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Abstract:

To stimulate sustainable economic development and a greener economy, the European Commission co-funds public projects through the European Structural and Investment Funds (ESIF), which are among the largest such funds in the world worth approximately 100 billion euros annually. Since 2014, ESIF beneficiaries are incentivized to increase their use of green public procurement (GPP). In this paper, we study to what extent ESIF co-funding affects the uptake of GPP, making use of a rare dataset containing all public tender notices in the Czech Republic (2006-2019). We find a positive effect of ESIF on GPP and suggestive evidence that ESIF co-funding instigates selection behaviour by contracting authorities, that allocate their projects and resources to improve their chances of receiving co-funding. Exploiting two policy changes, we show that the ESIF's effect on GPP is driven by financial incentives and not by 'greener' policy objectives. Finally, we study the effect of gained experience with GPP and find that it only increases contracting authorities' later uptake of GPP to a limited extent. Mainstreaming of GPP calls for a more systemic approach that covers public procurement as a whole, for instance, by making GPP on a national level less voluntary for ESIF eligibility.

Keywords: Green public procurement, EU, co-funding, climate policy, policy evaluation, sustainable development

JEL codes: D73, H57

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1. Introduction

With the launch of the European Green Deal, the European Union (EU) is taking a wide range of initiatives to make the transition to a clean, climate-neutral and circular economy by 2050 (EC, 2019). A key aim of the EU policy framework is its strategy to stimulate the development of lead markets for climate neutral and circular products, inside and outside of Europe, by directing industry towards climate and environmental action, while avoiding lock-in into unsustainable practices (EC, 2019, 2020).

Among other economic instruments, public procurement is marked as an essential instrument by the EU for the greening of industries, which also provides public authorities the opportunity to lead by example (EC, 2019, 2020). Public procurement accounts for about 14% of the EU's GDP (EC, 2023) and about 15% of greenhouse-gas emissions worldwide (WEF & BCG, 2022). Hence, green public procurement (GPP) can substantially contribute to climate change mitigation and other sustainable development objectives. Firstly, by procuring goods, services and works with a reduced environmental impact throughout their life cycle¹ and secondly, as an effective demand pull instrument that shapes and greens industries (Krieger & Zipperer, 2022; Lindström et al., 2020; Simcoe & Toffel, 2014). Despite the potential benefits, the uptake of GPP appears limited in the EU, especially in less economically developed countries (Rosell, 2021; Yu et al., 2020).

In this paper, we investigate whether and how the uptake of GPP is stimulated by the European Structural and Investment Funds (henceforth ESIF). ESIF primarily targets less economically developed EU Member States and regions, offering co-funding for public projects to stimulate sustainable regional development. Since 2014, ESIF explicitly promotes the increased use of GPP and requires that beneficiaries ensure the full mainstreaming of sustainable development and achieve net social, environmental and climate benefits (EC, 2015, p. 145). Between 2014-2020, ESIF amounted to €520 billion, co-funding a total of €713 billion together with its beneficiaries (EC, 2021a) and can therefore be considered one of the largest co-funding policy instruments in the world. The economic effects of ESIF transfers have been studied by Becker et al. (2010, 2013), who

¹ GPP is defined as: "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured" (EC, 2008).

find effects on growth and investment respectively, but only in 30% and 21% of EU regions which have sufficient absorptive capacity (i.e. human capital endowments and quality of government). No work to date answers to what extent ESIF or similar funding mechanisms contribute to sustainable development.

We examine the uptake and mainstreaming of GPP in response to ESIF in the Czech Republic, which provides an empirical context that enables generalisation to other Member States targeted by the policy. Similar to surrounding Central and Eastern European countries, the uptake of GPP has remained relatively low in the Czech Republic (Plaček et al., 2021; Rosell, 2021; Yu et al., 2020), despite consistent eligibility for ESIF co-funding in the past decades. Moreover, public procurement in the Czech Republic is subject to the same legal framework as every other EU Member State; the top 25% largest contracts (i.e. European tenders; EC, 2017) are directly regulated by EU procurement law in all Member States, while national procurement law in each Member State is based on the same core principles. In addition, the Czech Republic is the median EU Member State in terms of GDP per capita, similar to Italy or Spain (Eurostat, 2023).

Our analysis covers virtually all public tender notices in the Czech Republic from 2006 to 2019; tenders both above and below the EU threshold are included.² The EU thresholds are sector specific contract values, above which the public posting of tenders is required and EU public procurement rules apply. Accordingly, most studies that use tender data in Europe (e.g. Badell & Rosell (2021); Rosell (2021); Yu et al. (2020)) rely on only the publicly posted tender notices above the EU thresholds, which represent only 25% of the total public procurement expenditure (EC, 2017). To our knowledge, only Grandia and Kruyen (2020) analyse a full population of tenders in their study of Belgium.

We answer three specific research questions: 1) what is the effect of ESIF co-funding on the uptake of GPP in tenders; 2) is the effect driven by financial incentives, greener ESIF policy objectives or both; and 3) does gained prior experience with GPP increase GPP uptake, even in the absence of ESIF, and can ESIF co-funding thus contribute to the mainstreaming of GPP by building experience?

² Public procurement contracts below the national thresholds (circa €80,000 for supplies and services and €200,000 for works) are published only voluntarily until the end of 2015. After that all contracts are in our data. The analysis is not sensitive to excluding the voluntarily published contracts.

Answering our first research question, we find a statistically significant effect of ESIF co-funding on GPP of 2.8 percentage points and document a strong indication of selection behaviour of contracting authorities. Observing the unadjusted means, 8.7% of tenders with ESIF co-funding contain a green search term, compared to 1.3% without ESIF. We assume that various selection effects are at play, underlying this difference in means; contracting public authorities have the freedom to decide which projects to submit for co-funding and may allocate their GPP related internal (human) resources to increase their chances of receiving ESIF co-funding. We first control for characteristics of the project and the contracting authority by including fixed effects, estimating an effect of 4.9 percentage points. Then, making use of a bivariate probit estimator, to account for remaining selection that we assume takes place within the contracting authority, we estimate the effect of 2.4 percentage points.

Answering our second research question, we conclude that the effect of ESIF co-funding on GPP is driven by financial incentives, but not by ‘greener’ ESIF policy objectives. We observe a strong boost in GPP uptake following an ESIF policy adaptation that temporarily increased co-funding availability for certain priority areas (e.g. innovation energy efficiency and renewables), while also communicating updated policy objectives (i.e. sustainable rather than economic growth). As co-funding availability later returned to prior levels, so did GPP uptake, despite the further updating of policy objectives (i.e. beneficiaries must ensure sustainable development and net environmental and climate benefits and are therefore recommended to use GPP increasingly). Hence, our findings suggest that a change to ‘greener’ policy objectives did not affect GPP uptake. However, we acknowledge there may be other reasons why the update of policy objectives was ineffective.

Answering our third research question, we find that contracting authorities with GPP experience in the previous year are more likely to take it up in their current tender notice, but only to a limited extent. We account for the effect that prior GPP experience might have on obtaining ESIF co-funding, thereby increasing the uptake of GPP, using a bivariate probit estimator. The effect of prior GPP experience is not statistically different for tenders with and without ESIF co-funding, but only once selection effects are accounted for, again using a bivariate probit estimator. This further underpins the notion that contracting authorities allocate relevant resources, in this case prior GPP experience, to take up green procurement in tenders where this is incentivised by ESIF. Both the

selection behaviour and the small effect size of prior GPP experience might explain why we observe no mainstreaming of GPP, despite gained experience with GPP.

Our findings imply that financial incentives are key to stimulate the uptake of GPP in less economically developed EU Member States and regions. ESIF co-funding stimulates GPP by providing financial incentives, but also instigates selection behaviour by contracting authorities, who may allocate projects and efforts based on the opportunity to raise co-funding. As a result, policies that incentivise GPP only in specific public sector domains, programs or projects may create a substitution effect, lowering the relative priority given to GPP in areas where incentives for GPP are lacking.³

The contribution of our paper is twofold. Firstly, this paper contributes to the literature on climate policies, bringing to the table GPP behaviour by public authorities in response to ESIF co-funding. Despite its size and importance for the economic development and sustainability in the European Union, ESIF and its effects on GPP have not been previously evaluated in this respect. Secondly, we are the first to consider explicitly that knowledgeable or skilled procurement officers might face more incentives for GPP, being allocated to do such green tenders. We document selection effects that drive the estimate of ESIF co-funding on GPP upwards. The selection phenomenon is a contribution to the literature that studies the impact of institutional incentives and/or relevant experience (and knowledge) on GPP uptake (Shadrina et al., 2022; Testa et al., 2012; Zhu et al., 2013; Brammer & Walker, 2011). Once we account for selection effects, answering our third research question, our findings no longer confirm that there is a statistically significant interaction between institutional incentives and experience, as Zhu et al. (2013) find in China.

2. Background: ESIF and the Czech Republic

In this section, we first present the policy objectives and granting mechanism of ESIF co-funding and how these changed throughout the years that we analyse. Next, we elaborate on the context of the Czech Republic and explain why it provides a relevant context to study ESIF.

2.1 European Structural and Investment Funds

³ Note that this need not be a problem, as long as no high impact areas with a large environmental footprint are left outside the policy's coverage.

The European Commission (EC) offers co-funding for public projects through the European Structural and Investment Funds⁴ to stimulate development in Member States and their regions. Eligibility is based on the gross domestic or regional product relative to the EU average. While funds are also allocated at the Member State level, the majority of the funds are regional (EC, 2021a). ESIF co-funding can cover up to 85% of the project cost, depending on the type of project, and is granted by an appointed managing authority within the Member State (EC, 2015). From 2014 to 2020, ESIF amounted to about €520 billion, leading to a total public investment of €713 billion together with its beneficiaries (EC, 2021a). ESIF co-funding makes up for over a third of annual government capital expenditures in most EU12 countries (EC, 2013).

We also analyse two changes of ESIF policy. One change relates specifically to the change of policy objectives that ESIF targets. Compared to the earlier ESIF funding round of 2007-2013, when *growth* and *employment* were the main objectives, the objectives of the 2014-2020 funding round were more explicitly aimed at *sustainable development*. In the latter period, managing authorities were ordained to:

ensure the full mainstreaming of sustainable development [...] reduce environmentally harmful effects of interventions and ensure results in net social, environmental and climate benefits. [...] Actions to be undertaken may include the following: (a) directing investments towards the most resource-efficient and sustainable options; (b) avoiding investments that may have a significant negative environmental or climate impact, and supporting actions to mitigate any remaining impacts; (c) taking a long-term perspective when 'life-cycle' costs of alternative options for investment are compared; (d) increasing the use of green public procurement (EC, 2015, p. 145).

The second change of ESIF policy that we analyse is a so called *transition period* between the funding rounds, in which the EC adapted the co-funding availability and the policy objectives of ESIF. Near the end of the 2007-2013 funding round, the EC found that many of the available funds were yet to be transferred and increased efforts to allocate ESIF co-funding to Member States (EC, 2013). This was done by: 1) a swift reprogramming of funds to thematic areas where a more rapid implementation, before 2016 was possible

⁴ Which consists of the European Regional Development Fund, the Cohesion Fund, the European Social Fund, the European Agricultural Fund for Rural Development and the European Maritime and Fisheries Fund.

(e.g. roads have a shorter implementation time than R&D and railway projects) and 2) an increased co-funding rate for the high priority areas (e.g. innovation in SMEs, energy efficiency and renewables, rail, education and social inclusion, and capacity building). In April 2013, the EC reported that:

Significant results are still expected from these programmes over the next 33 months delivering job creation and smart, sustainable and inclusive growth. Member States and regions must redouble their efforts and implement the selected projects by the end of 2015. [...] [The EC] will also work closely with the Member States on the adoption of the new programmes and has already initiated informal preparations with all Member States (EC, 2013, pp. 11–12).

In sum, co-funding availability was higher in the transition period, compared to the surrounding periods, and the ESIF policy objectives were linked more explicitly to sustainable development, foreshadowing the coming update of policy objectives of the 2014-2020 funding round. While the start of the transition period is hard to pin down, we know that the EC had initiated informal preparations with all Member States before April 2013 and therefore consider that the transition period started in the first quarter of 2013. The differences between periods are shown schematically in Table 1.

Table 1 ESIF policy objectives and co-funding over time

	Policy objectives related to sustainability	Co-funding availability
Funding round 1 (2007 – Q4 2012)	Stimulating economic growth and employment	(+)
Transition period (Q1 2013 – Q4 2015)	Stimulating sustainable growth and employment	(++)
Funding round 2 (Q1 2016 – Q2 2020)	Stimulating sustainable development, net social, environmental and climate benefits and increased GPP uptake	(+)

We assume that the majority of tenders posted after 2014 are not covered by the conditions of the transition period, though the transition period formally lasted until Q4 of 2015. Projects must be completed by the end of 2015 to meet the conditions of the transition period. Assuming a lead time of about one year, between the posting of the tender and the completion of a project, most ESIF co-funded tenders posted during 2015

would not be completed before the end of 2015 and thus fall under the policy conditions of Funding round 2.

The Czech Ministry of Environment is the appointed managing authority that grants ESIF co-funding to submitting contracting authorities. The Ministry of Environment is concerned with policy objectives regarding environmental sustainability and hence we assume that it grants ESIF co-funding in line with the EC policy objectives on sustainable development and GPP.

2.2 The Czech Republic

The Czech Republic is a useful context to study the effect of ESIF on GPP. It is a middle sized EU Member State that has been consistently eligible for ESIF co-funding since 2006. In the studied period (2006-2019), there are only limited institutional drivers for GPP in the Czech Republic (Plaček et al., 2021) besides ESIF.⁵ Moreover, when the EC targeted the Czech Republic specifically, when it increased efforts to allocate ESIF co-funding during the transition period: “[m]any programmes are facing problems with national or regional co-financing [...] The expenditure rates are especially slow in BG, CZ, HU, IT, MT, SK and, in particular, RO. There is a growing risk in these countries that by not mobilising the available EU funds promptly a significant volume of them will be lost and the intended objectives not achieved” (EC, 2013). The lack of clear incentives for GPP besides ESIF, its consistent eligibility for ESIF co-funding and the pronounced efforts of the EC to allocate co-funding during the transition period make the Czech Republic an ideal research context that sharpens the empirical focus on ESIF and GPP behaviour.

In addition, the public procurement context of the Czech Republic enables us to generalise the finding on ESIF to a wider EU context. Firstly, the Czech Republic resembles the target group of the ESIF co-funding policy, which is primarily less economically developed Member States in Central and Eastern Europe. Secondly, the legal framework that regulates public procurement is similar across EU Member states. All procurement above the EU thresholds is regulated by harmonised EU public procurement law. All remaining public procurement is regulated by national procurement law, which is based on the same core principles all over Europe, such as transparency and equal treatment.

⁵ Since 2021, the contracting authorities in the Czech Republic have been obliged to take the ‘environmental impact, sustainable development and similar into account (EC, 2021b).

Finally, the Czech Republic is the median EU Member State in terms of GDP per capita, making it a somewhat common case in the EU, similar to Spain and Italy (Eurostat, 2023).

3. Data, empirical strategy and summary statistics

3.1 Dataset and pre-processing

The dataset used in this study contains all public tender notices by any public organisation in the Czech Republic above 2,000,000 CZK (€84,000) for goods and services and 6,000,000 CZK (€253,000) for construction works from 2006 to 2019. After removing cancelled tenders, the dataset contained 183,745 unique tenders done by 13,237 unique contracting authorities. If the contracting authority of a tender was unknown, a new ID was created and assigned based on its name. Contracting authorities whose names were at least 75% similar were assigned the same ID using a normalised Levenshtein edit distance.

Our dataset includes both tender notices that lie above and below the EU thresholds (about 20% and 80% of the dataset respectively). Tenders are above the EU thresholds when their monetary values exceed a given amount and must then be publicly published on the EU-wide online platform 'Tenders Electronic Daily' and follow harmonised EU public procurement law. Public procurement below the EU thresholds follows national procurement law, which is based on the EU public procurement directives (2014/24/EU and 2014/25/EU) and must still respect the core principles of EU public procurement law. The EU threshold values vary according to the type of contract (e.g. works or services) and type of contracting authority (e.g. defence, central or regional governments). In the EU, about 70-76% of the public procurement spend lies below the EU thresholds (EC, 2017).

3.2 Empirical strategy

This section presents the empirical approach per research question (i.e. how we: identify the effect of ESIF co-funding on GPP; illustrate through which mechanism(s) this effect might work; and answer whether and to what extent gained prior experience with GPP increases GPP uptake, even in the absence of ESIF). In our empirical approach, we mainly apply non-linear estimators, since the average uptake of GPP is close to zero in the Czech Republic. We want to use a model that gives predictions of GPP between 0 and 1 and hence, we prefer non-linear estimators over a linear probability model, which predicts negative probabilities of a tender being green for 36% of the dataset when estimating our

main specification (1) (analysis not shown). In all estimations, we cluster the standard errors at the level of the contracting public authority.

3.2.1 Estimation strategy: effect of ESIF co-funding on GPP in tenders

We first estimate the effect of ESIF co-funding (*ESIF*) on GPP uptake (*GPP*) in tenders, making use of a probit estimator as a benchmark, estimating for regression equation (1):

$$GPP^*_i = \beta_1 ESIF_i + \beta_2 Experience_{ct-1} + x'_{ict} \delta + \varepsilon_i, \quad (1)$$

where the error term ε_i follows a normal distribution and GPP_i is assumed to stem from the unobserved latent variable GPP^*_i so that:

$$GPP_i = \begin{cases} 1, & \text{if } GPP^*_i > 0 \\ 0, & \text{otherwise} \end{cases} .$$

Subscript i refers to any of the observed tenders in the dataset, c refers to the contracting authority that posted the tender, t refers to the budget year, and x' refers to a vector of control variables.

Next, we adopt a bivariate probit model, because we assume that the effect of ESIF co-funding on GPP is overestimated due to selection behaviour. Contracting authorities can select and submit planned projects that can be easily made to fit the ESIF policy objectives, to improve their chances of receiving co-funding; projects that are more likely to be green have a higher likelihood of receiving ESIF co-funding. Likewise, within a contracting authority, more skilled or motivated procurers might be allocated to do green projects, while also being better capable to write a successful co-funding application. Both the selection of projects or internal resources of the contracting authority will lead to an overestimation of the effect of ESIF co-funding in tenders. We account for this bias by allowing the error terms of *GPP* and *ESIF* to be correlated and simultaneously estimating regression equation (1) in a bivariate probit model⁶ with regression equation (2):

⁶ When both the dependent and endogenous explanatory variable of interest are dichotomous, as is the case here, a bivariate probit is proposed as the appropriate non-linear estimator for the purpose (Wooldridge, 2011). Alternatively, 2SLS is used to estimate specification (1) and (2), taking the transition period as a seemingly exogenous instrument with sufficient strength (see table A2 in the Appendix). Bivariate probit is preferred over 2SLS for two main reasons. First, it does not require the exclusion restriction of the instrumental variable, that is an identification assumption for 2SLS. Second, bivariate probit estimates an average treatment effect as opposed to a local average treatment effect estimated with 2SLS (Chiburis et al., 2012).

$$ESIF_i = \alpha_1 Experience_{ct-1} + x'_{ict} \eta + v_i . \quad (2)$$

The identification of the effect of ESIF in tenders is based on the functional form of the bivariate probit estimator, which assumes that the error terms ε_i and v_i follow a joint normal distribution with mean zero and correlation ρ (rho).

3.2.2 Estimation strategy: mechanisms of effect ESIF co-funding

We analyse GPP uptake following two changes in ESIF policy, to derive through which mechanisms ESIF affects GPP uptake in tenders. We consider changes in terms of greener policy objectives and co-funding availability. The ESIF policy objectives called more explicitly for sustainable behaviour by contracting authorities in the Transition period and Funding round 2, compared to Funding round 1. Co-funding availability increased temporarily during the Transition period. Accordingly, estimated differences between Funding round 1 and 2 can be attributed to ‘greener policy objectives’, while differences between Funding round 1 and the Transition period can be attributed to a combination of greener policy objectives and financial incentives. We argue that that ESIF stimulates GPP only through financial incentives when there are differences between Funding round 1 and the Transition period, but no differences between Funding round 1 and Funding round 2.

We use dummy variables for the three periods and make use of an interaction term of (*ESIF x Transition period*), or (*ESIF x Funding round 2*), to test whether the effect of ESIF co-funding differs compared to Funding round 1. We exclude observations before 2010, to ensure that sustainability objectives are sufficiently pronounced on the policy agenda and that the ESIF were running at capacity after the financial crisis. The implementation of ESIF co-funding has come up to speed since 2010 (EC, 2013):

3.2.3 Estimation strategy: effect of prior GPP experience on GPP in tenders

We first estimate the effect of a contracting authority’s prior GPP experience on GPP in tenders, again making use of the bivariate probit estimator, that estimates regression equations (1) and (2) simultaneously, following the empirical approach of Bryngemark et al. (2023). We use a bivariate probit estimator to control for the effect of ESIF co-funding, assuming that prior GPP experience may increase the likelihood of obtaining ESIF co-funding. Simply adding *ESIF* as control variable, without accounting for its correlation with prior GPP experience, leads to ‘bad control’ (Angrist & Pischke, 2008) that biases

the estimated effect of prior GPP experience. With the bivariate probit estimator, the estimated coefficient β_2 gives the estimated effect of *Prior GPP Experience*, holding constant the effect of ESIF co-funding in regression equation (1) and accounting for its correlation with prior GPP experience in regression equation (2). Finally, we estimate whether the effect of prior GPP experience on GPP holds in the absence of ESIF co-funding, by including an interaction term of ESIF and prior GPP experience.

3.3 Variables

The dependent variable *GPP* is a dichotomous variable on the tender level based on the following search terms including variations: *emission, savings, insulation, ecologic, emission reduction, energy reduction and sustainability*⁷. The dependent variable takes on the value 1, and 0 otherwise if any of the search terms is found in the available text (i.e. title, selection criteria or award criteria) of the tender notice. The texts were cleaned with lemmatization – a procedure where words are made identical based on their root in the Czech language – and the removal of stop words, regional entities and interpunction. Of all tenders in the dataset, 3.5% contained a green search term (see Table 2). This is 8.7% among tenders with ESIF co-funding and 1.3% among tenders without ESIF co-funding, indicating a higher concentration of green tenders among ESIF co-funded tenders.

Table 2 Descriptive statistics of main variables, Q3 2006 – Q2 2019

Variable	Mean	N.	Std. dev.	Min	Max
Dependent variable:					
<i>Tender contains a green term (GPP_i)</i>	0.035	183,735	0.185	0	1
- of which with ESIF co-funding	0.087	54,856	0.282	0	1
- of which without ESIF co-funding	0.013	128,879	0.113	0	1
Main independent variables:					
<i>ESIF co-funding (ESIF_i)</i>	0.299	183,735	0.458	0	1
<i>Contracting authority's share of GPP in t-1 (Experience_{ct-1})</i>	0.030	146,734	0.097	0	1

Notes: *GPP* indicates that the tender contains at least one green search term. *ESIF* indicates whether a tender is ESIF co-funded. *Experience* is the share of tenders done by the contracting authority in the previous budget year that contains at least one green search term.

⁷ In Czech: emis*, úspor*, ekolog*, ecolog* imis*, zateplen*, snížení energ*, snížení emis* and udržitel*

While the list of search terms underlying the dependent variable is not exhaustive, we have taken efforts to make a robust proxy for GPP, by manually checking a sample of 20 hits per search term for false positives and removing search terms that gave false positives more than once. (For example, the search term *waste* often classified tenders for waste collection services as GPP.) In addition, we consider and discuss search terms used in other two studies and to test the robustness of our results (see Appendix A1). We obtain similar estimates (differing by 1 percentage point) using the longer list of 104 search terms of Yu et al. (2020). However, we argue that the shorter more conservative list that we use should be preferred, reducing the variance of the dependent variable and sharpening the analysis of the effect of ESIF. We do not obtain similar results using the two search terms (i.e. *environmental* and *sustainable*) of Rosell (2021). The translated word for *sustainable* does not fit semantically in the Czech language and had few hits in the dataset, thereby leading to what seemed a strong underrepresentation of GPP.

The main explanatory variable is *ESIF*, a dichotomous variable on the tender level, taking on the value 1 when the tender was ESIF co-funded and 0 otherwise. In our dataset, 30% of the tenders received ESIF co-funding. Our dataset does not hold information on the ESIF co-funding rates per tender. We account for potential differences in co-funding rates that might lead to heterogeneous treatment effects by controlling for the industry type of the tender (e.g. infrastructure, IT or healthcare) and time fixed effects; the maximum ESIF co-funding rates for public projects vary per industry type (EC, 2015) and the ESIF co-funding rates could be increased during the Transition period (see policy background).

We use three mutually exclusive dummy variables for the policy periods. Funding round 1 takes on the value 1 if the tender was posted before Q1 2013 onwards and 0 otherwise. *Transition period* takes on the value 1 if the tenders was posted from Q1 2013 to Q4 2014 and 0 otherwise. Funding round 2 takes on the value 1 if the tender was posted from Q1 2015 onwards and 0 otherwise.

The explanatory variable *Experience* is a continuous variable [0, 1] that shows the proportion of tenders with a green search term in the past budget year at the level of the contracting authority. Various factors may determine the values of the variable *Experience*. The variable considers merely that a contracting authority did many or few green tenders in the past year. Such GPP experience might be the result of an adopted organisational GPP strategy or political ambition (Bryngemark et al., 2023; Lindström et

al., 2022; van Berkel & Schotanus, 2021), or might indicate that there is GPP-related awareness, possibly developed or trained among procurers (Testa et al., 2012). We use lagged values to reduce potential simultaneity issues.

We control for industry fixed effects that might determine the GPP potential and the chances of getting ESIF co-funding, adding the industry type of the tender as a control variable. The industry variable includes 14 mutually exclusive categories from the Common Procurement Vocabulary (CPV). The results are robust when using more fine grained CPV categories.

We control for contracting authority fixed effects that might determine the inclination to take up GPP and the eligibility to ESIF co-funding. Firstly, we include the type of public authority as control variable, distinguishing 11 contracting authority types (e.g. ministry, regional agency, hospital, city, village etc.). Secondly, we include a dummy variable for a contracting authority being located in the Prague region. Prague is considerably more wealthy and is therefore not eligible for some of the ESIF's sub-funds. In addition, we consider that sustainability objectives may be more salient in the Prague region. Finally, we include a proxy variable for procurement intensity, separating contracting authorities in quantiles, based on the total number of entries per contracting authority in the dataset.

Finally, we control for seasonality effects and yearly differences, such as changes in the Czech National Procurement Act in 2012, 2014 and 2016. The time-related control variables include month-of-year dummies to control for seasonality in budget cycles and dummies for each budget year. We use budget years, which last from July to the next June, instead of calendar years, to match the annual ESIF reporting cycles (EC, 2015).

4. Results

4.1 Effect of ESIF co-funding on GPP in tenders

The results in Table 3 show a statistically significant effect of 2.8%points of ESIF co-funding on GPP and support our hypothesis that ESIF instigates selection behaviour by contracting authorities. The first results of the probit estimator in column {1-2} suggest that tenders with ESIF co-funding are 4.9 percentage points more likely to contain one or more green search terms, with the full set of controls. The coefficient of *ESIF* becomes lower when the control variables for time effects, industry and contracting authority and the prior GPP experience variable are included in specification {2} compared to {1},

indicating that certain types of tenders (e.g. with more green potential) are selected for co-funding and that certain contracting authorities are more likely to receive ESIF co-funding, especially those who have experience with GPP. (See Table A3 in the Appendix for results of the probit estimator where parts of the control variables are included.)

We then use a bivariate probit estimator to account for assumed remaining selection effects, within the contracting authority, that may cause overestimation of the results from the probit estimator; contracting authorities can allocate individual procurers more knowledgeable of GPP to submit projects to ESIF co-funding. The results of the bivariate probit model in column {3} show that ESIF co-funding increases the likelihood of a tender containing a green search term by about 2.8 percentage points. The coefficient of *ESIF* from the bivariate probit model {3} is 2.1 percentage points lower than the earlier coefficient from the probit estimator {2}, which strongly suggests that the earlier results from the probit estimator were overestimated as we assumed. We mainly attribute the difference between the coefficients in column {2} and {3} to selection *within* the contracting authority, since the industry type of the project and characteristics at the level of the contracting authority were already controlled for using the probit estimator.

Table 3 Estimated marginal effects of ESIF on GPP, Q3 2006 – Q2 2019

	Probit {1}	Probit {2}	Bivariate probit {3}
<i>ESIF</i>	0.073*** (0.004)	0.049*** (0.004)	0.028*** (0.002)
<i>Prior GPP Experience_{ct-1}</i>		0.064*** (0.005)	
<i>Time FE</i>	No	Yes	No
<i>Contracting auth. FE</i>	No	Yes	No
<i>Industry FE</i>	No	Yes	No
Pseudo R ²	0.0933	0.2299	
Wald χ^2 (df)	317 (1)	2,586 (51)	989 (2)
ρ [rho]			-0.675***
N [tenders]	174,570	136,677	174,570

Notes: Standard errors in parentheses, clustered at the level of the contracting authority. Results in column {1-2} are based on the estimation of regression equations (1). Results in column {3} are based on the simultaneous estimation of regression equations (1) and (2). *GPP* indicates that the tender contains at least one green search term. *ESIF* indicates whether a tender is ESIF co-funded. *Prior GPP Experience* is the share of tenders done by the contracting authority in the previous budget year that contains at least one green search term. *Time FEs* include controls for seasonal effects per month and budget year fixed effects. *Contracting auth. FE* include controls for the type of organisation, its location in Prague and its number of entries in the dataset. *Industry FE* controls for the industrial category of the tender using CPV dummy variables.

*** p<0.01, ** p<0.05, * p<0.1

Table 3 shows that the correlation between error terms (ρ) is significant in the bivariate probit model. The significance of ρ suggests endogeneity of *ESIF* due to selection effects (similar to a Heckman selection test). Hence, the bivariate probit estimator should indeed be preferred over the probit estimator.

This identification of the bivariate probit model relies on its functional form (i.e. the joint normality of error terms). We test the joint normal distribution of the error terms using a Murphy's Rao test (Chiburis et al., 2012). The specification of the bivariate probit model in column {3} of Table 3 without covariates, is correctly specified, as shows from the insignificant test statistic (see Table A4 in the Appendix for results with different specifications of the bivariate probit model, including Murphy's Rao test.)

Table 3 shows a positive and statistically significant marginal effect of prior GPP experience in column {2}, holding constant ESIF co-funding and control variables, suggesting that past experience of the contracting authority increases the likelihood of GPP. However, this effect cannot be used for interpretation, since prior experience is very likely to increase the chances of receiving ESIF co-funding, which is also included in the specification, biasing the result of prior experience. We address this issue answering our third research question.

4.2 Mechanisms of the effect of ESIF co-funding

Our findings suggest that the effect of ESIF co-funding on GPP is driven by financial incentives and not by greener policy objectives. As Figure 1 shows, GPP uptake increased, following the initiatives of the EC to stimulate ESIF allocation, in the Transition period, by temporarily increasing co-funding availability (see also Figure A1 in the Appendix, presenting the marginal effect of ESIF on GPP over time, using a bivariate probit estimator). However, GPP uptake returned to earlier levels, despite the fact that the ESIF policy conditions called more explicitly for environmentally friendly behaviour from the Transition period onward.

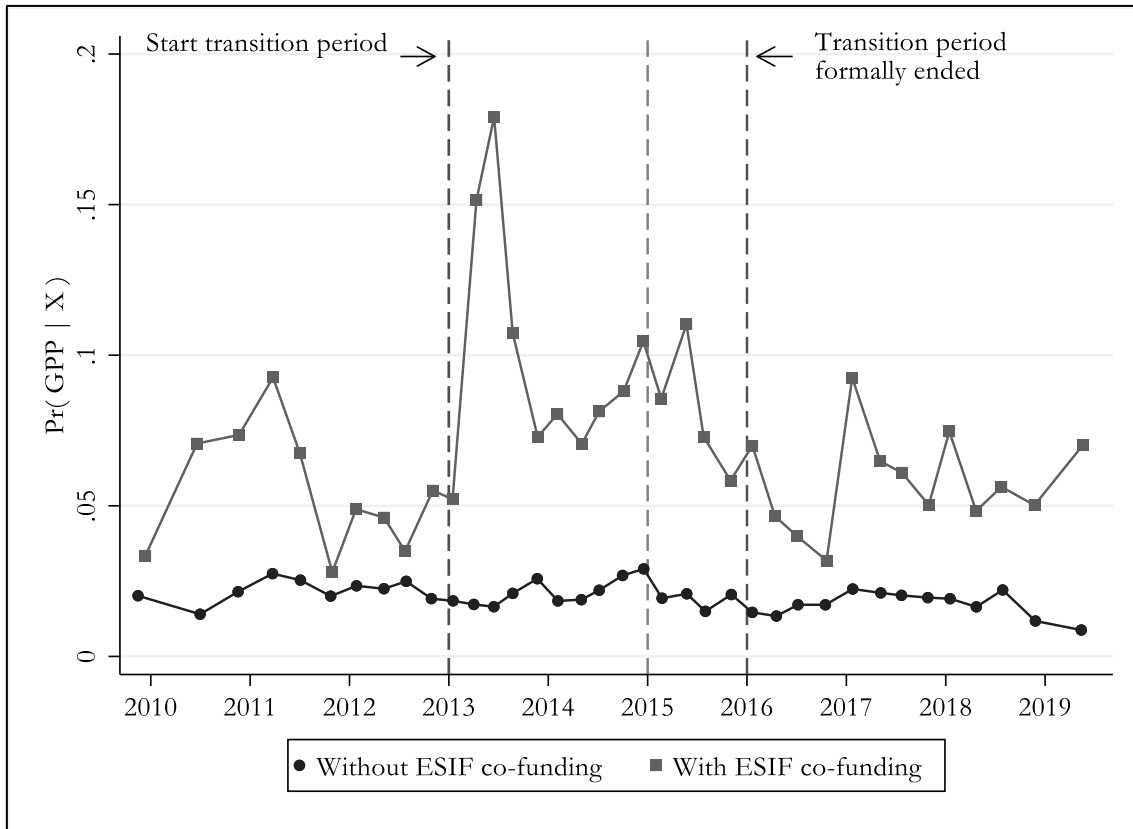


Figure 1 Predicted $Pr(\text{Tender containing green search term})$ per quarter, based on LPM estimation of specification (1), with full set of controls per policy period excluding year fixed effects.

Similarly, the top two rows of estimates in Table 4 show that ESIF co-funded tenders were more likely to contain one or more green search terms in the Transition period, compared to Funding round 1, while no such differences were found between Funding round 1 and 2. The results are robust to the estimator used. The size of the coefficients in Table 4 must be interpreted with caution, because we can make limited assumptions needed for causal inference. As the results in the earlier section suggest, ESIF instigates selection behaviour of contracting authorities, which implies that tenders done by the same contracting authority in the same year are not independent, thereby violating the Stable Unit Treatment Value Assumption (SUTVA). We test whether tenders without ESIF co-funding are affected by start of the Transition period making use of a regression discontinuity design and find no statistically significant results (see Table A5 of the Appendix).⁸

⁸ The non-linear functional form of the probit and bivariate probit estimators further complicates any identification assumptions needed for causal inference. The estimators are used here for robustness testing and therefore, we do not further elaborate to what extent their estimates can be accepted.

Table 42 Estimated marginal effects of ESIF co-funding on GPP compared to Funding round 1, 2010 – Q2 2019

	OLS	Probit	Bivariate probit	OLS	Probit	Bivariate probit
	{1}	{2}	{3}	{4}	{5}	{6}
(<i>ESIF x Transition period</i>)	0.037*** (0.009)	0.028*** (0.006)	0.026*** (0.004)			
(<i>ESIF x Funding round 2</i>)				0.008 (0.007)	0.011* (0.006)	-0.003 (0.002)
<i>ESIF</i>	0.048*** (0.007)	0.043*** (0.005)	0.029*** (0.003)	0.046*** (0.007)	0.039*** (0.005)	0.023*** (0.006)
<i>Transition period</i>	0.001 (0.002)	0.001 (0.002)	0.0000 (0.0000)			
<i>Funding round 2</i>				-0.001 (0.002)	-0.002 (0.002)	-0.000 (0.001)
<i>Funding round 1</i>	0.020*** (0.003)	0.018*** (0.002)	0.000 (0.000)	0.016*** (0.002)	0.017*** (0.002)	0.004 (0.005)
<i>Prior GPP Experience_{ct-1}</i>	Yes	Yes	No	Yes	Yes	No
<i>Time FE</i>	Yes	Yes	No	Yes	Yes	No
<i>Contracting auth. FE</i>	Yes	Yes	No	Yes	Yes	No
<i>Industry FE</i>	Yes	Yes	No	Yes	Yes	No
(Pseudo) R ²	0.10	0.24		0.07	0.21	
F / Wald χ^2 (df)	20 (42)	1,337 (40)	799 (2)	18 (42)	1,492 (40)	8 (2)
ρ [rho]			-0.89***			-0.08
N [tenders]	59,679	59,506	60,926	85,872	85,604	91,504

Notes: Standard errors in parentheses, clustered at the level of the contracting authority. Results in column {1-2} and {4-5} are based on the estimation of regression equations (1). Results in column {3} and {6} are based on the simultaneous estimation of regression equations (1) and (2) and are calculated taking the differences in the marginal effects of *ESIF* per period. *GPP* indicates that the tender contains at least one green search term. *ESIF* indicates whether a tender is ESIF co-funded. *Prior GPP Experience* is the share of tenders done by the contracting authority in the previous budget year that contains at least one green search term. *Time FEs* include controls for seasonal effects per month and budget year fixed effects. *Contracting auth. FE* include controls for the type of organisation, its location in Prague and its number of entries in the dataset. *Industry FE* controls for the industrial category of the tender using CPV dummy variables. In {3} and {6} the first year is excluded to ensure the similar sample is used as the specifications in the other columns that include a lagged variable.

*** p<0.01, ** p<0.05, * p<0.1

4.3 Effect of prior GPP experience on GPP in tenders

We find that GPP in tenders increases with the prior GPP experience of the contracting authority in the previous budget year, though in limited proportion. We estimate that 0.9% of tenders contain at least one green search term when the contracting authority took up GPP in none of its tenders in the previous year, compared to 5.7% of tenders when the contracting authority took up GPP in all its tenders in the previous budget year (see Figure

2).⁹ This effect can be considered to be limited. We estimate the effect of prior GPP experience using a bivariate probit estimator to control for the effect of ESIF co-funding, also taking into account the positive and statistically significant correlation between prior GPP experience and being granted ESIF co-funding (see specification {1} of Table 5), to avoid ‘bad control’.

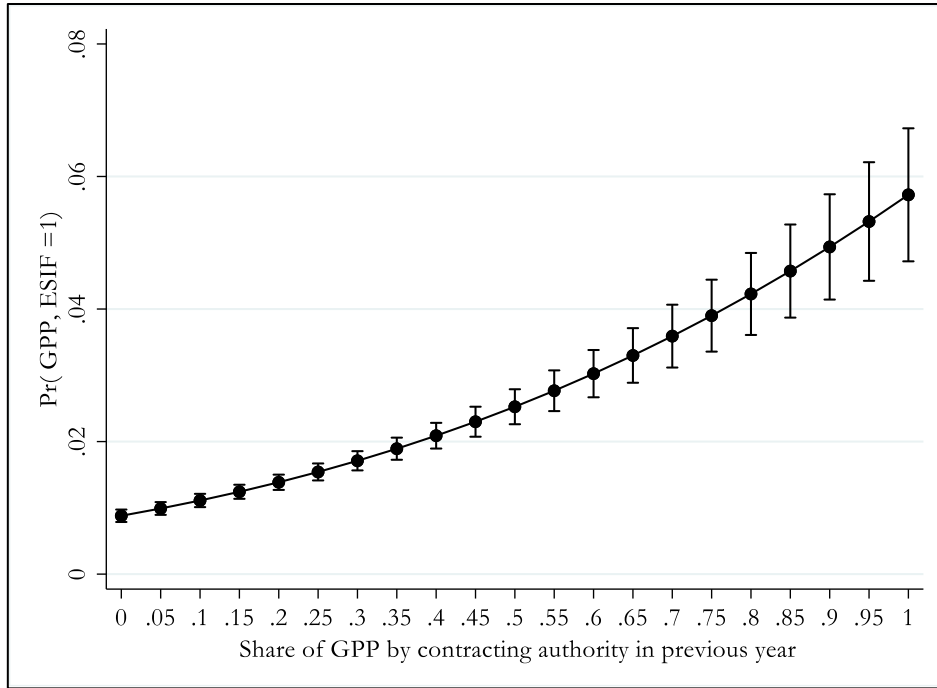


Figure 2 Predicted GPP in tenders at different levels of prior GPP experience of the contracting authority in previous budget year, with 95% confidence intervals. Estimates are based on specification {1} of Table 5, with a bivariate probit estimator.

We find that prior GPP experience has a positive and statistically significant effect on GPP in tenders, with or without ESIF co-funding, as shows from the maximum likelihood estimates in column {2} of Table 5. The estimated effect of prior GPP experience is not stronger when a tender has ESIF co-funding, as indicated by the statistically insignificant coefficient of the interaction term in the bivariate probit model. As expected, we find different results when comparing the maximum likelihood estimates of the bivariate probit and probit estimators in column {2} and {3} of Table 5. As opposed to the bivariate probit estimator, the probit estimator does not account for selection effects linked to ESIF co-funding. Contracting authorities may allocate gained GPP experience to do GPP in

⁹ In practice, the contracting authorities that have taken up GPP in all tenders in the previous budget year are mainly small authorities that have posted only one tender which is green. We exclude observations where $Prior\ GPP\ Experience_{ct-1} = 100\%$ and find that the results are robust (results not shown).

tenders where green behaviour is incentivised by ESIF co-funding. Accordingly, the interaction term is positive and statistically significant in the probit model in column {3}, when such selection is not accounted for, but statistically insignificant in the bivariate probit model in column {2} that does account for selection effects.

Table 5 Maximum Likelihood estimates of prior GPP experience on GPP, based on bivariate probit estimator, Q3 2006 – Q2 2019

	{1}		{2}		{3}
	Bivariate probit		Bivariate probit		Probit
	<i>GPP</i>	<i>ESIF</i>	<i>GPP</i>	<i>ESIF</i>	<i>GPP</i>
<i>Prior GPP Experience</i> _{ct-1}	0.804***	0.538***	0.645***	0.538***	0.750***
	(0.111)	(0.087)	(0.110)	(0.0873)	(0.115)
<i>(ESIF x Prior GPP Experience</i> _{ct-1})			0.255		0.481***
			(0.167)		(0.137)
<i>ESIF</i>	1.688***		1.612***		0.691***
	(0.217)		(0.263)		(0.051)
<i>Time FE</i>	Yes	Yes	Yes	Yes	Yes
<i>Contracting auth. FE</i>	Yes	Yes	Yes	Yes	Yes
<i>Industry FE</i>	Yes	Yes	Yes	Yes	Yes
Wald χ^2 (df)	9,055 (101)		8,882 (102)		2,590 (52)
ρ [rho]	-0.562***		-0.530***		
N [tenders]	136,677		136,677		136,677

Notes: Standard errors in parentheses, clustered at the level of the contracting authority in all estimations. Results in column {1-2} are based on the simultaneous estimation of regression equations (1) and (2). Results in column {3} are based on the estimation of regression equations (1). The estimates are maximum likelihood estimates that cannot be interpreted as marginal effects, but show only the sign and significance of independent variables. *GPP* indicates that the tender contains at least one green search term. *ESIF* indicates whether a tender is ESIF co-funded. *Prior GPP Experience* is the share of tenders done by the contracting authority in the previous budget year that contains a green search term. *Transition period* is a dummy variable for a tender being in the transition period. *Time FEs* include controls for seasonal effects per month and budget year fixed effects. *Contracting auth. FE* include controls for the type of organisation, its location in Prague and its number of entries in the dataset. *Industry FE* controls for the industrial category of the tender using CPV dummy variables.

*** p<0.01, ** p<0.05, * p<0.1

5. Conclusions and discussion

This paper investigates the impact of European structural and investment funds (ESIF) on the uptake of green public procurement (GPP). ESIF co-funds investment and development by public authorities in the less affluent regions of Europe. During the period under study, the policy objectives of the European Structural and Investment Funds (ESIF) shifted towards requiring beneficiaries to create net environmental and climate benefits with the funds, and to use GPP as a means to achieve these goals. We leverage this policy change in our analysis. We use a rare dataset that contains the population of public tender notices in the Czech Republic from 2006 to 2019. We find that ESIF co-funding increases the uptake of GPP by 2.4 percentage points after

accounting for various selection effects; first we use control variables and then a bivariate probit estimator to account for remaining unobserved selection effects. Exploring the mechanisms underlying the effect of ESIF, we find that GPP uptake responds positively to a rise of co-funding availability, but find no response to the updating of ESIF policy conditions. Finally, our results show that GPP uptake increases with a contracting authority's prior GPP experience, but to a rather limited extent.

The implications of our results stand in contrast to the measures that are currently being taken to stimulate GPP. Worldwide, GPP related training and information provision are the most used measures to stimulate GPP, while economic incentives are among the least used (UNEP, 2022). Our study, highlights that ESIF stimulates GPP by providing financial incentives and that gaining experience with GPP does not necessarily translate to its mainstreaming. Despite gained experience with GPP over the years – perhaps gained by already experienced staff, allocated to ESIF funded projects – there has been no significant increase in its adoption. Our findings suggests that the withdrawal of financial incentives (or ESIF) is likely to lead to a stabilization or even a decrease in GPP uptake.

Meanwhile, our results indicate that ESIF, while providing financial incentives, instigates selection behaviour by contracting authorities, which may select projects and allocate their internal resources strategically (e.g. gained experience that is relevant for GPP) to secure ESIF co-funding and optimise their budgets. Accordingly, we argue that the mainstreaming of GPP calls for systemic incentivises that cover procurement as a whole, rather than incentivising GPP in specific types of projects, for instance, by making GPP less voluntary if a Member State or region wants to be eligible for ESIF co-funding. An example of such a policy is an effective Dutch GPP policy, which applies to all tenders conducted by its central government (van Berkel & Schotanus, 2021). Policies that incentivise GPP only for programs, projects or specific public sector domains may create a substitution effect that lowers the priority given to GPP in areas without incentives.

Our findings are likely to be relevant beyond the Czech setting as many EU member states in Central and Eastern Europe have a similar GPP uptake welfare circumstances, although cultural and other factors must be considered when generalizing the implications of our study. Furthermore, our conclusions are based on the past implementation of ESIF policy. While the financial incentive was the only clear driver of the direct effect in our study, we have not included the ESIF monitoring and governance structures in our analysis. A

potential lack of enforcement and accountability mechanisms might explain why the change to greener policy objectives did not stimulate GPP. In addition, competing incentives from other formal institutions can counter GPP behaviour (Shadrina et al., 2022). Future research could therefore consider a mix of institutional drivers and barriers.

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Declaration of interests

The authors declare no known interests related to their submitted manuscript.

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