the effect of winning price-based procurement tenders on (H1) the introduction of new/improved products and services, and their associated turnovers, (H2) the turnover with established products and services, and the turnover share of new/improved products and services, and (H3) the introduction of new/improved processes to reduce costs, and the resulting total cost reduction.

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 (in mio. EUR)	20.292	603.569	0	48,995
Turnover with established products/services (in mio. EUR)	69.192	852.456	0	34,230
Turnover share with new/improved products/services (0-1)	0.075	0.173	0	1
Reduction of unit cost due to process innovation within last three years (0/1)	0.112	0.315	0	1
Total cost reduction due to process innovation (in mio. EUR)	1.527	49.899	0	3,923
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
Control variables				
Number of employees	296.363	4,721.54	0.5	379,000
Share of employees with university degree (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	3.4
Personnel costs/turnovers	0.367	0.268	0	8.5
Tangible assets/turnovers	0.632	1.934	0	38.3
Patent stock	1.649	22.329	0	900.2
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

Number of observation for variables related to process innovations equals 15,202. Number of observations for all other variables equals 15,623.

The combination of the Mannheim Innovation Panel and the Tenders Electronic Daily database allows to i) differentiate between firms from the treatment group, i.e. firms that won price-based public procurement tenders during our observation period, and firms in the control group, i.e. firms which did not receive a price-based public procurement tender during our observation period, and ii) to observe firms in both groups over time, i.e. we observe firms in the treatment group before and after they won a price-based public procurement tender within the last three years. Thus, we are able to implement a difference-in-differences estimator to test our hypotheses. A difference-in-differences estimator compares changes in our outcome variables (i) between firms in the treatment and control group and (ii) over time, i.e. before and after the firms in the treatment group received a price-based public procurement tender. Formally, we estimate:

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

where Y_{it} represents the different outcomes of firm i. PP_{it} is a dichotomous variable equal to one if a firm won at least one price-based public procurement tender during the last three years and zero otherwise. Thus, our coefficient of interest is the difference-in-differences estimator β_1^{DiD} that captures the average effect of the treatment on the treatment group (Athey and Imbens, 2006). The vector $\boldsymbol{X}_{it}$ includes our described 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 to control for unobservable time-constant firm characteristics and macroeconomic trends per industry and year. ε_{it} is the error term.

For a causal interpretation of the difference-in-differences estimate, the coefficient β_1^{DiD} has to be unbiased and consistent. The unbiasedness and consistency of β_1^{DiD} depend on the common trend assumption to hold. The common trend assumption states that both groups of firms, the treatment and control group, would have developed the same in terms of their outcomes in absence of the treatment and conditional on the included control variables. However, it might be possible that firms that won a price-based public procurement tender are particularly reluctant towards innovation per se, and thus would have performed worse in terms of their

innovation outcomes even without receiving the treatment.[6] In this case, the coefficient β_1^{DiD} would be biased and would not allow a causal interpretation.[7]

Thus, winning price-based public procurement tenders has to be conditionally unrelated to other factors that might affect the different outcomes. Only if this assumption holds, the difference-in-differences estimator reflects an unbiased and consistent estimate of the average treatment effect on the treated and allows for a causal interpretation. Therefore, we test the robustness of the common trend assumption with the following falsification tests:

Unconditional common trend - First, we compare the outcome trends between our treatment and control group during the absence of treatment. More precisely, we estimate the outcome trend differences between firms never winning a price-based public procurement tender within the last three years during our observational period (control group), and firms winning at least one price-based public procurement tender within the last three years at some point during our observational period (treatment group), but not during the investigated period (absence of treatment). As control variables are not considered in this test, it investigates the robustness of the unconditional common trend assumption. For the unconditional common trend assumption to hold, the investigated trends should be equal, whereas significant differences would indicate a violation of the assumption, and in turn, impede a causal interpretation of the coefficient of interest β_1^{DiD}.

Conditional common trend - Second, even if the unconditional common trend is falsified, the conditional common trend assumption, which considers the included controls to tackle omitted variable bias, might still hold. Therefore, we reproduce our baseline estimations with lead treatment variables, simulating a treatment before its actual implementation. This time,

[6] For example, previous research shows that more innovative firms are more likely to win public procurement tenders (Blind et al., 2020; Georghiou et al., 2014; Uyarra et al., 2014).

[7] One concern about the unbiasedness of our estimate refers to a situation in which public procurers might systematically implement price-based procurement in industries with standardized products. However, even in highly standardized industries, innovation can be an important parameter: For instance, in the German paper industry over 60 percent out of all companies are innovators (ZEW, 2024). Additionally, we mitigate this concern by including industry-year fixed effects in our baseline estimation.

significant lead estimates would indicate differences in the outcome before the implementation of the treatment conditional on our control variables. Thus, significant results would indicate a violation of the conditional common trend assumption and hinder a causal interpretation of the difference-in-differences estimate β_1^{DiD}.

5. Results

5.1. Baseline results

Table 2 reports our baseline results from the two-way fixed effects regression as specified in Equation (1). We investigate the effect of winning price-based public procurement within the last three years on the outcomes of our hypotheses.

Columns (1) and (2) reveal a persistent, adverse impact of winning price-based public procurement tenders on firms' product innovations. Consistent with H1, it is noted that winning price-based public procurement tenders leads to a significant decline in the likelihood of introducing new/improved products and services by 5.4 percentage points. Additionally, there is a notable decrease in firms' turnover associated with new/improved products and services by 10.6 percent. Concurrently, in accordance with H2, Columns (3) and (4) display an increase in turnover related to established products and services by 3.2 percent, along with a 1.8 percentage points decrease in the turnover share of new/improved products and services. As stated in H3, the expected effects of price-based public procurement contracts on cost-reducing process innovations are conflictive. However, the results in Columns (5) and (6) indicate that firms' probability to lower their costs due to the introduction of new/improved processes significantly decreases by 3.7 percentage points, while the total reduction of firms' costs generated with process innovations decreases by 4.7 percent.[8] Thus, the innovation hampering effect of winning price-based public procurement tenders seems to dominate.

[8] The effects on logarithmized variables (Columns 2, 3, and 6) are transformed for an exact interpretation in the following way: $(exp(\beta_1^{DiD})-1)*100$

Table 2 - Baseline results

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]PP (0/1)	-.054***	-.101***	.031*	-.018**	-.037**	-.046**
	(.019)	(.038)	(.017)	(.008)	(.018)	(.023)
Ln(employees)	.027**	.074***	.345***	.003	.013	.040***
	(.013)	(.015)	(.035)	(.006)	(.010)	(.015)
University degree (0-1)	.061	.082**	.060*	.022	.008	.008
	(.037)	(.035)	(.036)	(.016)	(.030)	(.029)
Regular R&D (0/1)	.225***	.233***	-.049***	.057***	.101***	.054***
	(.022)	(.031)	(.016)	(.008)	(.018)	(.018)
Occasional R&D (0/1)	.154***	.092***	-.030***	.032***	.094***	.051***
	(.019)	(.021)	(.012)	(.007)	(.015)	(.015)
Innovat. exp./turnovers	.195***	.037	-.029	.098***	.097***	.048**
	(.041)	(.034)	(.063)	(.025)	(.037)	(.020)
Pers. costs/turnovers	-.029**	-.093***	-.374***	-.009	.000	-.046*
	(.015)	(.025)	(.084)	(.006)	(.021)	(.027)
Tang. assets/turnovers	-.002	.000	-.004	.000	-.001	.000
	(.003)	(.002)	(.003)	(.002)	(.001)	(.001)
Ln(patent stock)	.011	.030	.055	-.038*	-.043	-.270***
	(.038)	(.083)	(.054)	(.021)	(.052)	(.100)
Exporter (0/1)	-.002	-.002	-.001	.002	-.003	-.010
	(.019)	(.019)	(.015)	(.007)	(.014)	(.013)
East Germany (0/1)	-.172	-.290	-.019	.008	.124	.137
	(.119)	(.325)	(.349)	(.153)	(.208)	(.122)
National group (0/1)	-.010	-.022	-.010	-.001	-.004	-.007
	(.016)	(.021)	(.011)	(.006)	(.013)	(.015)
Intern. group (0/1)	-.029	-.033	-.035	.004	-.016	-.013
	(.027)	(.053)	(.024)	(.010)	(.024)	(.037)
Constant	.207***	.145	.763***	.045	-.005	-.057
	(.066)	(.138)	(.181)	(.061)	(.088)	(.073)
Observations	15,623	15,623	15,623	15,623	15,202	15,202
R-squared	.759	.879	.985	.731	.616	.759

*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<.10*

[a]PP (0/1) refers to winning price-based public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

5.2. Falsification tests

As described above, the causal interpretation of our empirical results depends on the common trend assumption.

Unconditional common trend - We implement t-tests of equal means between currently non-treated and never-treated firms. As Figure 1 reveals, we do not identify significant differences between currently non-treated and never-treated firms for our outcome trends at large, indicating that both groups of firms behave similarly in absence of the treatment. We note, that Figure 1C illustrates an individual statistically significant difference in turnover with established products in 2012. However, all subsequent years demonstrate no further significant differences in the outcome trends. Thus, we do not reject the common trend assumption and our reported results are likely to be driven by the treatment itself.

Conditional common trend - We include a lead variable that simulates a treatment before it actually took place. If firms would already behave differently with respect to our hypothesized outcomes before the treatment, we would expect that the coefficients for the lead variables are significantly different from zero. Table 3 reveals that lead-variables remain insignificant for all six outcome variables. This result reassures that firms do not differ before the treatment takes place and therefore we do not have to reject the conditional common trend assumption.

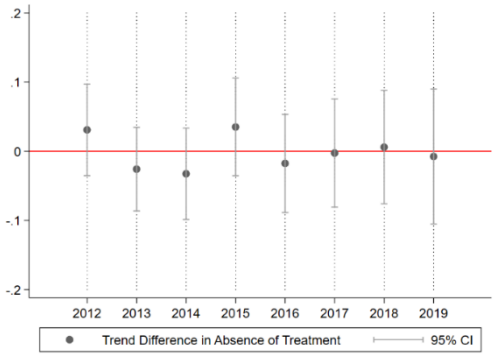

Figure 1A - Mean trend differences for introducing new/improved products and services (0/1)

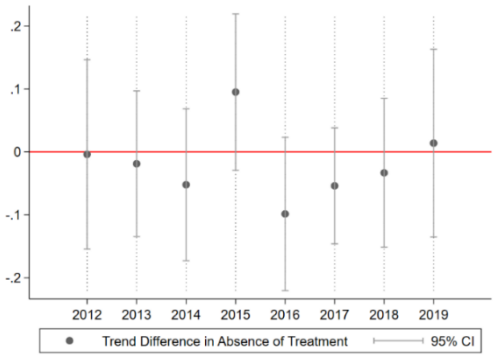

Figure 1B - Mean trend differences for ln(turnovers with new/ improved products and services + 1)

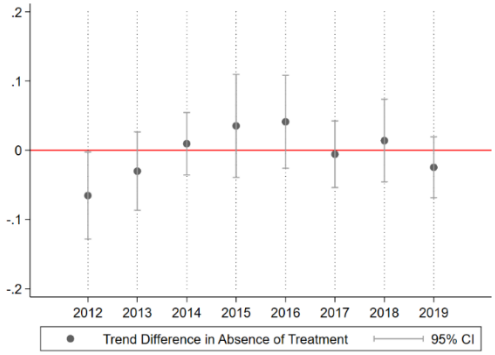

Figure 1C - Mean trend differences for ln(turnovers with established products + 1)

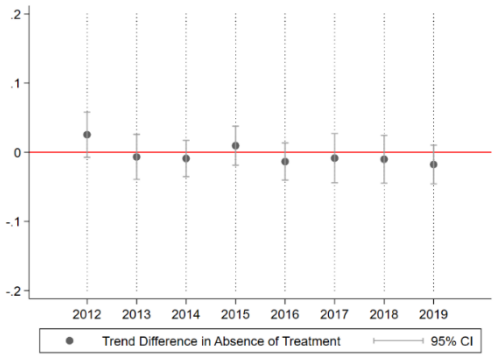

Figure 1D - Mean trend differences for turnover shares with new/improved products and services (0-1)

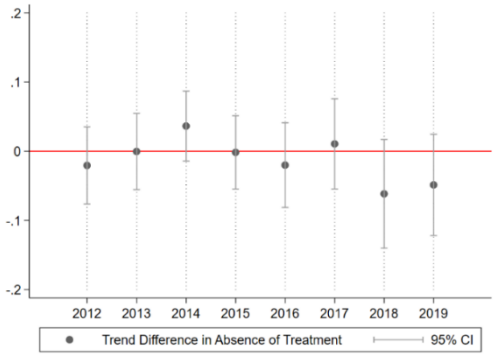

Figure 1E - Mean trend differences for introducing cost-reducing process innovations (0/1)

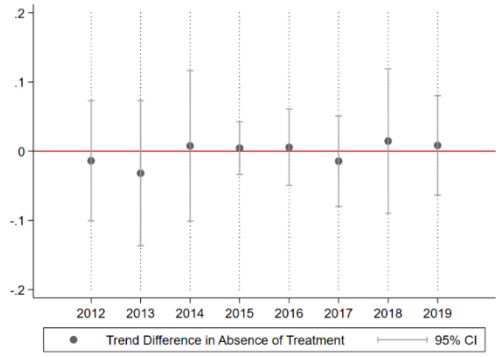

Figure 1F - Mean trend differences for Ln(total cost reductions due to process innovations + 1)

Figure 1 - Testing the unconditional common trend using t-tests of equal mean

Note: We estimate outcome variable trends for each firm i in year t as $(Y_{i,t-1} - Y_{i,t})/\,Y_{i,t-1} - 1$. Moreover, we compare the means of our variable trends between never-treated firms and currently non-treated firms in each year t. For this purpose, we implement t-tests of equal means and assume unequal variances. Figure 1A to Figure 1F illustrates the mean trend differences of both groups for the individual years from 2012 to 2019 for each one of our outcome variables during the absence of treatment, as well as their 95-percent confidence intervals.

Table 3 - Testing the conditional common trend using lead variables

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]Lead.PP (0/1)	-.021	-.024	.018	.003	-.011	-.026
	(.021)	(.035)	(.016)	(.008)	(.017)	(.024)
[a]PP (0/1)	-.046**	-.091**	.024	-.019**	-.032*	-.036*
	(.021)	(.038)	(.018)	(.009)	(.019)	(.021)
Ln(employees)	.027**	.074***	.345***	.003	.013	.040***
	(.013)	(.015)	(.035)	(.006)	(.010)	(.015)
University degree (0-1)	.062*	.083**	.060*	.021	.008	.009
	(.037)	(.035)	(.036)	(.016)	(.030)	(.029)
Regular R&D (0/1)	.225***	.233***	-.049***	.057***	.101***	.054***
	(.022)	(.031)	(.016)	(.008)	(.018)	(.018)
Occasional R&D (0/1)	.154***	.092***	-.030**	.032***	.094***	.051***
	(.019)	(.021)	(.012)	(.007)	(.015)	(.015)
Innovat. exp./turnovers	.195***	.038	-.03	.098***	.097***	.049**
	(.041)	(.034)	(.063)	(.025)	(.037)	(.02)
Pers. costs/turnovers	-.029**	-.093***	-.374***	-.009	.000	-.046*
	(.015)	(.025)	(.084)	(.006)	(.022)	(.027)
Tang. assets/turnovers	-.002	.000	-.004	.000	-.001	.000
	(.003)	(.002)	(.003)	(.002)	(.001)	(.001)
Ln(patent stock)	.012	.030	.055	-.038*	-.042	-.269***
	(.038)	(.083)	(.054)	(.021)	(.052)	(.100)
Exporter (0/1)	-.002	-.002	-.001	.002	-.003	-.010
	(.019)	(.019)	(.015)	(.007)	(.014)	(.013)
East Germany (0/1)	-.171	-.289	-.020	.008	.124	.138
	(.119)	(.326)	(.349)	(.153)	(.208)	(.122)
National group (0/1)	-.010	-.022	-.010	-.001	-.004	-.007
	(.016)	(.021)	(.011)	(.006)	(.013)	(.015)
Intern. group (0/1)	-.029	-.033	-.035	.004	-.016	-.013
	(.027)	(.053)	(.024)	(.010)	(.024)	(.037)
Constant	.207***	.145	.764***	.045	-.005	-.057
	(.066)	(.138)	(.180)	(.061)	(.088)	(.073)
Observations	15,623	15,623	15,623	15,623	15,202	15,202
R-squared	.759	.879	.985	.731	.616	.759

*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 public procurement tenders - tenders solely awarded based on the price criterion - within the last three years. Lead.PP (0/1) refers to the one year lead variable of PP (0/1).

5.3. Further robustness tests

To ensure the reliability of our empirical findings, we additionally conduct various robustness tests. First, we address the potential concern of treatment heterogeneity in our two-way fixed effects regressions. Specifically, we test if the estimated treatment effect is constant over time and reconduct our baseline estimations excluding years for which we observe significant treatment heterogeneity. Second, we address that the estimated effect may be driven by few firms receiving many price-based public procurement tenders and again reconduct our estimation by dropping firms that won more than one price-based public procurement tender within the last three years. Third, we also include criteria based public procurement tenders, i.e. tenders with additional award criteria beyond the price, in our estimation. By doing so, we ensure that the estimated effect is actually driven by the absence of award criteria and that it is not the public procurement tender in general driving our results. Fourth, to rule out the possibility of our results being driven by particular procurer, product, or service types related to firms' won price-based tenders, we exclude various procurer, product, and service types from our regressions. Finally, we test the robustness of our results to the exclusion of our control variables to tackle the risk of using bad controls.

Time specific treatment effect heterogeneity - Recent advances in the econometrics of difference-in-differences suggest that the standard two-way fixed effects approach can yield a biased estimate of the difference-in-differences parameter if treatment effects are not constant, but vary over time (e.g. de Chaisemartin and D'Haultfœuille, 2020). In order to ensure the validity of our difference-in-differences estimate we add an interaction term of our treatment variable and a year dummy to our baseline regressions separately for each year, resulting in eight regressions for each investigated dependent variable. Significant coefficients of the interaction terms would reveal heterogeneous treatment effects in specific years and therefore require a reevaluation of the estimate. Table B1 in the Appendix B.2 summarizes the interaction coefficients and reveals that treatment effect heterogeneity over time is a minor issue in our estimation. Almost all treatment-year interaction coefficients are insignificant. However, to further underscore the robustness of our results, we reconduct our baseline

estimation while excluding those years in which we found a significant interaction. At large, Tables B2 –B5 confirm our results are robust after addressing potential time-related treatment heterogeneity in our estimation.

Dose specific effect heterogeneity - We address potential concerns that the estimated effect might be driven by few firms that received several price-based public procurement tenders in a single year. Even though most of the firms in our sample won one price-based public procurement tender within three years, we exclude all firms in our estimation sample that received more than one in Table 4. The negative effect on firms' probability to introduce new/improved products and services as well as their associated turnovers in Columns (1) and (2) turn out to be robust and significant. The same is the case for the positive effect in Column (3) and the negative effect in Column (4), even though their statistical significance slightly decreased. Finally, we, again, obtain negative coefficients for process innovation-related outcomes in Columns (5) and (6), even though the coefficient in Column (5) turns out to be slightly insignificant. In total, we interpret our previous results as verified.

Criteria-based public procurement - We address that the estimated effects might be driven by winning public tenders in general, rather than by winning public procurement tenders without additional criteria. Therefore, we include public procurement tenders that contain additional award criteria in our empirical analysis. Table 5 shows that the coefficients for winning criteria-based public procurement tenders (PPC) are insignificant, while those for price-based public procurement tenders (PP) remain significant for all our hypothesized outcomes. This highlights the innovation-hampering effect arising from the absence of award criteria in public procurement tenders. The insignificant coefficients for winning criteria-based procurement are surprising given the previously found positive effects of winning public tenders with environmental criteria on environmental product innovations (Krieger and Zipperer, 2022). Thus, we explore alternative specifications for including criteria-based public procurement.

Table 4 - Dose specific effect heterogeneity

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]PP (0/1)	-.054**	-.100**	.034*	-.018*	-.033	-.062**
	(.022)	(.043)	(.020)	(.010)	(.020)	(.025)
Ln(employees)	.022*	.067***	.334***	.003	.010	.038**
	(.013)	(.015)	(.036)	(.006)	(.009)	(.015)
University degree (0-1)	.061	.065*	.070*	.018	.001	.009
	(.038)	(.034)	(.036)	(.016)	(.030)	(.029)
Regular R&D (0/1)	.216***	.219***	-.051***	.060***	.098***	.040**
	(.022)	(.032)	(.016)	(.009)	(.018)	(.017)
Occasional R&D (0/1)	.145***	.084***	-.036***	.034***	.093***	.037***
	(.020)	(.022)	(.012)	(.007)	(.015)	(.013)
Innovat. exp./turnovers	.192***	.030	-.031	.096***	.095***	.052**
	(.041)	(.033)	(.062)	(.025)	(.036)	(.020)
Pers. costs/turnovers	-.026*	-.090***	-.362***	-.010	-.005	-.047*
	(.015)	(.026)	(.085)	(.006)	(.018)	(.028)
Tang. assets/turnovers	-.003	.000	-.005	.000	-.001	.000
	(.003)	(.002)	(.003)	(.002)	(.001)	(.001)
Ln(patent stock+1)	.013	.039	.055	-.038*	-.037	-.250**
	(.038)	(.084)	(.055)	(.022)	(.052)	(.101)
Exporter (0/1)	-.006	-.006	.003	.001	-.004	-.008
	(.019)	(.019)	(.016)	(.008)	(.015)	(.014)
East Germany (0/1)	-.171	-.289	-.014	.009	.130	.145
	(.123)	(.326)	(.353)	(.153)	(.209)	(.125)
National group (0/1)	-.017	-.032	-.016	-.001	-.003	-.009
	(.016)	(.021)	(.012)	(.007)	(.013)	(.015)
Intern. group (0/1)	-.040	-.063	-.040	.005	-.023	-.030
	(.027)	(.054)	(.025)	(.011)	(.024)	(.037)
Constant	.230***	.176	.762***	.048	.008	-.052
	(.067)	(.137)	(.184)	(.062)	(.088)	(.073)
Observations	15,014	15,014	15,014	15,014	14,615	14,615
R-squared	.762	.880	.985	.730	.616	.758

*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. Sample is reduced to firms winning not more than one price-based public procurement contract in the last three years. P-values correspond to: *** p<.01, ** p<.05, * p<.1*

[a]PP (0/1) refers to winning price-based public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Table 5 – Criteria-based public procurement (dichotomous specification)

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]PP (0/1)	-.053***	-.100***	.031*	-.019**	-.036**	-.045**
	(.019)	(.038)	(.017)	(.008)	(.018)	(.023)
[b]PPC (0/1)	-.017	-.011	-.004	.007	-.011	-.017
	(.022)	(.035)	(.018)	(.010)	(.020)	(.037)
Ln(employees)	.027**	.074***	.345***	.003	.013	.040***
	(.013)	(.015)	(.035)	(.006)	(.010)	(.015)
University degree (0-1)	.062*	.082**	.060*	.021	.008	.009
	(.037)	(.035)	(.036)	(.016)	(.030)	(.029)
Regular R&D (0/1)	.225***	.233***	-.049***	.057***	.101***	.054***
	(.022)	(.031)	(.016)	(.008)	(.018)	(.018)
Occasional R&D (0/1)	.154***	.092***	-.030***	.032***	.094***	.051***
	(.019)	(.021)	(.012)	(.007)	(.015)	(.015)
Innovat. exp./turnovers	.194***	.037	-.029	.098***	.096***	.048**
	(.041)	(.033)	(.063)	(.025)	(.037)	(.020)
Pers. costs/turnovers	-.029**	-.092***	-.374***	-.010	.000	-.046*
	(.015)	(.025)	(.084)	(.006)	(.022)	(.027)
Tang. assets/turnovers	-.002	.000	-.004	.000	-.001	.000
	(.003)	(.002)	(.003)	(.002)	(.001)	(.001)
Ln(patent stock+1)	.012	.030	.055	-.038*	-.043	-.27***
	(.038)	(.083)	(.054)	(.021)	(.052)	(.100)
Exporter (0/1)	-.002	-.002	-.001	.002	-.003	-.010
	(.019)	(.019)	(.015)	(.007)	(.014)	(.013)
East Germany (0/1)	-.173	-.291	-.019	.009	.123	.135
	(.119)	(.325)	(.349)	(.153)	(.208)	(.123)
National group (0/1)	-.010	-.022	-.010	-.001	-.004	-.007
	(.016)	(.021)	(.011)	(.006)	(.013)	(.015)
Intern. group (0/1)	-.029	-.033	-.035	.004	-.016	-.013
	(.027)	(.053)	(.024)	(.010)	(.024)	(.037)
Constant	.208***	.146	.764***	.045	-.004	-.056
	(.066)	(.138)	(.181)	(.061)	(.088)	(.073)
Observations	15623	15623	15623	15623	15202	15202
R-squared	.759	.879	.985	.731	.616	.759

*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. Sample is reduced to firms winning not more than one price-based public procurement contract in the last three years. P-values correspond to: *** p<.01, ** p<.05, * p<.1*

[a]PP (0/1) refers to winning price-based public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

[b]PPC (0/1) refers to winning criteria-based public procurement tenders - tenders awarded based on criteria other than price - within the last three years.

First, instead of including two binary variables for price-based and criteria-based public procurement, we introduce one binary variable for winning public tenders within the last three years in general (PPG), as well as the average number of words within the criteria of all tenders won by a firm within the last three years (PPCL). As a result, the coefficient of PPG reflects the effect of winning price-based procurement without additional criteria, whereas the coefficient of PPCL represents the effect of increasing the average word count of the won tenders by one additional word. Thus, we account for the intensity of criteria-based procurement within these regressions. As shown in Table B6, all coefficients related to criteria-based tenders remain statistically insignificant, whereas our main results stay largely robust - although the statistical significance for process innovations is reduced while maintaining their sign.

Second, we decided to account for a diminishing positive marginal effect of additional words within the selection criteria for public tenders in Table 6. While including award criteria can incentivize innovation by giving firms the flexibility to propose unique solutions or approaches that might outperform conventional, established options, an excessive number of criteria may actually hinder innovation efforts. This is because an overly complex set of criteria can increase the difficulty of the contract. To capture this nuance, we add a squared term for our previously included average word count. Table 6 demonstrates statistically significant positive coefficients for our linear terms combined with statistically significant negative squared terms when using product and service innovation measures as a dependent variable (Columns 1, 2, and 4). Furthermore, we observe the opposite effect when focusing on established products and services (Column 3). Finally, our binary variable, PPG, as well as our (squared) average word count, PPL, remain statistically insignificant when process innovations are used as the dependent variable. Thus, our estimates from Table B6 and Table 6 indicate that firms' products and services are affected more strongly than their processes, in accordance with the results of Krieger and Zipperer (2022).

Table 6 – Criteria-based public procurement (squared specification)

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]PPG (0/1)	-.068***	-.122***	.043**	-.018**	-.027	-.022
	(.019)	(.035)	(.018)	(.009)	(.018)	(.025)
[b]PPCL - Criteria length	.018**	.039***	-.016**	.007*	-.001	-.007
	(.008)	(.015)	(.008)	(.004)	(.008)	(.016)
[b]PPCL - Criteria Length^2	-.001**	-.003***	.001**	-.001**	.000	.000
	(.001)	(.001)	(.001)	(.000)	(.001)	(.001)
Ln(employees)	.026**	.074***	.346***	.003	.013	.040***
	(.013)	(.015)	(.035)	(.006)	(.010)	(.015)
University degree (0-1)	.062*	.084**	.060*	.022	.009	.010
	(.037)	(.035)	(.036)	(.016)	(.03)	(.029)
Regular R&D (0/1)	.225***	.233***	-.049***	.057***	.100***	.053***
	(.022)	(.031)	(.016)	(.008)	(.018)	(.018)
Occasional R&D (0/1)	.153***	.091***	-.030***	.032***	.093***	.050***
	(.019)	(.021)	(.012)	(.007)	(.015)	(.015)
Innovat. exp./turnovers	.195***	.038	-.030	.098***	.096***	.048**
	(.041)	(.034)	(.063)	(.025)	(.037)	(.020)
Pers. costs/turnovers	-.029**	-.093***	-.374***	-.010	.000	-.046*
	(.015)	(.025)	(.084)	(.006)	(.021)	(.027)
Tang. assets/turnovers	-.002	.000	-.004	.000	-.001	.000
	(.003)	(.002)	(.003)	(.002)	(.001)	(.001)
Ln(patent stock+1)	.012	.030	.055	-.038*	-.043	-.270***
	(.038)	(.083)	(.054)	(.021)	(.052)	(.100)
Exporter (0/1)	-.001	.000	-.002	.002	-.003	-.009
	(.019)	(.019)	(.015)	(.007)	(.014)	(.013)
East Germany (0/1)	-.170	-.287	-.020	.009	.123	.135
	(.120)	(.327)	(.349)	(.153)	(.208)	(.123)
National group (0/1)	-.010	-.023	-.010	-.001	-.004	-.007
	(.016)	(.021)	(.011)	(.006)	(.013)	(.015)
Intern. group (0/1)	-.029	-.033	-.035	.004	-.016	-.013
	(.027)	(.053)	(.024)	(.010)	(.024)	(.037)
Constant	.208***	.146	.763***	.045	-.004	-.055
	(.066)	(.138)	(.18)	(.062)	(.088)	(.073)
Observations	15623	15623	15623	15623	15202	15202
R-squared	.759	.879	.985	.731	.616	.759

*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]PPG (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 public tenders won by a firm over the past three years.

Figure 2 presents the predicted values of our product and service measures along with their 95 percent confidence intervals for different average criteria lengths - keeping all remaining variables at their mean. Figure 2.A, 2.B, and 2.D illustrate the inverse U-shaped effects of criteria-based procurement on product innovation, showing that a significant number of firms winning criteria-based procurement tenders reach the point of negative marginal effects - specifically, 22.54 (100-77.46) percent for our dichotomous innovation variable, 24.16 (100-75.574) percent for our innovation turnover variable, and 23.32 (100-76.68) percent for our turnover share variable. In line with this, Figure 2.C highlights the U-shaped relationship between criteria-based procurement and turnover from established products and services, where an initial increase in the average word count reduces turnover, but further increases subsequently raise it.

Public procurer types - Another 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 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 our primary estimations on ten subsamples, each excluding firms that have won a price-based tender from a particular procurer type within the last three years. The results of this robustness test are summarized in Figure B1 in Appendix B.1. Overall, our previous findings remain robust, though their statistical significance decreases slightly, likely due to the reduction in observations.

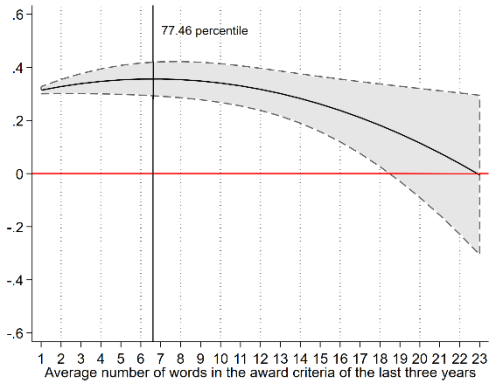

Figure 2A – Introducing new/improved products and services (0/1)

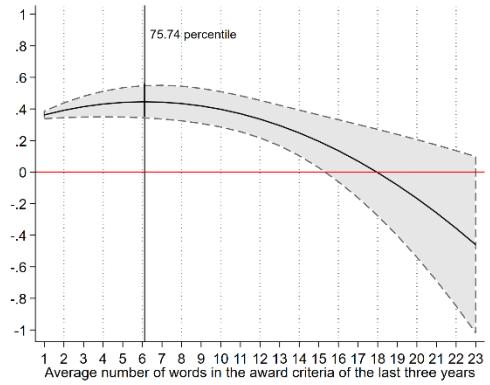

Figure 2B - Ln(turnover with new/ improved products and services + 1)

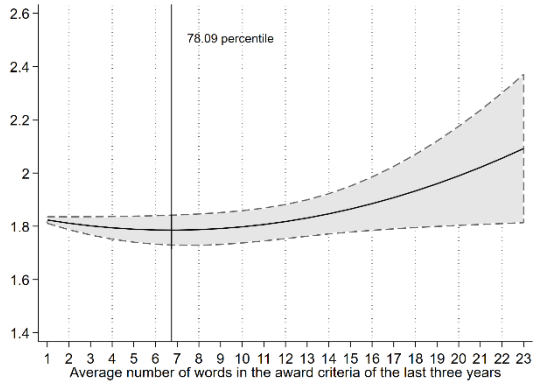

Figure 2C – Ln(turnover with established products and services +1)

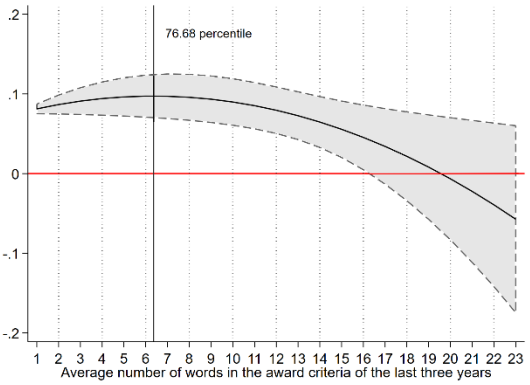

Figure 2D – Turnover shares with new/ improved products and services (0-1)

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.

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, and re-run our primary estimations on subsamples excluding each class separately.[9] As shown in Figure B2 in Appendix B.1, 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 B8 our previous results are robust.

5.4. Economic wide effects

We estimate the economic wide effects of price-based public procurement on firms located in Germany using a back of the envelope analysis. For this, we utilize the Mannheim Enterprise Panel. The Mannheim Enterprise Panel is a database sourced from Creditreform e.V., the largest German credit rating agency, and managed by the ZEW Mannheim since 1992. It builds the sampling frame of the Mannheim Innovation Panel, covers roughly 90 percent of the population of active firms in Germany, and presents a representative overview of the German corporate landscape (Bersch et al., 2014; Bersch et al., 2020; Krieger et al. 2022). More precisely, i) we estimate the number of firms winning price-based public procurement tenders over the last three years within the population of the Mannheim Innovation Panel by matching the Mannheim Enterprise Panel with the Tenders Electronic Daily database, and ii) we combine this estimate with our firm effects from Table 2 and the projections on the innovativeness of

[9] A list of all classes is provided as Table B7 in Appendix B.2.

the German enterprise sector by the ZEW Mannheim. The detailed estimation procedure is described step-by-step in Appendix C.

We summarize the results of our back of the envelope analysis in Table 7. Using our estimates, we present: Column (1) - the yearly percentage change in turnovers with new/improved products and services in the German enterprise sector, Column (2) - the yearly percentage change in turnovers with established products in the German enterprise sector, Column (3) - the yearly percentage change in turnovers in the German enterprise sector, and Column (4) - the yearly percentage change in total cost reductions due to process innovations in the German enterprise sector. In total, our analysis indicates increasing, sizeable effects of winning price-based public procurement tenders within the last three years on the German enterprise sector. Between 2012 and 2019, the back of the envelope estimations demonstrate a reduction of turnovers with new/improved products and services between 7.0 and 9.8 percent, a gain in turnovers with established products between 6.6 and 9.2 percent, and a gain in total turnovers between 4.6 and 6.3 percent. Thus, even though the percentage changes from Column (1) and (2) are close, total turnovers in Column (3) increase, as the total turnover with established products and services is larger than the total turnover with new/improved products and services in the German enterprise sector. Furthermore, in addition to affecting the turnovers of the German enterprise sector, winning criteria-based public procurement tenders decreased cost reductions based on process innovations between 1.6 and 2.3 percent.

Table 7 - Effects of winning price-based public procurement tenders on the German enterprise sector

Year	Percentage change in turnovers with new/improved pro-ducts and services	Percentage change in turnovers with established pro-ducts and services	Percentage change in turnovers with products and services	Percentage change in total cost reductions due to process innovations
	(1)	(2)	(3)	(4)
2012	-7.0%	6.6%	4.6%	-1.6%
2013	-7.3%	6.8%	5.0%	-1.7%
2014	-7.5%	7.0%	5.1%	-1.9%
2015	-7.8%	7.2%	5.3%	-2.2%
2016	-8.4%	7.8%	5.6%	-1.9%
2017	-9.1%	8.5%	6.1%	-2.1%
2018	-9.8%	9.2%	6.3%	-2.3%
2019	-9.6%	9.0%	6.2%	-2.0%

Note: The German enterprise sector is defined as the population of the Mannheim Innovation Panel.

6. Conclusion

Contribution - The examination of price-based public procurement reveals significant effects on firm innovations at both firm and enterprise sector levels. Drawing from a theoretical framework based on Geroski (1990), Edler and Georghiou (2007), and Edquist and Zabala-Iturriagagoitia (2020), we enrich the theoretical discussion around public procurement and innovation in two dimensions: First, we introduce the concept of price-based procurement as opposed to criteria-based procurement. Second, we discuss the adverse effects of price-based public procurement tenders on product and process innovations separately.

Furthermore, we empirically validate our theoretical hypotheses. Specifically, our findings indicate that firms winning price-based public procurement tenders experience a reduction in turnovers with new/improved products and services, an increase in turnovers with established products and services, and a decrease in cost reductions due to process innovations at the levels of the firm and the entire German enterprise sector.

In addition, exploring the effects of winning criteria-based procurement within our robustness tests reveals a previously unestablished inverse U-shaped relationship between the average criteria length of won tenders, and firms' innovation probabilities, turnovers, and turnover

shares. Thus, while the inclusion of award criteria can stimulate innovation by allowing firms to propose solutions that may surpass established options, an excessive amount of criteria appears to impede innovation efforts, likely due to an overly complex set of requirements that makes the contract more challenging for firms.[10]

Implications - The observed reductions in firm innovations due to price-based procurement, both at the firm and enterprise sector levels, underscore the potential risks of price-based public procurement to long-term competitiveness. This highlights the importance of public procurers adopting a long-term perspective and incorporating award criteria beyond price to better support firm innovation. However, our explorative findings also reveal an inverse U-shaped relationship between the average criteria length of won tenders and firms' innovation outcomes. This suggests that while award criteria can stimulate innovation by encouraging firms to propose superior solutions, an excessive number of criteria can hinder these efforts by creating overly complex requirements that challenge firms' capacity to innovate effectively.

To maximize the benefits of criteria-based procurement, public procurers should strike a balance in the use of award criteria: sufficient to encourage innovation without burdening firms with excessive complexity. Achieving this balance is essential for fostering a procurement environment that promotes long-term competitiveness and innovation. Policymakers play an important role in this process, whether through refining procurement guidelines or implementing training programs for procurers that emphasize balanced practices. Such measures can reduce over-reliance on price as the primary award criterion while avoiding overly complex requirements. Similarly, firm managers should navigate the trade-off between prioritizing short-term gains from selling established products to public procurers and sustaining long-term innovation by participating in tenders that incentivize creative solutions without imposing excessive constraints. By maintaining this equilibrium, public procurers and firms alike can contribute to a procurement landscape that supports continuous innovation and drives economic growth.

[10] As previous research has focused on dichotomous variables as measures for winning (potentially) innovative public tenders (e.g., Krieger and Zipperer, 2022; Czarnitzki et al., 2020), no previous analysis has uncovered this relationship thus far.

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 are 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 specification of a public procurement tender are not covered within our empirical investigation (Igarashi et al., 2015). Furthermore, we cannot identify innovative public procurement - tenders requiring innovation - within the Tenders Electronic Daily database (Krieger and Zipperer, 2022). This is why, we are limited to examining public procurement tenders with additional criteria within our robustness tests - tenders with the potential to reward innovation (Krieger and Zipperer, 2022). Finally, our analysis concentrates on the effects of price-based 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 - From our limitations, a naturally emerging extension would be an estimation of the costs of including different kinds of additional criteria within a public procurement tender on 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, taking the different effects of price-based public procurement on the drivers of cost-reducing process innovations empirically into account would further enhance our understanding, as we were limited to demonstrating a negative net-effect.

References

Acemoglu, D., Restrepo, P., 2019. Automation and New Tasks: How Technology Displaces and Reinstates Labor. Journal of Economic Perspectives 33 (2), 3-30. https://doi.org/10.1257/jep.33.2.3.

Adner, R., Levinthal, D., 2001. Demand Heterogeneity and Technology Evolution: Implications for Product and Process Innovation. Management Science 47 (5), 611-733. https://doi.org/10.1287/mnsc.47.5.611.10482.

Aschhoff, B., Sofka, W., 2009. Innovation on demand – Can public procurement drive market success of innovations? Research Policy 38 (8), 1235–1247. https://doi.org/10.1016/j.respol.2009.06.011.

Aschhoff, B., Crass, D., Doherr, T., Hud, M., Hünermund, P. Iferd, Y., Köhler, C., Peters, B., Rammer, C., Schubert, T., Schwiebacher F., 2014. Dokumentation zur Innovationserhebung 2013. ZEW-Dokumentation Nr.14-01

Baron, R., 2016. The Role of Public Procurement in Low-Carbon Innovation. Background Paper for the 33rd Round Table on Sustainable Development. OECD. https://www.oecd.org/sd-roundtable/papersandpublications/The%20Role%20of%20Public%20Procurement%20in%20Low-carbon%20Innovation.pdf.

Bersch, J., Degryse, H., Kick, T., Stein, I., 2020. The real effects of bank distress: Evidence from bank bailouts in Germany. Journal of Corporate Finance 60, 101521. https://doi.org/10.1016/j. jcorpfn.2019.101521.

Bersch, J., Gottschalk, S., Müller, B., Niefert, M., 2014. The Mannheim Enterprise Panel (MUP) and Firm Statistics for Germany. ZEW Discussion Paper 14-104, ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung, Mannheim.

Bessen, J., 2002. Technology Adoption Costs and Productivity Growth: The Transition to Information Technology. Review of Economic Dynamics 5 (2), 443-469. https://doi.org/10.1006/redy.2001.0152.

Blind, K., Pohlisch, J., Rainville A., 2020. Innovation and standardization as drivers of companies' success in public procurement: an empirical analysis. The Journal of Technology Transfer 45 (3), 664-693. https://doi.org/10.1007/s10961-019-09716-1.

Bunduchi, R., Weisshaar, C., Smart, A.U., 2011. Mapping the benefits and costs associated with process innovation: The case of RFID adoption. Technovation 31 (9), 505-521. https://doi.org/10.1016/j.technovation.2011.04.001.

Caravella, S., Crespi, F., 2020. The role of public procurement as innovation lever: evidence from Italian manufacturing firms. Economics of Innovation and New Technology 30 (7), 1–22. https://doi.org/10.1080/10438599.2020.1761591.

Chiappinelli, O., Giuffrida, L.M., Spagnolo G., 2023 : Public Procurement as an Innovation Policy : Where Do We Stand? ZEW Discussion Papers 23-002, ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung, Mannheim.

Czarnitzki, D., Hünermund, P., Moshgbar, N., 2020. Public Procurement of Innovation: Evidence from a German Legislative Reform. International Journal of Industrial Organization 71, 102620. https://doi.org/10.1016/j.ijindorg.2020.102620.

Damanpour, F., Gopalakrishnan, S., 2002. The Dynamics of the Adoption of Products and Process Innovations in Organizations, Journal of Management Studies 38 (1), 45-65, https://doi.org/10.1111/1467-6486.00227.

De Chaisemartin, C., D' Haultfœuille, X., 2020. Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects. American Economic Review 110 (9), 2964-2996. https://doi.org /10.1257/aer.20181169.

Doherr, T., 2023. The SearchEngine: A Holistic Approach to Matching. ZEW Discussion Paper 23-001, ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung, Mannheim.

Edler, J., Georghiou, L., 2007. Public procurement and innovation – resurrecting the demand side. Research Policy 36 (7), 949–963. https://doi.org/10.1016/j.respol.2007.03.003.

Edquist, C., Zabala-Iturriagagoitia, J.M., 2020. Functional procurement for innovation, welfare, and the environment. Science and Public Policy 47 (5), 595–603. https://doi.org/10.1093/scipol/scaa046.

European Council, 2022. International Procurement Instrument: Council gives green light to new rules promoting reciprocity. https://www.consilium.europa.eu/en/press/press-releases/2022/06/17/international-procurement-instrument-council-gives-final-go-ahead-to-new-rules-boosting-reciprocity/.

Georghiou, L., Edler, J., Uyarra, E., Yeow, J., 2014. Policy instruments for public procurement of innovation. Choice, design and assessment. Technological Forecasting & Social Change 86, 1-12. https://doi.org/10.1016/j.techfore.2013.09.018.

Geroski, P.A., 1990. Procurement policy as a tool of industrial policy. International Review of Applied Economics 4 (2), 182-198. https://doi.org/10.1080/758523673.

Guerzoni, M., Raiteri, E., 2015. Demand-side vs. supply-side technology policies: hidden treatment and new empirical evidence on the policy mix. Research Policy 44 (3), 726–747. https://doi.org/10.1016/j.respol.2014.10.009.

Hullova, D., Trott, P., Don Simms, C., 2016. Uncovering the reciprocal complementarity between product and process innovations. Research Policy 45 (5), 929-940. https://doi.org/10.1016/j.respol.2016.01.012.

Igarashi, M., de Boer, L. Michelsen, O., 2015. Investigating the anatomy of supplier selection in green public procurement. Journal of Cleaner Production 108 (A), 442-450. https://doi.org/10.1016/j.jclepro.2015.08.010.

Krieger, B., Pellens, M., Blind, K., Gruber, S., Schubert, T., 2021. Are firms withdrawing from basic research? An analysis of firm-level publication behavior in Germany. Scientometrics 126, 9677-9698. https://doi.org/10.1007/s11192-021-04147-y.

Krieger, B., Zipperer, V. 2022. Does green public procurement trigger environmental innovations? Research Policy 51 (6), 104516. https://doi.org/10.1016/j.respol.2022.104516.

Kundu, O., James, A.D., Rigby, J. 2020. Public procurement and innovation: a systematic literature review. Science and Public Policy 47 (4), 490-502. https://doi.org/10.1093/scipol/scaa029.

Lichtenberg, F.R., 1988. The private R&D investment response to federal design and technical competitions. American Economic Review 78 (3), 550–559. https://www.jstor.org/stable/1809152.

Mairesse, J., Mohnen, P., 2010. Using Innovation Surveys for Econometric Analysis. In: Hall, B.H., Rosenberg. N. (Eds.), Handbook of the Economics of Innovation, Vol. 2. Elsevier, Amsterdam, pp. 1129-1155. https://doi.org/10.1016/S0169-7218(10)02010-1.

Obwegeser, N., Müller, S.D., 2018. Innovation and public procurement: terminology, concepts, and applications. Technovation 74–75, 1–17. https://doi.org/10.1016/j.technovation.2018.02.015.

OECD, 2023. Size of public procurement. In: Government at a Glance 2023, OECD Publishing, Paris. https://doi.org/10.1787/ce2208f6-en.

Patsali, S., 2024. University procurement-led innovation: Sources, procedures, and effects. Some field-study evidence. Technovation 130, 102901. https://doi.org/10.1016/j.technovation.2023.102901.

Peters, B., Rammer, C., 2023. Innovation panel surveys in Germany: the Mannheim Innovation Panel. Handbook of Innovation Indicators and Measurement. Second Edition. Edward Elgar Publishing, Northampton, MA, pp. 54-87. https://doi.org/10.4337/9781800883024.00014.

Peters, B., Rammer, C., Gault, F., 2013. Innovation panel surveys in Germany. Handbook of Innovation Indicators and Measurement. Edward Elgar Publishing, Northampton, MA, pp. 135–177.

Rammer, C., 2023. Measuring process innovation output in firms: Cost reduction versus quality improvement. Technovation 124, 102753. https://doi.org/10.1016/j.technovation.2023.10275.

Rammer, C., 2017. Dokumentation zur Innovationserhebung 2016. ZEW-Dokumentation Nr. 17-02.

Rammer, C., 2018. Dokumentation zur Innovationserhebung 2017. ZEW-Dokumentation Nr. 18-01.

Rammer, C., 2019. Dokumentation zur Innovationserhebung 2018. ZEW-Dokumentation Nr. 19-01.

Rammer, C., 2020. Dokumentation zur Innovationserhebung 2019. ZEW-Dokumentation Nr. 20-01.

Rammer, C., Hünermund, P., 2013. Schwerpunktbericht zur Innovationserhebung 2012. ZEW-Dokumentation Nr. 13-03.

Rammer, C., Peters, B., 2015. Dokumentation zur Innovationserhebung 2014 – Innovationen mit Bezug zur Energiewende, Finanzierung von Innovationen. ZEW-Dokumentation Nr. 15-02.

Rammer, C., Schubert, T., Hünermund, P., Köhler, M., Iferd, Y., Peters, B., 2016. Dokumentation zur Innovationserhebung 2015. ZEW-Dokumentation Nr. 16-01.

Reichstein, T., Salter, A., 2006. Investigating the sources of process innovation among UK manufacturing firms. Industrial and Corporate Change 15 (4), 653-682. https://doi.org/10.1093/icc/dtl014.

Rostad Sæther, S., Moe, E., 2021. A green maritime shift: Lessons from the electrification of ferries in Norway, Energy Research & Social Science 81, 102282, https://doi.org/10.1016/j.erss.2021.102282.

Roth, J., Sant'Anna, H.C.P., Bilinski, A., Poe, J., 2023. What's trending in difference-in-differences? A synthesis of the recent econometrics literature. Journal of Econometrics 235 (2), 2218-2244. https://doi.org/10.1016/j.jeconom.2023.03.008.

Siemens Energy and Bellona, 2022. Decarbonizing maritime transport: A study on the electrification of the European Ferry Fleet. https://network.bellona.org/content/uploads/sites/2/2023/09/Report-Ferry-Study-Siemens-Energy-Bellona-Final-2022.pdf.

Slavtchev, V., Wiederhold, S., 2016. Does the technological content of government demand matter for private R&D? Evidence from US States. American Economic Journal: Macroeconomics 8 (2), 45–84. https://doi.org/10.1257/mac.20130069.

Stake, J., 2017. Evaluating quality or lowest price: consequences for small and medium-sized enterprises in public procurement. The Journal of Technology Transfer 42. 1143-1169. https://doi.org10.1007/s10961-016-9477-4.

Stojčić, N., Srhoj, S., Coad, A., 2020. Innovation procurement as capability-building: evaluating innovation policies in eight Central and Eastern European countries. European Economic Review 121, 103330. https://doi.org/10.1016/j.euroecorev.2019.103330.

TED, 2020. TED CSV Open Data. NOTES & CODEBOOK. (3.3).

Uyarra, E., Edler, J., Garcia-Estevez, J., Georghiou, L., Yeow, J., 2014. Barriers to innovation through public procurement: A supplier perspective. Technovation 34 (10), 631-645. https://doi.org/10.1016/j.technovation.2014.04.003.

ZEW, 2024. Papierindustrie. ZEW Branchenreport Innovationen 31(7). https://ftp.zew.de/pub/zew-docs/brarep_inno/issue/2023/BRInno24_07.pdf?v=1708612414&_gl=1*rnyl9r*_ga*ODI1MjI1Njg2LjE2NDU2MDU4Njc.*_ga_KFD4G5CY27*MTcxNTY3NjE5OS4xMjQuMS4xNzE1Njc2MjA0LjAuMC4w

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

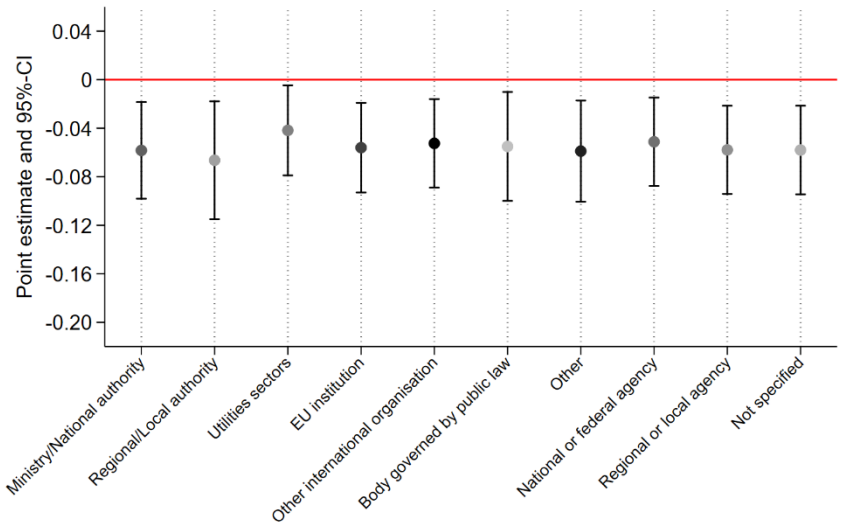

Figure B1 A – Point estimates for introducing new/improved products and services (0/1) excluding public authority types

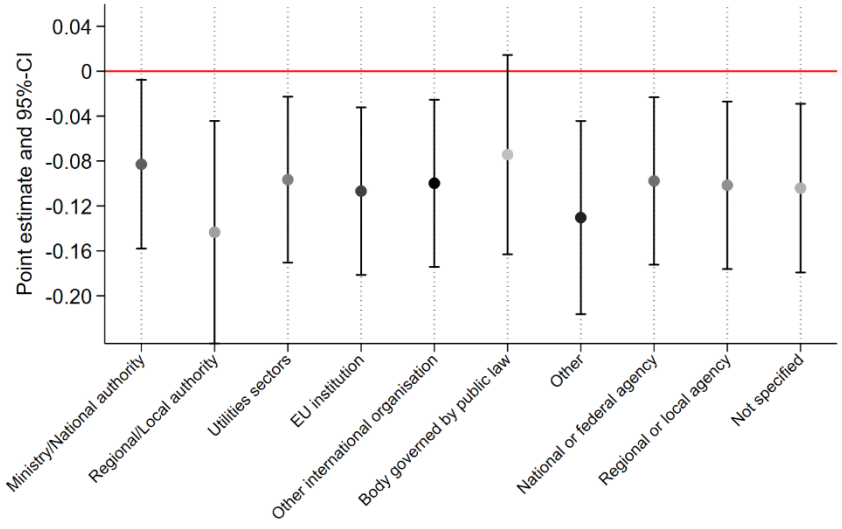

Figure B1 B – Point estimates for ln(turnover with new/improved products and services +1) excluding public authority types

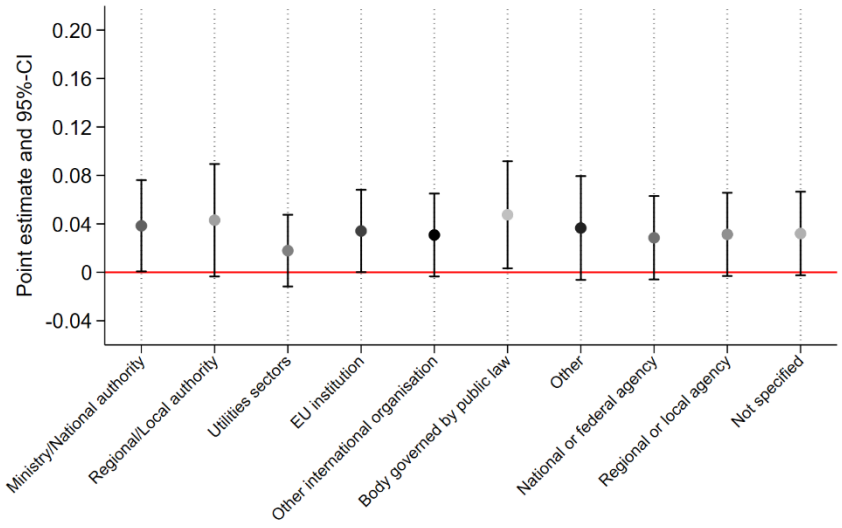

Figure B1 C – Point estimates for ln(turnovers with established products +1) excluding public authority types

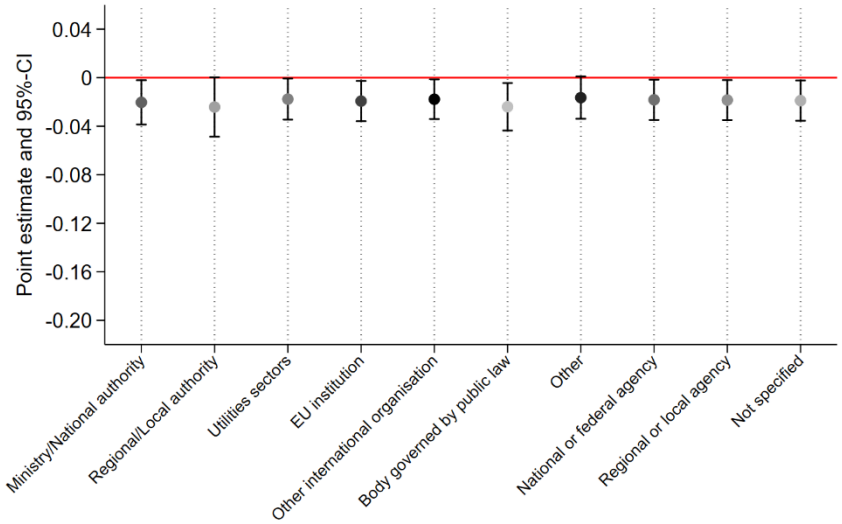

Figure B1 D – Point estimates for turnover shares with new/improved products and services excluding public authority types

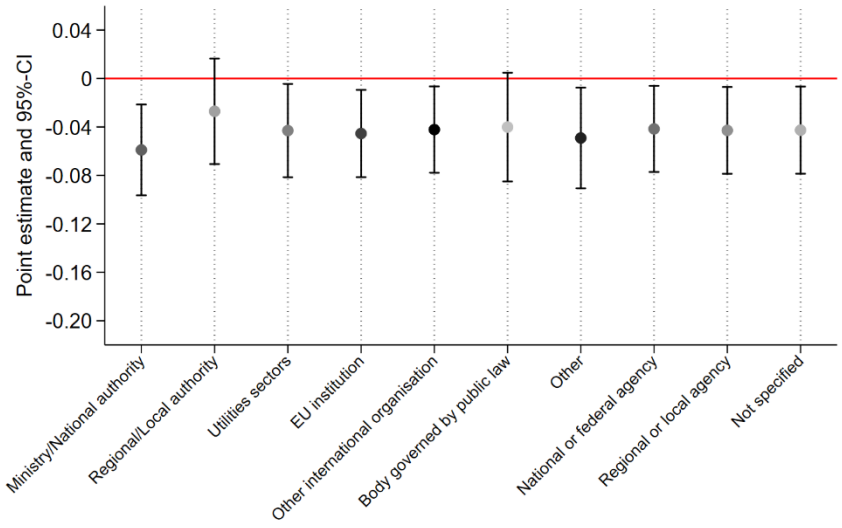

Figure B1 E – Point estimates for introducing cost-reducing process innovations (0/1) excluding public authority types

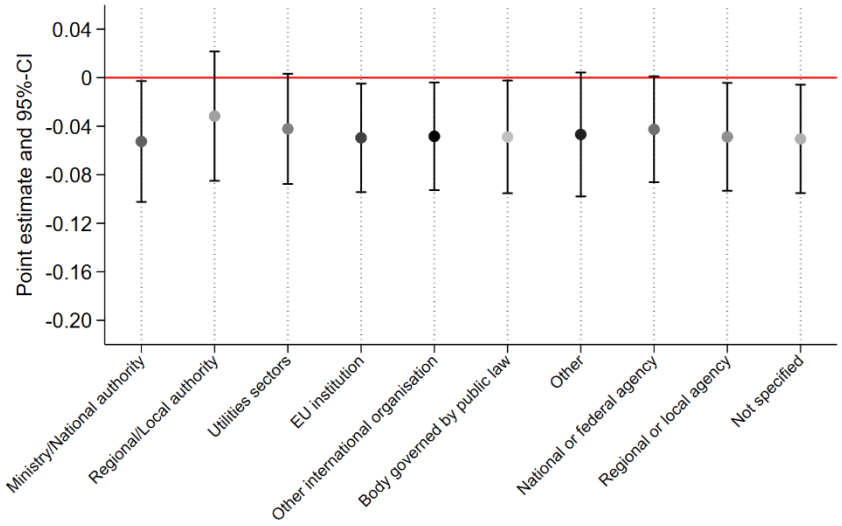

Figure B1 F – Point estimates for ln(total cost reductions due to process innovations +1) excluding public authority types

Figure B1 – Baseline estimates excluding tenders of each public authority type

Note: Each point estimate represents the results 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.

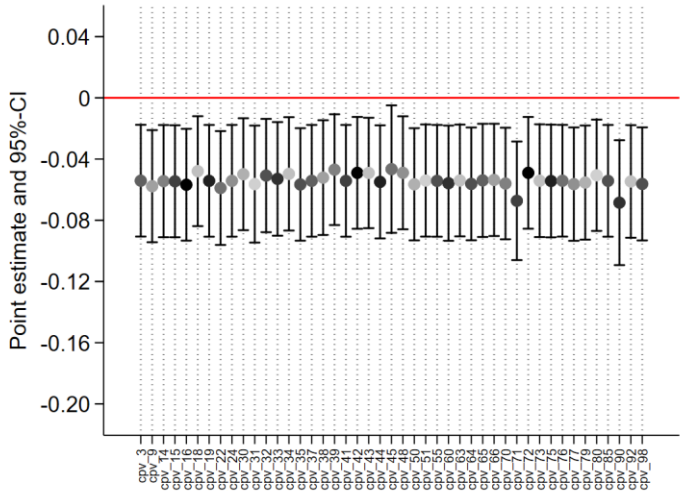

Figure B2 A – Point estimates for introducing new/improved products and services (0/1) excluding tenders for each product/service type

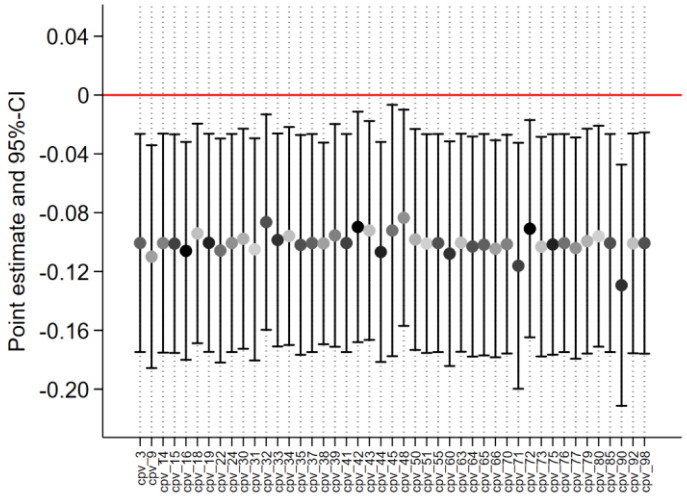

Figure B2 B – Point estimates for ln(turnover with new/improved products and services +1) excluding tenders for each product/service type

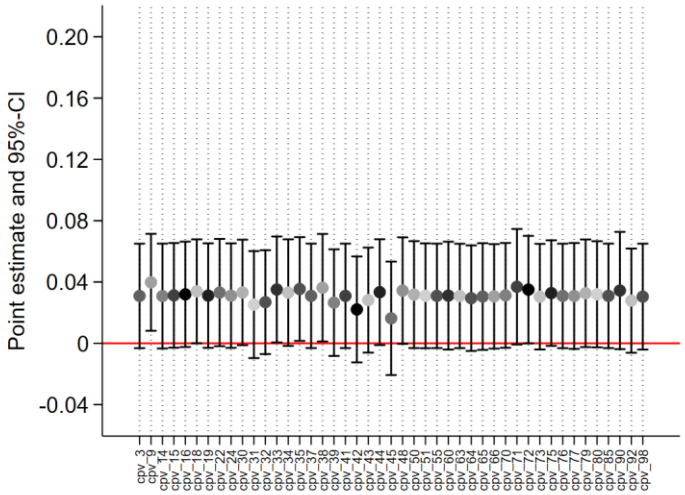

Figure B2 C – Point estimates for ln(turnovers with established products +1) excluding tenders for each product/service type

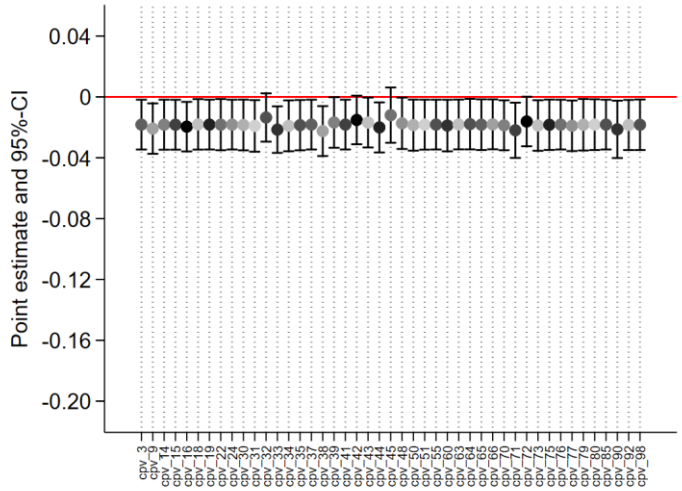

Figure B2 D – Point estimates for turnover shares with new/improved products and services (0-1) excluding tenders for each product/service type

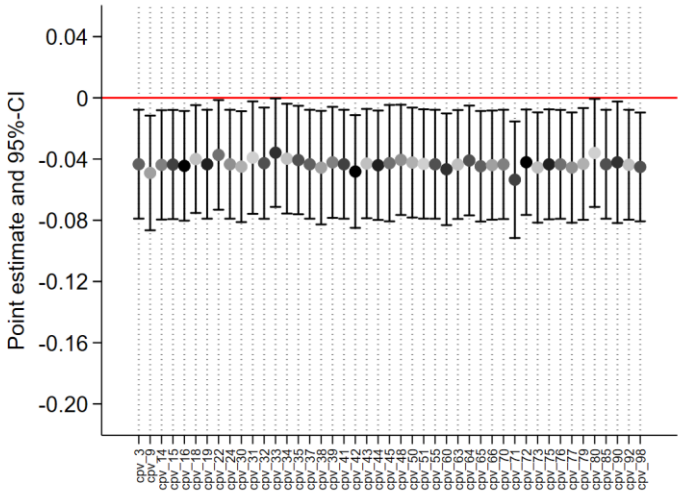

Figure B2 E – Point estimates for introducing cost-reducing process innovations (0/1) excluding tenders for each product/service type

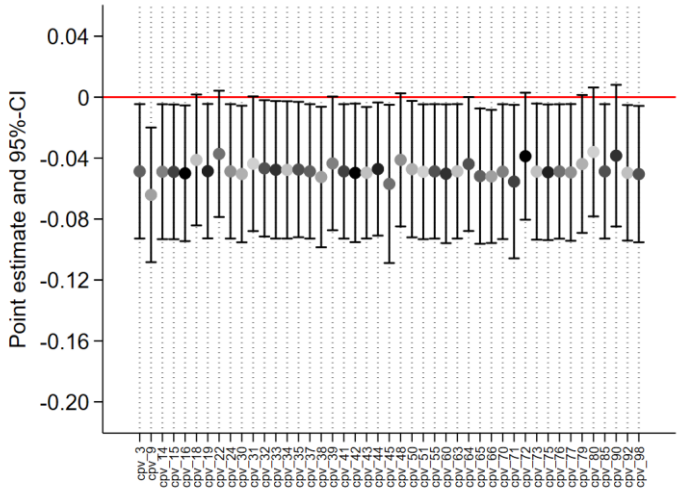

Figure B2 F – Point estimates for ln(total cost reductions due to process innovations +1) excluding tenders for each product/service type

Figure B2 – Baseline estimates excluding tenders for each product and service type

Note: Each point estimate represents the results 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 B7 in Appendix B.2.

B.2. Additional tables

Table B1 -Treatment-year interaction coefficients

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
PP 2012 (0/1)	-.053	-.019	-.021	.001	.017	.042
	(.035)	(.056)	(.032)	(.012)	(.031)	(.050)
PP 2013 (0/1)	.072**	.118*	-.052	.026	-.048*	-.086
	(.034)	(.064)	(.040)	(.016)	(.027)	(.055)
PP 2014 (0/1)	-.032	-.038	.027	-.007	-.004	.007
	(.029)	(.048)	(.025)	(.011)	(.023)	(.044)
PP 2015 (0/1)	-.007	-.035	-.021	.010	.039	.026
	(.031)	(.051)	(.018)	(.010)	(.028)	(.054)
PP 2016 (0/1)	.008	.018	-.016	-.007	.002	.031
	(.031)	(.041)	(.019)	(.010)	(.020)	(.031)
PP 2017 (0/1)	.004	-.114*	.018	-.002	-.068**	-.060**
	(.034)	(.063)	(.017)	(.008)	(.027)	(.029)
PP 2018 (0/1)	-.009	.037	.045*	-.015	-.005	-.001
	(.034)	(.063)	(.026)	(.011)	(.028)	(.041)
PP 2019 (0/1)	.042	.050	.012	.002	.102**	.050
	(.043)	(.081)	(.036)	(.014)	(.041)	(.041)
Observations	15,623	15,623	15,623	15,623	15,202	15,202

*All estimates are based on OLS. Each line represents individual estimations equivalent to our baseline Table 2 with an additional interaction term as indicated by PP YEAR (0/1). PP YEAR (0/1) refers to the interaction of "Winning price-based public procurement tenders within the last three years (0/1)" and a year variable equal to one if YEAR is the current year, and zero otherwise. P-values correspond to: *** p<.01, ** p<.05, * p<.1*

Table B2 - Exclusion of year 2013

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]PP (0/1)	-.050**	-.107***	.031**	-.015**	-.042**	-.047**
	(.020)	(.038)	(.014)	(.007)	(.020)	(.024)
Ln(employees)	.024*	.075***	.365***	.005	.013	.047***
	(.013)	(.017)	(.036)	(.006)	(.011)	(.017)
University degree (0-1)	.059	.065*	.044	.024	.028	.021
	(.039)	(.037)	(.033)	(.018)	(.032)	(.032)
Regular R&D (0/1)	.214***	.221***	-.041**	.050***	.096***	.050***
	(.024)	(.033)	(.017)	(.009)	(.019)	(.018)
Occasional R&D (0/1)	.151***	.087***	-.019	.027***	.090***	.055***
	(.02)	(.023)	(.013)	(.007)	(.016)	(.016)
Innovat. exp./turnovers	.190***	.032	.052	.083***	.088**	.047**
	(.044)	(.035)	(.070)	(.026)	(.037)	(.022)
Pers. costs/turnovers	-.039**	-.111***	-.446***	-.016**	.001	-.055
	(.018)	(.029)	(.081)	(.008)	(.024)	(.037)
Tang. assets/turnovers	-.004	-.001	-.004	-.001	-.002	-.001
	(.003)	(.002)	(.003)	(.001)	(.001)	(.001)
Ln(patent stock+1)	.024	.035	.036	-.035	-.022	-.268**
	(.043)	(.091)	(.06)	(.024)	(.056)	(.107)
Exporter (0/1)	.004	.006	-.011	.006	.008	-.007
	(.021)	(.022)	(.016)	(.008)	(.016)	(.015)
East Germany (0/1)	-.236	-.321	.081	-.017	.072	.122
	(.163)	(.426)	(.293)	(.149)	(.202)	(.127)
National group (0/1)	-.014	-.024	-.006	-.002	-.004	-.004
	(.017)	(.022)	(.012)	(.007)	(.014)	(.015)
Intern. group (0/1)	-.030	-.026	-.018	.003	-.017	-.002
	(.028)	(.058)	(.024)	(.011)	(.025)	(.039)
Constant	.254***	.171	.686***	.055	.009	-.076
	(.078)	(.174)	(.171)	(.061)	(.089)	(.079)
Observations	13,258	13,258	13,258	13,258	12,858	12,858
R-squared	.762	.879	.985	.745	.622	.767

*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 public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Table B3 - Exclusion of year 2017

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]PP (0/1)	-.050**	-.074*	.027	-.017*	-.034*	-.039*
	(.020)	(.038)	(.019)	(.009)	(.019)	(.023)
Ln(employees)	.028**	.071***	.349***	.003	.010	.038***
	(.013)	(.016)	(.036)	(.006)	(.010)	(.014)
University degree (0-1)	.049	.098**	.068*	.023	.014	.005
	(.042)	(.039)	(.041)	(.019)	(.034)	(.031)
Regular R&D (0/1)	.230***	.243***	-.052***	.061***	.099***	.059***
	(.023)	(.033)	(.016)	(.009)	(.019)	(.020)
Occasional R&D (0/1)	.145***	.092***	-.028**	.032***	.093***	.051***
	(.020)	(.023)	(.012)	(.007)	(.016)	(.016)
Innovat. exp./turnovers	.197***	.037	-.030	.104***	.107**	.047**
	(.043)	(.035)	(.065)	(.026)	(.042)	(.023)
Pers. costs/turnovers	-.030*	-.093***	-.361***	-.008	.004	-.048
	(.015)	(.026)	(.086)	(.007)	(.023)	(.030)
Tang. assets/turnovers	-.002	.000	-.004	.000	-.001	.000
	(.003)	(.002)	(.003)	(.002)	(.001)	(.001)
Ln(patent stock+1)	.016	.029	.058	-.046**	-.047	-.269***
	(.040)	(.089)	(.055)	(.023)	(.050)	(.100)
Exporter (0/1)	.006	.016	-.001	.005	-.002	-.011
	(.02)	(.019)	(.016)	(.008)	(.017)	(.014)
East Germany (0/1)	-.175	-.292	-.029	.009	.130	.146
	(.125)	(.339)	(.361)	(.158)	(.217)	(.126)
National group (0/1)	-.023	-.043**	-.006	-.004	-.008	-.002
	(.017)	(.021)	(.013)	(.006)	(.014)	(.015)
Intern. group (0/1)	-.035	-.049	-.021	.001	-.026	-.032
	(.029)	(.057)	(.026)	(.012)	(.026)	(.042)
Constant	.210***	.151	.747***	.047	.005	-.049
	(.068)	(.142)	(.184)	(.063)	(.091)	(.071)
Observations	13,672	13,672	13,672	13,672	13,264	13,264
R-squared	.771	.884	.985	.741	.630	.764

*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 public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Table B4 - Exclusion of year 2018

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]PP (0/1)	-.052***	-.109***	.035*	-.017*	-.031	-.042*
	(.02)	(.038)	(.018)	(.009)	(.020)	(.025)
Ln(employees)	.015	.059***	.345***	.005	.009	.028**
	(.014)	(.015)	(.038)	(.005)	(.010)	(.014)
University degree (0-1)	.049	.068*	.070	.020	-.014	.008
	(.041)	(.039)	(.043)	(.019)	(.031)	(.03)
Regular R&D (0/1)	.225***	.216***	-.048***	.058***	.099***	.044**
	(.024)	(.031)	(.017)	(.009)	(.02)	(.018)
Occasional R&D (0/1)	.162***	.105***	-.032**	.033***	.090***	.047***
	(.021)	(.023)	(.013)	(.007)	(.017)	(.016)
Innovat. exp./turnovers	.189***	.044	-.017	.090***	.092**	.034*
	(.041)	(.035)	(.065)	(.026)	(.039)	(.019)
Pers. costs/turnovers	-.034**	-.097***	-.384***	-.012*	.004	-.046
	(.016)	(.027)	(.093)	(.007)	(.024)	(.031)
Tang. assets/turnovers	-.002	.001	-.004	.000	.000	.001
	(.004)	(.001)	(.003)	(.002)	(.001)	(.001)
Ln(patent stock+1)	-.007	.023	.040	-.030	-.035	-.288***
	(.039)	(.085)	(.059)	(.021)	(.052)	(.104)
Exporter (0/1)	.0110	.015	.004	.007	-.016	-.024**
	(.020)	(.016)	(.017)	(.008)	(.016)	(.010)
East Germany (0/1)	-.052	-.103	-.052	.019	.156	.175
	(.043)	(.343)	(.448)	(.197)	(.272)	(.153)
National group (0/1)	-.009	-.012	-.010	-.001	-.005	-.009
	(.018)	(.024)	(.014)	(.007)	(.015)	(.016)
Intern. group (0/1)	.006	.044	-.054*	.013	.008	-.006
	(.032)	(.058)	(.032)	(.012)	(.029)	(.038)
Constant	.189***	.106	.779***	.030	-.006	-.022
	(.053)	(.142)	(.214)	(.076)	(.109)	(.078)
Observations	13,044	13,044	13,044	13,044	12,659	12,659
R-squared	.774	.890	.985	.738	.625	.780

*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 public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Table B5 - Exclusion of year 2019

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]PP (0/1)	-.041**	-.080**	.027	-.015	-.045**	-.058**
	(.020)	(.040)	(.019)	(.009)	(.018)	(.025)
Ln(employees)	.025*	.069***	.337***	.001	.014	.042**
	(.013)	(.015)	(.035)	(.006)	(.010)	(.016)
University degree (0-1)	.041	.079**	.0380	.018	-.020	-.001
	(.039)	(.037)	(.036)	(.017)	(.030)	(.033)
Regular R&D (0/1)	.232***	.239***	-.042***	.060***	.098***	.048**
	(.023)	(.033)	(.015)	(.009)	(.019)	(.020)
Occasional R&D (0/1)	.154***	.093***	-.028**	.035***	.093***	.053***
	(.021)	(.023)	(.012)	(.007)	(.016)	(.016)
Innovat. exp./turnovers	.211***	.039	-.022	.099***	.102***	.050**
	(.041)	(.034)	(.064)	(.026)	(.038)	(.021)
Pers. costs/turnovers	-.032**	-.097***	-.367***	-.007	-.002	-.046
	(.016)	(.026)	(.084)	(.007)	(.023)	(.029)
Tang. assets/turnovers	-.004	-.001	-.003	-.002	-.001	.001
	(.003)	(.002)	(.003)	(.001)	(.001)	(.001)
Ln(patent stock+1)	.008	.003	.100**	-.049**	-.034	-.255**
	(.038)	(.084)	(.042)	(.021)	(.055)	(.104)
Exporter (0/1)	-.016	-.011	.005	-.002	.004	-.004
	(.019)	(.020)	(.016)	(.007)	(.015)	(.014)
East Germany (0/1)	-.173	-.271	-.098	.021	.018	.070
	(.132)	(.365)	(.385)	(.171)	(.214)	(.124)
National group (0/1)	-.013	-.020	-.018	.001	-.005	-.015
	(.018)	(.023)	(.013)	(.007)	(.015)	(.015)
Intern. group (0/1)	-.038	-.029	-.050*	.010	-.011	-.017
	(.029)	(.058)	(.026)	(.012)	(.027)	(.036)
Constant	.227***	.160	.807***	.052	.034	-.036
	(.070)	(.151)	(.190)	(.068)	(.089)	(.075)
Observations	14,308	14,308	14,308	14,308	13,908	13,908
R-squared	.761	.881	.986	.729	.619	.764

*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 public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Table B6 – Criteria-based public procurement (linear specification)

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]PPG (0/1)	-.059***	-.101***	.035**	-.015*	-.025	-.022
	(.019)	(.033)	(.018)	(.009)	(.017)	(.022)
[b]PPCL - Criteria length	.002	.002	-.002	.001	-.003	-.006
	(.004)	(.005)	(.003)	(.001)	(.003)	(.005)
Ln(employees)	.026**	.073***	.346***	.003	.013	.040***
	(.013)	(.016)	(.035)	(.006)	(.010)	(.015)
University degree (0-1)	.062*	.084**	.059*	.022	.009	.010
	(.037)	(.035)	(.036)	(.016)	(.030)	(.029)
Regular R&D (0/1)	.224***	.232***	-.049***	.056***	.100***	.053***
	(.022)	(.031)	(.016)	(.008)	(.018)	(.018)
Occasional R&D (0/1)	.153***	.090***	-.030**	.032***	.093***	.050***
	(.019)	(.021)	(.012)	(.007)	(.015)	(.015)
Innovat. exp./turnovers	.194***	.036	-.029	.098***	.096***	.048**
	(.041)	(.033)	(.063)	(.025)	(.037)	(.020)
Pers. costs/turnovers	-.029**	-.093***	-.374***	-.010	.000	-.046*
	(.015)	(.025)	(.084)	(.006)	(.021)	(.027)
Tang. assets/turnovers	-.002	.000	-.004	.000	-.001	.000
	(.003)	(.002)	(.003)	(.002)	(.001)	(.001)
Ln(patent stock+1)	.012	.031	.055	-.038*	-.043	-.270***
	(.038)	(.083)	(.054)	(.021)	(.052)	(.100)
Exporter (0/1)	-.002	-.001	-.001	.002	-.003	-.009
	(.019)	(.019)	(.015)	(.007)	(.014)	(.013)
East Germany (0/1)	-.172	-.290	-.019	.008	.123	.135
	(.119)	(.326)	(.349)	(.153)	(.208)	(.123)
National group (0/1)	-.010	-.023	-.010	-.001	-.004	-.007
	(.016)	(.021)	(.011)	(.006)	(.013)	(.015)
Intern. group (0/1)	-.029	-.033	-.035	.004	-.016	-.013
	(.027)	(.053)	(.024)	(.010)	(.024)	(.038)
Constant	.210***	.150	.762***	.046	-.003	-.055
	(.066)	(.138)	(.181)	(.061)	(.088)	(.073)
Observations	15623	15623	15623	15623	15202	15202
R-squared	.759	.879	.985	.731	.616	.759

*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]PPG (0/1) refers to winning price-based or general public procurement tenders, 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 public tenders won by a firm over the past three years.

Table B7 – 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

Table B7 - Continuation

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 B8 – Baseline results without covariate

	(1) Innovative products (0/1)	(2) Ln(innovative turnover+1)	(3) Ln(established turnover+1)	(4) Share innovative turnover	(5) Innovative processes (0/1)	(6) Ln(cost reductions process in.+1)
[a]PP (0/1)	-.045**	-.090**	.053**	-.016**	-.032*	-.045*
	(.019)	(.038)	(.022)	(.008)	(.018)	(.023)
Constant	.302***	.335***	1.833***	.076***	.114***	.097***
	(.001)	(.003)	(.001)	(.001)	(.001)	(.001)
Observations	15,623	15,623	15,623	15,623	15,202	15,202
R-squared	.752	.877	.982	.726	.612	.757

*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 public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Appendix C - Step-by-step estimation description

We proceed as follows:

i. The Mannheim Enterprise Panel and the Tenders Electronic Daily database are matched based on firms' name and address histories by the ZEW Mannheim

ii. We keep firms winning price-based public procurement tenders within the last three years from 2012 to 2019

iii. We keep firms being part of the population of the Mannheim Innovation Panel based on their employee number, industry classification, and location

iv. We count the yearly number of remaining firms - the number of firms winning price-based public procurement within the last three years and being part of the Mannheim Innovation Panel population

v. We take the projected yearly total turnovers with new/improved products and services, the projected yearly total turnovers with established products and services, and the projected yearly total cost reductions due to process innovations from the ZEW Mannheim

vi. We take the yearly total number of firms within the population of the Mannheim Innovation Panel from the ZEW Mannheim

vii. We estimate the *average* projected yearly total turnovers with new/improved products and services of a firm, the *average* projected yearly total turnovers with established products and services of a firm, as well as the *average* projected yearly total cost reductions due to process innovations of a firm by dividing v. by vi.

viii. We multiply the number of firms winning price-based public procurement tenders from iv. by our transformed point estimates from Column (2) in Table 2, and by the yearly average of total turnovers with new/improved products and services from vii.
The result is the yearly loss in total turnovers with new/improved products and services as a consequence of winning price-based public procurement tenders within the last three years in the German enterprise sector.

ix. We multiply the number of firms winning price-based public procurement tenders from iv. by our transformed point estimates from Column (3) in Table 2, and by the yearly average of total turnovers with established products and services from vii.
The result is the yearly gain in total turnovers with established products and services as a consequence of winning price-based public procurement tenders within the last three years in the German enterprise sector.

x. We multiply the number of firms winning price-based public procurement tenders from iv. by our transformed point estimates from Column (6) in Table 2, and by the yearly average of total cost reductions due to process innovations from vii.
The result is the yearly loss in total cost reductions due to process innovations as a consequence of winning price-based public procurement tenders within the last three years in the German enterprise sector.

The results are used to estimate the Columns of Table 7 as follows:

Column (1) is estimated by dividing the yearly values from v. focused on new/improved products or services by the yearly values from viii.

Column (2) is estimated by dividing the yearly values from v. focused on established products or services by the yearly values from ix.

Column (3) is estimated by dividing the yearly summed values from v. by the summed values of viii. and ix.

Column (4) is estimated by dividing the yearly values from v. focused on cost reductions by the yearly values from x.

Download ZEW Discussion Papers:

https://www.zew.de/en/publications/zew-discussion-papers

or see:

https://www.ssrn.com/link/ZEW-Ctr-Euro-Econ-Research.html
https://ideas.repec.org/s/zbw/zewdip.html

IMPRINT

ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH Mannheim
ZEW – Leibniz Centre for European Economic Research

L 7,1 · 68161 Mannheim · Germany
Phone +49 621 1235-01
info@zew.de · zew.de