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DISCUSSION PAPER

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Public Procurement Can Hinder Innovation

Public procurement can hinder innovation

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Abstract

Public procurement accounts for 15 to 20 percent of global GDP and is considered an effective innovation policy. However, the detrimental effects of non-innovative public procurement - public procurement tenders awarded solely based on their price - on firm innovations have been largely neglected, even though it represents the majority of all tenders. We contribute by i) developing a comprehensive theory on the effects of winning non-innovative 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 non-innovative 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
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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 detrimental effects of non-innovative 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 non-innovative public procurement on heterogeneous firm innovation and test our hypotheses using two-way fixed effects estimations on a representative survey of German firms.

The theoretical framework builds on 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 non-innovative public procurement and extends previous theories by deriving individual hypotheses on the effects of winning non-innovative 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 introduced 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 public procurement tenders without additional award criteria next to the price 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

[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.

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 non-innovative 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.

Therefore, as a whole, we contribute by extending the scientific discussion on the effects of public procurement on firm innovations with a detailed analysis of the innovation-reducing effects of non-innovative public procurement (Chiappinelli et al., 2023; Kundu et al., 2020; Obwegeser and Müller, 2018). Moreover, we demonstrate significant reductions in firm innovations at the level of the individual firm and the level of the German enterprise sector, implying potential detrimental effects on long-term competitiveness at both levels. Thus, next to adding to the scientific discussion, our results aim to create awareness for the neglected negative effects of non-innovative public procurement on firm innovation among public authorities, policy makers, and firm managers, in particular, as to date the majority of public procurement tenders is awarded solely based on the price criterion.[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 enterpsie sector (Edler and Georghiou, 2007; Obwegeser and Müller, 2018). Specifically, public procurement can promote

[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.

innovation through three channels: i) It provides a critical market size for firms to scale up their production capacities, ii) it enhances rates of return while minimizing the risk associated with innovation investments, and iii) it mitigates information asymmetries between suppliers and purchasers of innovative solutions (e.g. Edler and Georghiou, 2007; Geroski, 1990; Uyarra et al., 2014). Moreover, in total, 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).

However, limitations of public procurement as an innovation policy tool or even threats of public procurement to actively prevent innovation remained mostly unaddressed. Thus, further research is needed to uncover the nuanced dynamics between public procurement and innovation, particularly by shedding light on how individual components of the public procurement procedure impact innovation positively or negatively (Chiappinelli et al., 2023).

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 - non-innovative public 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). 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 public procurement tenders with no additional award criteria beyond the price 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 practice of public authorities waiving additional award criteria in their procurement tenders has multiple effects 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 public procurement tenders without additional award criteria reduces firms' probability of introducing new/improved products and services and the turnover generated with them.

H1: Winning public procurement tenders without additional award criteria 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

[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.

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 public procurement tenders without additional award criteria decreases firms' turnover share with innovative products and services while increasing firms' turnover with established products and services.

H2: Winning public procurement tenders without additional award criteria 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 procurement tenders without additional award criteria 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 procurement tenders without additional award criteria that could also decrease the probability of a firm coming up with a cost-reducing process innovation. Hence, the overall effect of winning public procurement tenders without additional award criteria on cost-reducing process innovations is ambiguous and depends on which of the aforementioned mechanisms is dominating.

H3: Winning public procurement tenders without additional award criteria 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 non-innovative public procurement tenders, we create a dichotomous variable equal to one, if a firm won at least one public procurement tender solely award based on the price criterion 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 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).

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

[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.

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 public procurement tender solely awarded on the price within the last three years, and 4.7 percent of our sample won at least one public procurement tender covering additional award criteria. 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).

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 public procurement tender awarded solely based on price within last three years (0/1)	0.066	0.248	0	1
Winning public procurement tender awarded based on additional criteria 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.

4. Identification strategy

The empirical strategy identifies the effect of winning public procurement tenders without additional award criteria - non-innovative tender - within the last three years on our hypothesized outcomes. More specifically, we estimate the effect of winning public tenders without additional award criteria 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.

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 public procurement tenders without additional award criteria during our observation period, and firms in the control group, i.e. firms which did not receive a public procurement tender without additional award criteria 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 public procurement tender without additional award criteria within the last three years. Thus, we are able to implement a difference-in-difference estimator to test our hypotheses. A difference-in-difference 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 public procurement tender without additional award criteria. Formally, we estimate:

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

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 public procurement tender without additional award criteria during the last three years and zero otherwise. Thus, our coefficient of interest is the difference-in-difference 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-difference 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 public procurement tender without additional award criteria 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.

Thus, winning public procurement tenders without additional award criteria has to be conditionally unrelated to other factors that might affect the different outcomes. Only if this assumption holds, the difference-in-difference 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 public procurement tender without additional award criteria within the last three years during our observational period (control group), and firms winning at least one public procurement tender without additional award criteria 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, significant lead estimates would indicate differences in outcome before the implementation of the treatment conditional on our control variables. Thus, this time, significant results would indicate a violation of

[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).

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 public procurement without additional award criteria within the last three years on the outcomes of our hypotheses.

Columns (1) and (2) reveal a persistent, adverse impact of winning public procurement tenders without additional award criteria on firms' product innovations. Consistent with H1, it is noted that winning public procurement tenders without additional award criteria 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 public procurement contracts without additional award criteria 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.[7] Thus, the innovation hampering effect of winning public procurement tenders without additional award criteria seems to dominate.

[7] 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)	(2)	(3)	(4)	(5)	(6)
PP (0/1)[a]	-.054***	-.101***	.031*	-.018**	-.037**	-.046**
	(.019)	(.038)	(.017)	(.008)	(.018)	(.023)
Ln(employees+1)	.027**	.074***	.345***	.003	.013	.040***
	(.013)	(.015)	(.035)	(.006)	(.01)	(.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)	(.02ß)
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+1)	.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 non-innovative public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Dependent variables

(1) Introduction of innovative products and services (0/1)
(2) Ln(turnover innovative products and services+1)
(3) Ln(turnover established products and services+1)
(4) Share of turnover innovative products and services (0-1)
(5) Introduction of process innovation reducing unit costs (0/1)
(6) Ln(total cost reduction due to process innovation+1)

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.

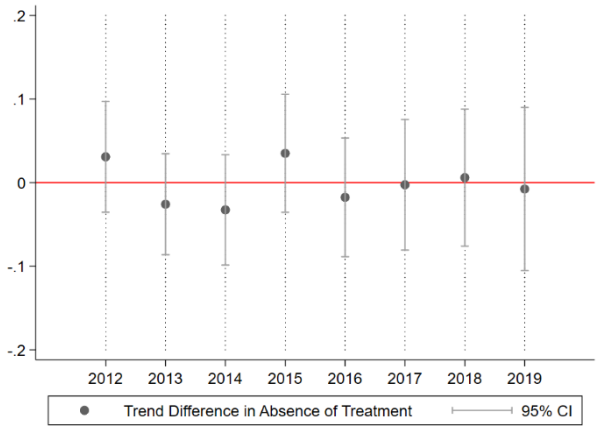

Figure 1A - Mean trend differences for introducing new/improved products and services (0/1)

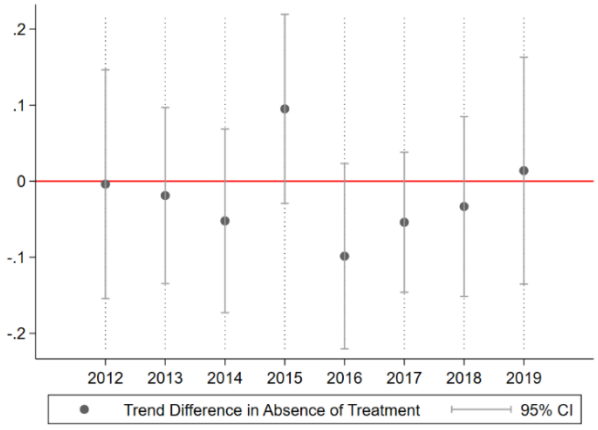

Figure 1B - Mean trend differences for ln(turnovers with new/ improved products and services + 1)

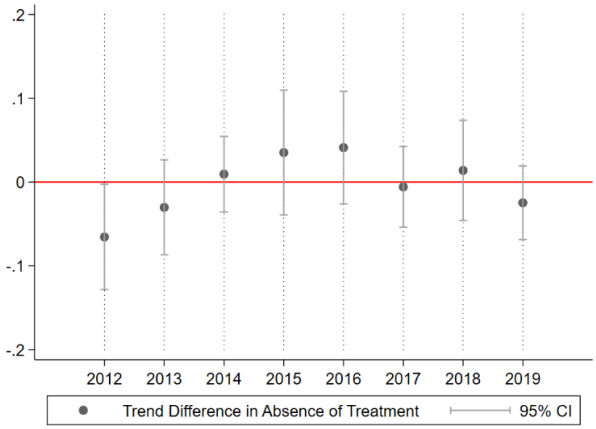

Figure 1C - Mean trend differences for ln(turnovers with established products + 1)

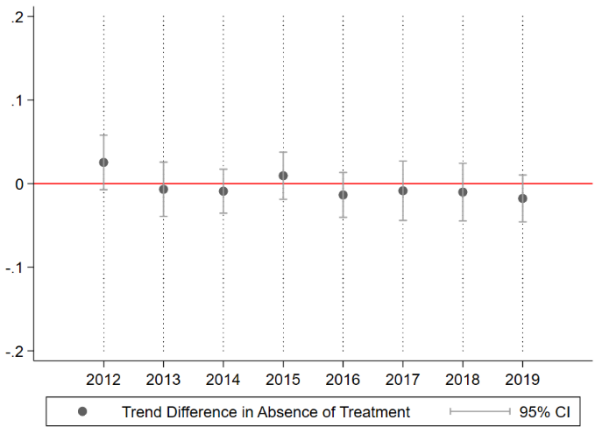

Figure 1D - Mean trend differences for turnover shares with new/improved products and services (0-1)

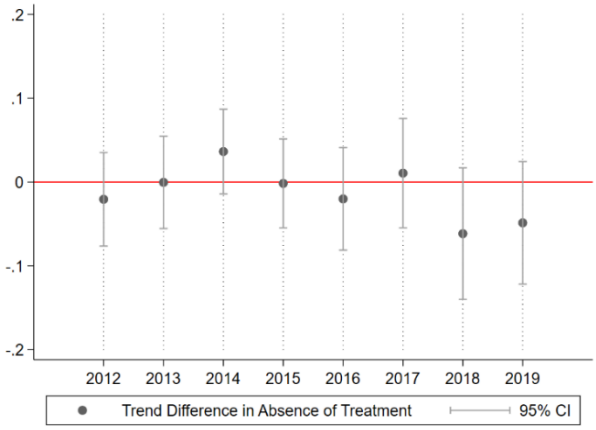

Figure 1E - Mean trend differences for introducing cost-reducing process innovations (0/1)

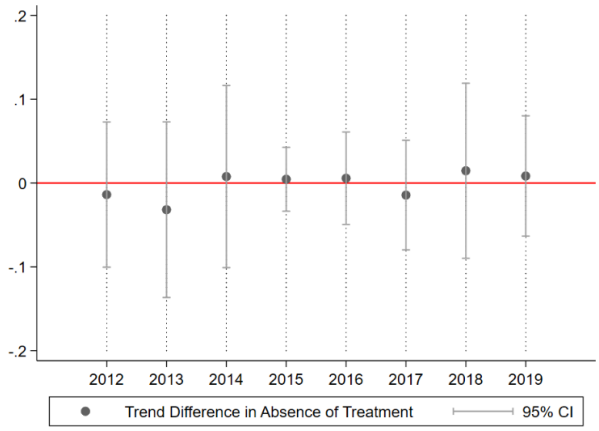

Figure 1F - Mean trend differences for Ln(total cost reductions due to process innovations + 1)

Figure 1 - Testing the unconditional common trend using t-test 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)	(2)	(3)	(4)	(5)	(6)
Lead.PP[a] (0/1)	-.021	-.024	.018	.003	-.011	-.026
	(.021)	(.035)	(.016)	(.008)	(.017)	(.024)
PP (0/1)[a]	-.046**	-.091**	.024	-.019**	-.032*	-.036*
	(.021)	(.038)	(.018)	(.009)	(.019)	(.021)
Ln(employees+1)	.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+1)	.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 non-innovative 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).

Dependent variables

(1) Introduction of innovative products and services (0/1)
(2) Ln(turnover innovative products and services+1)
(3) Ln(turnover established products and services+1)
(4) Share of turnover innovative products and services (0-1)
(5) Introduction of process innovation reducing unit costs (0/1)
(6) Ln(total cost reduction due to process innovation+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

regression. Specifically, we test if the estimated treatment effect is constant over time and reconduct our baseline estimation excluding years for which we observe significant treatment heterogeneity. Second, we address that the estimated effect may be driven by few firms receiving many public procurement tenders without additional award criteria and again reconduct our estimation by dropping firms that won more than one public procurement tender without additional award criteria within the last three years. Third, we also include public procurement contracts with additional award criteria 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. 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-difference suggest that the standard two-way fixed effects approach can yield a biased estimate of the difference-in-difference 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-difference 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 careful reevaluation of the estimate. Table B1 in the Appendix 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 public procurement tenders without additional award criteria in a single year. Even though most of the firms in our sample won one public procurement tender without additional award criteria 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, even though the statistical significance decreased on average.

Table 4 - Dose specific effect heterogeneity

	(1)	(2)	(3)	(4)	(5)	(6)
PP (0/1)[a]	-.054**	-.100**	.034*	-.018*	-.033	-.062**
	(.022)	(.043)	(.020)	(.010)	(.020)	(.025)
Ln(employees+1)	.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	-.25**
	(.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 non-innovative 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 non-innovative public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Dependent variables

(1) Introduction of innovative products and services (0/1)
(2) Ln(turnover innovative products and services+1)
(3) Ln(turnover established products and services+1)
(4) Share of turnover innovative products and services (0-1)
(5) Introduction of process innovation reducing unit costs (0/1)
(6) Ln(total cost reduction due to process innovation+1)

Public procurement with additional criteria - We address potential concerns that the estimated effects are driven by winning public tenders in general, and not winning public procurement tenders without additional criteria. Therefore, we include public procurement tenders which include additional award criteria in our empirical analysis. Table 5 shows that the coefficients for winning public procurement tenders with award criteria are insignificant, while those for public procurement tenders without additional award criteria remain significant for all of our hypothesized outcomes. This underlines the innovation hampering effect resulting from the absence of award criteria in public procurement tenders.

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 B6 our previous results are robust.

Table 5 - Public procurement with additional criteria

	(1)	(2)	(3)	(4)	(5)	(6)
PP (0/1)[a]	-.053***	-.100***	.031*	-.019**	-.036**	-.045**
	(.019)	(.038)	(.017)	(.008)	(.018)	(.023)
PP criteria (0/1)[b]	-.017	-.011	-.004	.007	-.011	-.017
	(.022)	(.035)	(.018)	(.010)	(.020)	(.037)
Ln(employees+1)	.027**	.074***	.345***	.003	.013	.04***
	(.013)	(.015)	(.035)	(.006)	(.01)	(.015)
University degree (0-1)	.062*	.082**	.060*	.021	.008	.009
	(.037)	(.035)	(.036)	(.016)	(.03)	(.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	.03	.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)	(.01)	(.024)	(.037)
Constant	.208***	.146	.764***	.045	-.004	-.056
	(.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<.1*

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

[b]PP criteria (0/1) refers to winning potentially innovative public procurement tenders - tenders awarded based on additional award criteria beyond the price - within the last three years.

Dependent variables

(1) Introduction of innovative products and services (0/1)
(2) Ln(turnover innovative products and services+1)
(3) Ln(turnover established products and services+1)
(4) Share of turnover innovative products and services (0-1)
(5) Introduction of process innovation reducing unit costs (0/1)
(6) Ln(total cost reduction due to process innovation+1)

5.4. Economic wide effects

We estimate the economic wide effects of non-innovative 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, we estimate the number of firms winning non-innovative public procurement tenders during the last three years within the population of the Mannheim Innovation Panel and combine the estimate with our firm effects from Table 2, and the projections on the innovativeness of the German enterprise sector by the ZEW Mannheim.[8] More precisely, 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 non-innovative 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 non-innovative 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.

[8] The estimations of firms' projected innovativeness are described in Rammer and Hünermund (2013), Aschhoff et al. (2013), Rammer and Peters (2015), Rammer et al. (2016), Rammer (2017), Rammer (2018), Rammer (2019), Rammer (2020)

viii. We multiply the number of firms winning non-innovative 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 non-innovative public procurement tenders within the last three years in the German enterprise sector.

ix. We multiply the number of firms winning non-innovative 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 non-innovative public procurement tenders within the last three years in the German enterprise sector.

x. We multiply the number of firms winning non-innovative 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 non-innovative public procurement tenders within the last three years in the German enterprise sector.

We summarize the results of our back of the envelope analysis in Table 6. Using our described 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 non-innovative 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 innovative public procurement tenders decreased cost reductions based on process innovations between 1.6 and 2.3 percent.

Table 6 - Effects of winning non-innovative public procurement tenders on the German enterprise sector

Year	Percentage change in turnovers with new/improved products and services (1)	Percentage change in turnovers with established products and services (2)	Percentage change in turnovers with products and services (3)	Percentage change in total cost reductions due to process innovations (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: Column (1) - estimated by dividing the yearly values from v. focused on new/improved products or services by the yearly values from viii. Column (2) - 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. The German enterprise sector is defined as the population of the Mannheim Innovation Panel.

6. Conclusion

Contribution - The examination of non-innovative 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 discuss the adverse effects of public procurement tenders without additional award criteria. Shifting the focus from innovative to non-innovative procurement and individually examining product and process innovations, we extend existing theories.

Furthermore, we empirically validate our theoretical hypotheses. Specifically, our findings indicate that firms winning non-innovative 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.

Implications - The observed reductions in firm innovations, both at the firm and enterprise sector levels, underscore the potential threats of non-innovative public procurement to long-term competitiveness. Therefore, prioritizing additional award criteria in the procurement process and adopting a long-term perspective is crucial for public procurers to support firm innovation.

Furthermore, intensified efforts by policymakers to facilitate the use of award criteria have the potential to diminish the reliance on price as the sole award criterion, thereby increasing the innovativeness of firms. Finally, firm managers are responsible for balancing the trade-off between selling established products and services to public procurers for short-run turnovers, risking a reduction in long-term competitiveness due to their diminished innovativeness.

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 non-innovative 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 non-innovative 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.

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Appendix A - Example of public procurement tender with additional award criteria

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 - Additional tables

Table B1 -Treatment-year interaction coefficients

	(1)	(2)	(3)	(4)	(5)	(6)
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 non-innovative 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*

Dependent variables

(1) Introduction of innovative products and services (0/1)
(2) Ln(turnover innovative products and services+1)
(3) Ln(turnover established products and services+1)
(4) Share of turnover innovative products and services (0-1)
(5) Introduction of process innovation reducing unit costs (0/1)
(6) Ln(total cost reduction due to process innovation+1)

Table B2 - Exclusion of year 2013

	(1)	(2)	(3)	(4)	(5)	(6)
PP (0/1)[a]	-.050**	-.107***	.031**	-.015**	-.042**	-.047**
	(.02)	(.038)	(.014)	(.007)	(.020)	(.024)
Ln(employees+1)	.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***	.05***
	(.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	.19***	.032	.052	.083***	.088**	.047**
	(.044)	(.035)	(.07)	(.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 non-innovative public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Dependent variables

(1) Introduction of innovative products and services (0/1)
(2) Ln(turnover innovative products and services+1)
(3) Ln(turnover established products and services+1)
(4) Share of turnover innovative products and services (0-1)
(5) Introduction of process innovation reducing unit costs (0/1)
(6) Ln(total cost reduction due to process innovation+1)

Table B3 - Exclusion of year 2017

	(1)	(2)	(3)	(4)	(5)	(6)
PP (0/1)[a]	-.050**	-.074*	.027	-.017*	-.034*	-.039*
	(.02)	(.038)	(.019)	(.009)	(.019)	(.023)
Ln(employees+1)	.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***
	(.02)	(.023)	(.012)	(.007)	(.016)	(.016)
Innovat. exp./turnovers	.197***	.037	-.030	.104***	.107**	.047**
	(.043)	(.035)	(.065)	(.026)	(.042)	(.023)
Pers. costs/turnovers	-.03*	-.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***
	(.04)	(.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 non-innovative public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Dependent variables

(1) Introduction of innovative products and services (0/1)
(2) Ln(turnover innovative products and services+1)
(3) Ln(turnover established products and services+1)
(4) Share of turnover innovative products and services (0-1)
(5) Introduction of process innovation reducing unit costs (0/1)
(6) Ln(total cost reduction due to process innovation+1)

Table B4 - Exclusion of year 2018

	(1)	(2)	(3)	(4)	(5)	(6)
PP (0/1)[a]	-.052***	-.109***	.035*	-.017*	-.031	-.042*
	(.02)	(.038)	(.018)	(.009)	(.020)	(.025)
Ln(employees+1)	.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)	(.01)
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 non-innovative public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Dependent variables

(1) Introduction of innovative products and services (0/1)
(2) Ln(turnover innovative products and services+1)
(3) Ln(turnover established products and services+1)
(4) Share of turnover innovative products and services (0-1)
(5) Introduction of process innovation reducing unit costs (0/1)
(6) Ln(total cost reduction due to process innovation+1)

Table B5 - Exclusion of year 2019

	(1)	(2)	(3)	(4)	(5)	(6)
PP (0/1)[a]	-.041**	-.08**	.027	-.015	-.045**	-.058**
	(.02)	(.04)	(.019)	(.009)	(.018)	(.025)
Ln(employees+1)	.025*	.069***	.337***	.001	.014	.042**
	(.013)	(.015)	(.035)	(.006)	(.01)	(.016)
University degree (0-1)	.041	.079**	.0380	.018	-.020	-.001
	(.039)	(.037)	(.036)	(.017)	(.03)	(.033)
Regular R&D (0/1)	.232***	.239***	-.042***	.06***	.098***	.048**
	(.023)	(.033)	(.015)	(.009)	(.019)	(.02)
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 non-innovative public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Dependent variables

(1) Introduction of innovative products and services (0/1)
(2) Ln(turnover innovative products and services+1)
(3) Ln(turnover established products and services+1)
(4) Share of turnover innovative products and services (0-1)
(5) Introduction of process innovation reducing unit costs (0/1)
(6) Ln(total cost reduction due to process innovation+1)

Table B6 – Baseline results without covariate

	(1)	(2)	(3)	(4)	(5)	(6)
PP (0/1)[a]	-.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 non-innovative public procurement tenders - tenders solely awarded based on the price criterion - within the last three years.

Dependent variables

(1) Introduction of innovative products and services (0/1)
(2) Ln(turnover innovative products and services+1)
(3) Ln(turnover established products and services+1)
(4) Share of turnover innovative products and services (0-1)
(5) Introduction of process innovation reducing unit costs (0/1)
(6) Ln(total cost reduction due to process innovation+1)

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