

Nicolas, Ruben; Titl, Vitězslav; Schotanus, Fredo

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European Funds and Green Public Procurement

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Poschingerstr. 5, 81679 Munich, Germany

Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de

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European Funds and Green Public Procurement

Abstract

The European Commission co-funds public projects through the European Structural and Investment Funds (ESIF) to stimulate the sustainable economic development of EU Member States. The ESIF budget is about 90 billion euros annually and ESIF beneficiaries are explicitly encouraged to increase their use of Green Public Procurement (GPP) since 2014. In this paper, we study to what extent ESIF co-funding affects the uptake of GPP, using a dataset with all public tender notices in the Czech Republic (2006-2019). Our findings suggest that ESIF co-funding instigates selection behaviour by contracting authorities to improve chances of receiving co-funding. After accounting for selection effects, we find that ESIF co-funding has a small but significant effect on the uptake of GPP. Studying exogenous changes in the ESIF policy conditions, we find that GPP uptake responds to changes in the availability of co-funding and not to stronger policy objectives related to sustainability. Finally, we find that the contracting authority's prior experience with GPP is positively associated with ESIF co-funding and has only a small effect on GPP uptake aside from ESIF.

JEL-Codes: H570, D730.

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

*Ruben Nicolas**
School of Economics
Centre for Public Procurement
Utrecht University / The Netherlands
r.m.nicolas@uu.nl

Vítězslav Titl
School of Economics
Centre for Public Procurement
Utrecht University / The Netherlands
v.titl@uu.nl

Fredo Schotanus
School of Economics
Centre for Public Procurement
Utrecht University / The Netherlands
r.schotanus@uu.nl

*corresponding author

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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, 2019a). A key aim of the EU policy framework is to stimulate the development of lead markets for climate neutral and circular products and direct industry towards climate and environmental action, while avoiding lock-in into unsustainable practices (EC, 2019a, 2020).

Besides other economic instruments, public procurement has been highlighted as a promising demand-side instrument that public organizations may use to lead by example and drive sustainable market transitions (EC, 2019a, 2020; Edler & Georghiou, 2007; IPCC, 2022; Rogge & Reichardt, 2016). 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, in potential, green public procurement (GPP), could have substantial impact on climate change mitigation and other sustainable development objectives (Grandia & Meehan, 2017).² Firstly, by procuring goods, services and works with a lower environmental impact throughout their life cycle³ and secondly, by stimulating environmental innovation and supply (Krieger & Zipperer, 2022; Lindström et al., 2020; Simcoe & Toffel, 2014).

However, despite the potential impact, the uptake of GPP appears limited in the EU, especially in less economically developed countries (Rosell, 2021; Yu et al., 2020). The prior literature points out that both institutional drivers and resources are the main determinants explaining GPP uptake (Brammer & Walker, 2011; Cheng et al., 2018; Schotanus & Nicolas, 2023; Shadrina et al., 2022; Zhu et al., 2013). Specifically, the largest barriers are the perceived extra cost of sustainable goods, works and services, the lack of relevant experience and the lack of organizational and policy pressures (Cheng et al., 2018; Chiappinelli, 2022). As such, a possible explanation for the lagging GPP uptake in the EU may be the lack of institutional (or policy) drivers and limited financial and human resources.

² The potential impacts of GPP are more widely recognized. Meanwhile, the (cost) effectiveness of GPP as a policy instrument is debated (Drake et al., 2024).

³ 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).

This paper studies whether and to what extent and how co-funding by the European Structural and Investment Funds (henceforth ESIF) increases the uptake of GPP. ESIF primarily targets less economically developed EU Member States and regions and offers co-funding for public projects to stimulate (sustainable) regional development. Since 2014, ESIF explicitly promotes the increased use of GPP and urges beneficiaries to ensure the full mainstreaming of sustainable development and achieve net social, environmental and climate benefits (EC, 2015, p. 145). As such, ESIF might address the main barriers to GPP, directly, by alleviating financial constraints and providing explicit institutional support for GPP and indirectly, when contracting authorities gain more experience with doing GPP.

ESIF amounted to €520 billion between 2014-2020, co-funding a total of €713 billion together with its beneficiaries (EC, 2021a) and can therefore be considered one of the largest co-funding schemes in the world, making it an interesting object of study. Earlier studies have shown that ESIF transfers affect economic growth and investment (Bachtrögler-Unger et al., 2023; Becker et al., 2010, 2013). To the best of our knowledge, no academic work to date answers the question whether and how sustainable development efforts are affected by ESIF, or similar programmes that combine institutional and financial support and aim to increase sustainability and economic growth.

We examine the effect of ESIF on the uptake of GPP in the Czech Republic. The Czech Republic provides an empirical context that enables generalisation to other Member States that are also targeted by ESIF. 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), growing only more recently (Špaček et al., 2024), despite consistent eligibility for ESIF co-funding in the past decades. Moreover, the Czech Republic is the median EU Member State in terms of GDP per capita, similar to the richest countries in Central and Eastern Europe such as Estonia and Poland, as well as to countries in Southern Europe such as Italy or Spain (Eurostat, 2023). Furthermore, as a result of EU public procurement directives, the applicable legal framework that regulates public procurement in Czechia is similar to that of the other Member States.

Our analysis uses practically all public tender notices in the Czech Republic from 2006 to 2019, including tenders above and below the EU public procurement thresholds. 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) and Yu et al. (2020)) rely on only the publicly posted tender notices above the EU thresholds, which represent only about 25% of the total public procurement expenditure (EC, 2017). Using this more complete and detailed dataset, this paper makes an empirical contribution by studying the almost complete population of public procurement over a long time period.

We answer three specific research questions: 1) what is the effect of ESIF co-funding on the uptake of GPP; 2) is the effect driven by co-funding availability, greener ESIF policy objectives, or both; and 3) does the gained prior experience with GPP increase GPP uptake, aside from ESIF? Answering our first research question, we find an average treatment effect of ESIF co-funding on GPP uptake in tenders of 2.7 percentage points; a tender is 2.7 percentage points more likely to be classified as green when it is ESIF co-funded. The initial comparison of unadjusted means shows that GPP uptake is 6.1 percentage points higher among tenders with ESIF co-funding; part of this difference is explained by unobserved selection effects and prior GPP experience, meaning that contracting authorities with GPP experience are more likely to take up GPP in their tenders and have a higher probability to get ESIF co-funding. The average treatment effect of 2.7 percentage points appears relatively small, compared to the coverage of ESIF.

Answering our second research question, we study two exogenous changes in ESIF policy and conclude that GPP uptake responds primarily to the co-funding availability and not to a ‘greener’ focus of the ESIF objectives. Aside from a transition period that was characterized by higher co-funding availability in-between funding rounds, we see no significant differences in GPP uptake between the 2007-2013 and 2014-2020 funding rounds, that differed in their focus on sustainable development. Finally, answering our third research question, we find a significant but small positive effect of prior GPP experience, aside from ESIF.

The contribution of our paper is threefold. Firstly, this paper is the first to study the relationship between ESIF and environmentally friendly development efforts (in this case GPP). We thereby extend the literature on climate policy. Although voluminous, ESIF (which might be regarded as an indirect climate policy) has not been previously studied

in this regard. Secondly, we contribute to the literature on GPP uptake that studies the impact of institutional drivers and/or relevant experience (Shadrina et al., 2022; Testa et al., 2012; Zhu et al., 2013; Brammer & Walker, 2011; Bryngemark et al., 2023; Drake et al., 2024). We introduce a theoretical model with financial support for both green and non-green tenders and analyse officers' behaviour under various assumptions. Subsequently, we empirically test the model's predictions and estimate the effect of ESIF on GPP. Our study demonstrates that policy makers (and scholars) should anticipate the selection behaviours of contracting authorities when they introduce institutional incentives that apply to a part, but not all of public procurement. Thirdly, we contribute to the discussion on GPP experience that often highlights the importance of relevant knowledge and experience for GPP uptake. We show, however, that the effects of GPP experience are limited in the Czech Republic where institutional and policy drivers for GPP appear to have been less present; this illustrates that GPP experience in itself will not be enough to stimulate GPP uptake when drivers are absent.

The remainder of the paper is structured as follows. Section 2 presents the theoretical framework. Section 3 discusses ESIF and the institutional background of the Czech procurement market. In Section 4, we describe our data and empirical strategy. Section 5 presents the main analysis answering the three research questions. Section 6 concludes, discusses our findings and lays out the policy implications of the findings.

2. Theoretical framework

In this section, we discuss the decision that a procurement officer faces when implementing public procurement projects. The critical concern in our theoretical consideration is whether the procurement officer chooses to take up GPP in the procurement project or not and what role institutional incentives in the form of subsidies play in this decision. In the studied model, GPP is optional and not required by law and subsidies are not exclusively allocated to GPP projects. While the extant literature discusses the typical reasons for GPP uptake (Brammer & Walker, 2011; Cheng et al., 2018), we will focus more specifically on the role of subsidies in this decision and how altering the conditions of the subsidies influences procurement officers' decisions.

In this theoretical model, we build on Shadrina et al. (2022) and model a decision of an officer that must provide a certain level of public good through public procurement and minimizes costs to do that. We make several simplifying assumptions. Compared to the

model of Shadrina et al. (2022), we assume that there are no implicit incentives for GPP (i.e. public buyers have no concerns for their reputation that relate to procuring more sustainable solutions). In addition, we assume that, apart from the subsidy, public buyers face no pressures to align with sustainability-focused policy preferences from higher level of governments' (see Raj et al. (2020) for various ways in which governments can pressure public buyers for GPP).

Consider first a model of the procurement officer's decision in a setting without subsidies. The procurement officer can choose from two procurement procedures: type 0 for procedures with environmental demands (with cost c_0) and type 1 for those without (cost c_1). We denote fraction $\alpha \in [0,1]$ the share of procurement contracts in a given time period of type 0, with the remainder $(1 - \alpha)$ being of type 1. Effectively, α denotes GPP uptake. In this setting, the choice faced by the officer – that wants to provide a certain level of public good for the least resources – boils down to minimizing total cost $\alpha c_0 + (1 - \alpha)c_1$. Although GPP might minimize cost under certain conditions (Chiappinelli & Seres, 2024), we make the generally accepted assumption that $c_0 > c_1$, as sustainable projects tend to be more time intensive and often have larger initial costs (Aldenius & Khan, 2017; Stritch et al., 2020; Wang et al., 2020). In this simple model, the solution minimizing the costs is $\alpha^* = 0$, i.e. the procurer does no green projects. Note that we assume here that the officer does not care about future costs and negative externalities that might be lower for environmentally sustainable projects. Furthermore, the simplified model assumes that the procurement officer's decision will not change if the government declares that it prioritizes sustainable projects, unless there is a material consequence in the form of, for instance, a legal requirement or fine.

We now consider a model in which subsidies can be awarded to either type of project. We will assume that the subsidy s is proportional to the cost of the project, i.e. $s_0 = r * c_0$ and $s_1 = r * c_1$, where r is the subsidy rate. The officer's choice now boils down to minimizing total cost $\alpha(c_0 - s_0) + (1 - \alpha)(c_1 - s_1)$. Given that both types of projects are eligible for the same subsidy rate and assuming that the success rates of subsidy applications are the same, the solution then again is $\alpha^* = 0$, as long as $c_0 > c_1$.

We now add one more feature to this simple model. We assume that green projects are more complicated, and errors happen with probability π . The additional cost in case of an error is ζ . Based on Testa et al. (2012), we consider that the probability of an error π is a

decreasing function of experience with sustainable projects e .⁴ This changes the total expected cost for a sustainable project to $c_0 + \pi\xi$. The officer's decision now boils down to minimizing total cost $\alpha(c_0 + \pi\xi - s_0) + (1 - \alpha)(c_1 - s_1)$. If $c_0 > c_1$ and the probability of getting a subsidy is the same for both type, then again $\alpha^* = 0$.

Let us now discuss a situation when the probability of getting a subsidy differs across project types: p_0 for projects where attention is paid to GPP and p_1 for other projects. Now, $s_0 = p_0 * r * c_0$ and $s_1 = p_1 * r * c_1$ and so the officers' s decision is to minimize total cost $\alpha(c_0 + \pi\xi - p_0 * r * c_0) + (1 - \alpha)(c_1 - p_1 * r * c_1)$. This again leads to a corner solution either $\alpha^* = 0$ or $\alpha^* = 1$, depending on whether $(c_0 + \pi\xi - p_0 * r * c_0)$ is larger than $(c_1 - p_1 * r * c_1)$ or the other way around. If we simplify to the situation and assume that $c_0 = c_1$ and $\pi = 0$, the decision depends on whether the probabilities p_0 and p_1 . If $p_0 > p_1$ then only sustainable projects will be pursued ($\alpha^* = 1$) and the other way around.

Related to our research questions, our first hypothesis is that $p_0 - p_1$ is positive and it becomes larger as the ESIF conditions are updated to favour GPP projects more substantially. (A more detailed discussions of the ESIF policy and its changes over time is given in the following section.) In Section 5, we empirically test this hypothesis and measure how much α increases on average as a consequence of ESIF co-funding. For our second hypothesis, we consider the role of officers' experience with sustainable projects. We assume that the probability π decreases with an increase in the level of experience e that an officer has (i.e. a feedback or learning effect). For simplicity, let us consider a simple example when $c_0 = c_1$ and $p_0 > p_1$;⁵ with experience e growing, α^* should also increase as sustainable projects become less costly. We also test this second hypothesis in Section 5.

⁴ In the subsequent empirical analysis, we operationalize experience as the number of sustainable procurement contracts, the officer worked on in the past.

⁵ Equivalently, we could think of a case when $c_0 > c_1$. We make this assumption to keep the situation simpler. It does not change the prediction.

3. 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.

3.1 European Structural and Investment Funds

The European Commission (EC) offers co-funding for public projects through ESIF⁶ 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, 2015, p. 30, 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). The volume of ESIF co-funding is equivalent to 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 *cohesion objectives* of *growth* and *employment* were the main objectives, the objectives of the 2014-2020 funding round were more explicitly aimed at *missions* and the Europe 2020 strategy objectives of *sustainable growth*. Specifically, for the latter period, the EC laid out ‘strategic guiding principles’ stating that managing authorities should:

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-

⁶ 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.

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 strategic guiding principles are no hard requirements and leave beneficiaries with freedom to arrange their projects. Meanwhile, the EC does govern how the ESIF co-funds are used through a so-called Partnership Agreement that is drafted together with the Member State before the funding round. The Partnership Agreement states the specific budgets and objectives of the ESIF co-funding and lays out the thematic areas that are most important for the applicable Member State and should eventually contribute to the wider EU objectives. In addition, the Partnership Agreement sets ex-ante conditionalities that must be met for the Member State to draw funds from ESIF. The allocation of ESIF to contracting authorities is based on the budgets per thematic area in the Partnership Agreement. Each thematic area (or programme) in turn has a Managing Authority (often a ministry) that is responsible for the allocation of ESIF.

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 (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

	ESIF 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.

3.2 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.⁷ 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

⁷ 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).

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. 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).

4. Data, variables and empirical strategy

4.1 Dataset and pre-processing

The dataset used in this study contains all public tender notices by any public organization 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 2019.⁸ We removed cancelled tenders ($\approx 10\%$ of the observations) to avoid an overrepresentation of these tenders, assuming that the cancellation of a tender often results in a second try by the same contracting authority.⁹ After removing cancelled tenders, the dataset contained 183,745 unique tenders done by 13,237 unique contracting authorities. Most observations (99,4%) have unique IDs of contracting authorities. Missing IDs are imputed using a Levenshtein edit distance algorithm, matching authorities based on name similarity of more than 75%. (More stringent or laxer thresholds delivered poorer matches, to the judgment of the researchers.)

⁸ The data also includes public procurement contracts below these values that are published only voluntarily until the end of 2015. After 2015 all contracts are in our data. The analysis is not sensitive to excluding the voluntarily published contracts.

⁹ The share of ESIF co-funded tenders among the cancelled observations was equal among the population.

The dataset includes both tender notices that lie above and below the EU thresholds (about 20% and 80% of the observations 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)¹⁰ 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).

4.2 Variables

4.2.1 Dependent variable

The dependent variable *GPP* is a dichotomous variable, based on a dictionary of search terms, that indicates the uptake of GPP on the tender level.¹¹ The dependent variable takes on the value 1, if any of the search terms is found in the available text of the tender notice (i.e. the title, selection criteria and award criteria of the tender) and 0 otherwise. Table A1 in the Appendix shows the number of hits per search term with and without ESIF co-funding, illustrating that energy reduction and insulation are the most salient terms among ESIF funded tenders. The texts were pre-processed with lemmatization – a procedure where words are made identical based on their root in the Czech language. Of all tenders in the dataset, 4.2% contains a green search term (see Table 2a). This is 8.5% among tenders with ESIF co-funding and 2.4% among tenders without ESIF co-funding, indicating a higher concentration of green tenders among ESIF co-funded tenders.

4.2.2 Explanatory variables

The main explanatory variable is ESIF, a dichotomous variable on the tender level that takes on the value 1 when the tender is co-funded by ESIF and 0 otherwise. In our dataset,

¹⁰ From 2004 to 2014 public procurement in the EU was regulated by Directive 2004/18/EC.

¹¹ The dictionary contains the following search terms (translated from Czech to English): environment*, sustain*, ecolog*, emiss*, reduce_emiss*, pollut*, CO2, NOX, PM10, PM2_5, toxic, hazardous, vegetable, waste_sort*, organic*, chemic*, biodeg*, two_side_print*, titanium_dioxide, water_sav*, gas_sav*, fuel_sav*, reduc*_energ*, insulat*, dimming, LED, ISO14001, EMS, FSC, recycl*, recharg*, endur*, durab*, demont*, rehab*, life*, renew*. The dictionary is based on that of Yu et al. (2020), who rely on the EU GPP criteria and requirements repository that was available in 2019 (EC, 2019b), which is the final year in the dataset. Examining samples of 20 hits per search term, we omitted terms that we considered generic and not typical to GPP or fitting its aims (e.g. maintenance, waste, energy, replace).

30% of the tenders received ESIF co-funding (see Table 2a). The dataset does not hold information on the ESIF co-funding rates per tender. The maximum ESIF co-funding rates for public projects vary per industry type (e.g. infrastructure, IT or healthcare) and were raised by the EC during the transition period (see the first subsection of the background section), hence we account for potential differences in co-funding rates with control variables for the industry and time characteristics of the tender.

The second explanatory variable marks the distinctive ESIF policy periods. We use three dummy variables for the policy periods. *FundingRound1* takes on the value 1 if the tender was posted before Q1 2013 and 0 otherwise. *PolicyChange* takes on the value 1 if the tender was posted from Q1 2013 onwards and 0 otherwise. *TransitionPeriod* takes on the value 1 if the tenders was posted from Q1 2013 to Q1 2015 and 0 otherwise, thus overlapping with part of the *PolicyChange* dummy. Table 2a shows that the uptake of GPP was 5.5 percentage points in the transition period, compared to 3.4-4.2% in the surrounding periods.

The explanatory variable *GPPEXperience* is a continuous variable [0, 1] that shows the proportion of tenders with a green search term, done by the contracting authority in the previous budget year. Various factors may determine the values of the variable *GPPEXperience*. The variable shows 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 organizational 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.¹²

4.2.3 Control variables

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.

¹² Alternative variables were tried (a two-year rolling average, or a two year lag) that delivered similar, but slightly weaker results, suggesting autocorrelation of GPP uptake and experience. Hence, the one-year lagged variable is preferred, which also limits loss of observations due to variable lags.

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 wealthier 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. To control for the size of the contracting authority and its related procurement activity, we include an ordinal variable that ranks the contracting authority in quantiles based on the number of tender entries per authority in the dataset.

Finally, we account for seasonality effects and yearly differences (e.g. changing norms with respect to sustainability or more general changes of the institutional setting, such as changes in the Czech National Procurement Act in 2012, 2014 and 2016 (Celis Galvez et al., 2024)). The time-related control variables include month-of-year dummies to control for seasonality in budget cycles and dummies for each year. Instead of calendar years, the year dummies are based on cycles that last from July to the next June, to match the annual ESIF accounting and reporting cycles (EC, 2015).

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

Variable	Mean	Obs.	Std. dev.	Min	Max
Dependent variable:					
<i>Tender contains a green term (GPP)</i>	0.042	183,734	0.201	0	1
<i>- of which with ESIF co-funding</i>	0.085	54,855	0.279	0	1
<i>- of which without ESIF co-funding</i>	0.024	128,879	0.153	0	1
<i>- during funding round 1: 2007 – Q4 2012</i>	0.034	67,960	0.180	0	1
<i>- during transition period: Q1 2013 – Q4 2015</i>	0.055	56,940	0.227	0	1
<i>- during funding round 2: Q1 2016 – Q2 2020</i>	0.042	51,452	0.201	0	1
Main independent variables:					
<i>ESIF co-funding (ESIF)</i>	0.299	183,734	0.458	0	1
<i>Contracting authority's GPP uptake in year t-1 (GPPEXperience)</i>	0.037	147,008	0.099	0	1

Table 2b Descriptive statistics of main variables, comparing means with and without ESIF co-funding, Q3 2006 – Q2 2019

Variable	With ESIF		Without ESIF		Difference	T-statistic
	co-funding		co-funding			
	Mean	Std.dev.	Mean	Std.dev		
<i>GPP</i>	0.085	0.282	0.024	0.153	0.061***	(48.498)
<i>GPPExperience</i>	0.048	0.136	0.031	0.078	0.022***	(29.935)
<i>Contracting authority:</i>						
- <i>National Agency</i>	0.039	0.193	0.118	0.323	-0.079***	(-62.895)
- <i>National Authority</i>	0.075	0.263	0.165	0.371	-0.090***	(-57.213)
- <i>Public body</i>	0.215	0.411	0.285	0.451	-0.070***	(-31.459)
- <i>Regional Agency</i>	0.052	0.222	0.056	0.231	-0.004***	(-3.590)
- <i>Regional Authority</i>	0.425	0.494	0.296	0.456	0.130***	(51.358)
- <i>Other</i>	0.194	0.395	0.081	0.272	0.113***	(60.035)
- <i>Located in Prague region</i>	0.013	0.115	0.059	0.236	-0.046***	(-56.015)
<i>Type of tender:</i>						
- <i>Transport</i>	0.050	0.219	0.051	0.220	-0.001	(-0.688)
- <i>Energy</i>	0.003	0.056	0.029	0.169	-0.026***	(-49.964)
- <i>IT</i>	0.094	0.292	0.118	0.323	-0.024***	(-15.752)
- <i>Office supplies</i>	0.041	0.199	0.029	0.168	0.012***	(12.780)
- <i>Forestry and agriculture</i>	0.020	0.140	0.076	0.265	-0.056***	(-58.681)
- <i>Medical</i>	0.034	0.181	0.048	0.213	-0.014***	(-14.424)
- <i>Clothing</i>	0.008	0.089	0.014	0.119	-0.006***	(-12.746)
- <i>Consulting</i>	0.041	0.197	0.046	0.210	-0.006***	(-5.509)
- <i>Subsidiary</i>	0.005	0.070	0.013	0.112	-0.008***	(-17.701)
- <i>Construction</i>	0.475	0.499	0.370	0.483	0.105***	(41.670)
- <i>Engineering</i>	0.159	0.366	0.045	0.208	0.114***	(68.420)
- <i>Tech services</i>	0.015	0.122	0.049	0.215	-0.034***	(-42.171)
- <i>Health and social care</i>	0.043	0.203	0.011	0.104	0.032***	(35.200)
- <i>Other</i>	0.011	0.103	0.100	0.300	-0.089***	(-94.538)

Notes: *GPP* indicates that the tender contains at least one green search term. *GPPEXperience* is the share of tenders done by the contracting authority in the previous budget year that contains at least one green search term. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.3 Empirical strategy

This section presents the empirical approach per research question. We explain how we identify the effect of ESIF co-funding on GPP in tenders, what strategy we use to explore the mechanisms through which the effect works; and answer whether and to what extent gained prior experience with GPP increases GPP uptake, aside from ESIF. The analysis relies mainly on non-linear estimators. The average uptake of GPP is close to zero in the Czech Republic and this results in negative predicted values of GPP when using a linear probability model with covariates. The linear probability model predicts negative values of 37% of the observations when estimating regression equation (1). A non-linear estimator that gives predictions of GPP between 0 and 1 is preferred. In all estimations, we cluster the standard errors at the level of the contracting public authority.

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

Answering the research question, we use a probit estimator to estimate the effect of ESIF co-funding (*ESIF*) on GPP uptake (*GPP*) in tenders, using regression equation (1):

$$GPP_i = \beta_1 ESIF_i + \mathbf{x}'_i \delta + \varepsilon_i, \quad (1)$$

where subscript i refers to any of the observed tenders in the dataset, \mathbf{x} refers to a vector of control variables and the error term ε_i follows a normal distribution. *GPP* and *ESIF* are assumed to stem from the unobserved latent variables GPP^* and $ESIF^*$ respectively, such that:

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

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

Meanwhile, similar to Bryngemark et al. (2023) and Lindström et al. (2022), we consider that the effect of ESIF co-funding on GPP may be overestimated due to unobserved selection on outcomes, even after using control variables. Projects that are more likely to be ‘green’ may be disproportionately submitted for ESIF co-funding, assuming that green procurement projects are more likely to receive co-funding. Likewise, within the public organization, capabilities that are used for GPP may also be allocated for co-funding applications; sustainability motivated and capable procurers that do more GPP may do better jobs explaining how sustainable development objectives will be integrated in the public project and thereby be more successful in obtaining co-funding. Such potential selection behaviours will result in overestimation of the effect of ESIF co-funding. We account for the selection on outcomes by allowing the error terms of *GPP* and *ESIF* to be correlated and simultaneously estimating the following regression equations in a bivariate probit model (2):

$$\begin{aligned} GPP_i &= \alpha_1 ESIF_i + v_i \\ ESIF_i &= \mu_1 TransitionPeriod_i + \omega_i. \end{aligned} \quad (2)$$

where the error terms v and ω are assumed to follow a joint normal distribution with mean zero and correlation ρ (rho). The variable *TransitionPeriod* is an exogenous variable that is assumed to affect *ESIF* directly, but not *GPP*, other than through *ESIF* (this is commonly referred to as the exclusion restriction). We assume that the independence of

TransitionPeriod is not conditional on \mathbf{x} and include no additional covariates.¹³ The functional form of the bivariate probit estimator (e.g. the joint normality of the error terms¹⁴ and $\rho \neq 0$) and the exclusion restriction of *TransitionPeriod* are the identification assumptions for an average treatment effect (Chiburis et al., 2012; Han & Lee, 2019).

4.3.2 Estimation strategy: mechanisms of effect ESIF co-funding

We analyse two exogenous changes in ESIF policy to derive through which mechanisms ESIF affects GPP uptake. 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 from the transition period onward and co-funding availability increased temporarily during the transition period. Accordingly, aside from the transition period, the differences between funding round 1 and the later time can be attributed to ‘greener policy objectives’. Conversely, the changes in GPP uptake are affected only by co-funding availability when there are no significant differences between funding round 1 and the latter period, aside from the transition period. This line of reasoning is formalized in the following regression equation (3) that contains interaction terms between *ESIF* and the policy periods:

$$GPP_i = \gamma_1 ESIF_i + \gamma_2 PolicyChange_i + \gamma_3 TransitionPeriod_i + \gamma_4 (ESIF \cdot PolicyChange)_i + \gamma_5 (ESIF \cdot TransitionPeriod)_i + \mathbf{x}'_i \pi + \eta_i, \quad (3)$$

where η denotes the error term. We apply both OLS and probit estimators to determine the marginal effects for the interaction terms. While the non-linear structure of probit is more appropriate when the dependent variable is close to zero (as *GPP* is), imposing linear structure on the variables through OLS may give more robust estimates for interacted variables.

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

We estimate the effect of a contracting authority’s prior GPP experience on GPP uptake in tenders, again making use of a bivariate probit model, similar to Bryngemark et al.

¹³ One might assume that other events occur during the transition period that affect GPP directly, thus violating the exclusion restriction of *TransitionPeriod*. To test the robustness of our assumption, we ran a bivariate probit model with budget year dummies added to both regression equations of the bivariate probit specification (2); we find that the final estimate does not change at all (results not shown).

¹⁴ Meanwhile, Chiburis et al. (2012a) demonstrate that the misspecification of the bivariate probit model, where the joint normality of the error terms does not hold, is not problematic with large sample sizes and a treatment probability that is not close to 1 or 0. Therefore, misspecification is not a serious concern for our identification; we have many observations and 30% of the tenders are treated with ESIF co-funding.

(2023). We assume that prior GPP experience has a direct effect on GPP and an indirect effect that runs through ESIF co-funding; prior GPP experience may increase the likelihood of obtaining ESIF co-funding. Accordingly, simply adding *ESIF* as a control variable, will create a ‘bad control problem’ that leads to biased results (Angrist & Pischke, 2008). Using a bivariate probit model, we estimate the average treatment effect of prior GPP experience on GPP, controlling for the effect of ESIF co-funding and also accounting for the correlation between prior GPP experience and ESIF, thereby resolving the bad control situation. The bivariate probit model is formalized as follows:

$$\begin{aligned} GPP_i &= \tau_1 GPPEXperience_i + \tau_2 ESIF_i + \mathbf{x}'_i \boldsymbol{\kappa} + \xi_i \\ ESIF_i &= \phi_1 GPPEXperience_i + \mathbf{x}'_i \boldsymbol{\psi} + \iota_i, \end{aligned} \quad (4)$$

where the error terms ξ and ι are assumed to follow a joint normal distribution with mean zero and correlation ρ (rho). As a benchmark, we first determine the total effect of prior GPP experience by estimating the model (4) excluding *ESIF*, using a univariate probit estimator. Comparing the models with and without *ESIF*, we show to what extent prior GPP experience affects GPP uptake directly, or indirectly through ESIF.

5. Results

5.1 Effect of ESIF co-funding on GPP in tenders

Table 3 first shows the results of the univariate probit model. The results in column {3} show that tenders with ESIF co-funding are 4.4 percentage points more likely to contain one or more green search terms, with the full set of controls included in the specification. (Table A2 in the Appendix presents extended results with the different sub-sets of the control variables.) The different estimates in columns {2} and {3} suggest that the prior GPP experience of contracting authorities positively affects GPP and also has a positive association with ESIF co-funding.

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

	Probit			Bivariate probit
	{1}	{2}	{3}	{4}
<i>ESIF</i>	0.060*** (0.004)	0.054*** (0.004)	0.044*** (0.004)	0.027*** (0.002)
<i>GPP Experience</i>	No	No	Yes	No
<i>Time FE</i>	No	Yes	Yes	No
<i>Contracting auth. FE</i>	No	Yes	Yes	No
<i>Industry FE</i>	No	Yes	Yes	No
Pseudo R ²	0.0457	0.0951	0.1180	
Wald χ^2 (df)	233 (1)	1552 (51)	1763 (51)	958 (2)
ρ [rho]				-0.709***
N [tenders]	174,569	171,705	136,942	174,569

Notes: Standard errors in parentheses, clustered at the level of the contracting authority. Results in column {1-3} are based on the estimation of regression equations (1). Results in column {4} are based on the bivariate probit model (2). *GPP* indicates that the tender contains at least one green search term. *ESIF* indicates if a tender is ESIF co-funded. *GPP Experience* is the share of tenders containing a green search term, done by the contracting authority in the previous budget year. *Time FEs* include controls for seasonal effects per month and budget year fixed effects. *Contracting auth. FE* include controls for the type of organisation, whether its location is in Prague and whether it does few or many tenders. *Industry FE* is a set of dummy variables that controls for the industrial category of the tender based on CPV codes. *** p<0.01, ** p<0.05, * p<0.1

We then apply a bivariate probit estimator to account for the potential unobserved selection behaviours that may result in the overestimation of the effect of ESIF (e.g. contracting authorities can allocate specific procurement officers that are more knowledgeable of GPP to submit projects to ESIF co-funding, assuming they can prepare more convincing applications). The results of the bivariate probit model in column {4} show that ESIF co-funding increases the likelihood of a tender containing a green search term by 2.7 percentage points; this is the average treatment effect. The coefficient of the bivariate probit model {4} is 1.7 percentage points smaller than the coefficient from the probit model in column {3}, which fits the assumption that unobserved selection behaviours remain that are not controlled for in the full univariate probit model and result in overestimation of the effect of ESIF co-funding. In addition, Table A3 in the Appendix presents the maximum likelihood estimates of a bivariate probit model that includes all covariates of the univariate probit model and shows that the correlation of error terms is negative and statistically significant (p-value: 0.079). The sign and significance of rho suggests endogeneity of *ESIF* due to positive selection into both ESIF co-funding and GPP and implies that the bivariate probit model should indeed be preferred over the univariate probit specification.

5.2 Mechanisms of the effect of ESIF co-funding

Our findings suggest that the effect of ESIF co-funding on GPP is driven mainly by co-funding availability and not by a general shift of the ESIF policy objectives that reflect sustainable development. As Figure 1 and the interaction terms in Table 4 show, GPP uptake increased significantly among co-funded tenders in the transition period, following the initiatives of the EC to stimulate ESIF allocation by temporarily increasing co-funding availability for certain areas. After the transition period, the GPP uptake among co-funded tenders dropped to levels that are similar to the period before the policy change, despite the stronger focus of the ESIF policy conditions on sustainable development since the transition period. Meanwhile, the results show a gradual increase of GPP among tenders without co-funding after the transition period, which might reflect an overall upwards trend of GPP uptake.

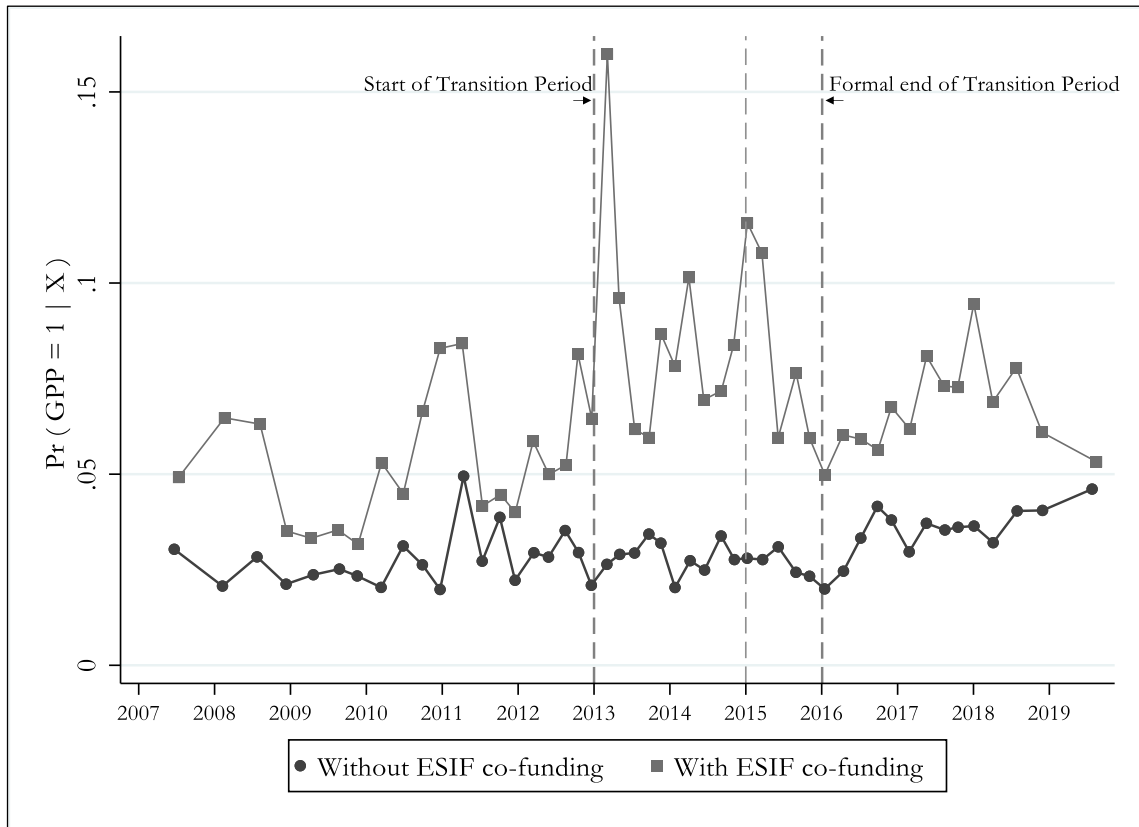


Figure 1 Predicted Probability of GPP per quarter, based on linear probability model estimation of (1), with full set of controls per policy period excluding year fixed effects

Table 4 Estimated marginal effects of ESIF co-funding and related policy changes on GPP compared to Funding round 1, 2007 – Q2 2019

	OLS	Probit
	{1}	{2}
<i>ESIF</i>	0.033*** (0.006)	0.032*** (0.004)
<i>PolicyChange</i>	0.007*** (0.002)	0.009*** (0.003)
<i>TransitionPeriod</i>	-0.007*** (0.002)	-0.009*** (0.003)
<i>(ESIF x PolicyChange)</i>	0.012 (0.007)	0.004 (0.005)
<i>(ESIF x TransitionPeriod)</i>	0.026*** (0.007)	0.017*** (0.004)
<i>GPP Experience</i>	Yes	Yes
<i>Time FE</i>	Yes	Yes
<i>Contracting auth. FE</i>	Yes	Yes
<i>Industry FE</i>	Yes	Yes
(Pseudo) R ²	0.052	0.117
F / Wald χ^2 (df)	24 (44)	1,749 (44)
N [tenders]	136,942	136,942

Notes: Standard errors in parentheses, clustered at the level of the contracting authority. Results are based on the estimation of regression equations (3). *GPP* indicates that the tender contains at least one green search term. *ESIF* indicates if a tender is ESIF co-funded. *GPP Experience* is the share of tenders containing a green search term, done by the contracting authority in the previous budget year. *Time FEs* include controls for seasonal effects per month and budget year fixed effects. *Contracting auth. FE* include controls for the type of organisation, whether its location is in Prague and whether it does few or many tenders. *Industry FE* is a set of dummy variables that controls for the industrial category of the tender based on CPV codes. *** p<0.01, ** p<0.05, * p<0.1

As the results in the previous section point out, contracting authorities select into ESIF and GPP, meaning that tenders done by the same contracting authority in the same period are not independent; the increase of GPP among co-funded tenders could be at the expense of tenders without ESIF co-funding in certain periods, which could lead to overestimation of *ESIF* in Table 4.¹⁵ The size of the estimates in Table 4 should thus be interpreted with caution. We run a placebo test using a regression discontinuity design that shows that the policy change is not significantly affecting GPP among tenders without ESIF co-funding (see Figure A1 in the Appendix). Hence, our concerns of overestimation are alleviated to some extent. In addition, Figure A2 in the Appendix shows the marginal effect of ESIF over time, based on a bivariate probit model that accounts for selection effects; the figure confirms that the marginal effect of ESIF co-funding on GPP peaks in the transition period, compared to the surrounding periods.

¹⁵ This is more formally a violation of the Stable Unit Treatment Value Assumption (SUTVA).

5.3 Effect of prior GPP experience on GPP in tenders

We find a positive and significant effect of prior GPP experience on GPP uptake and find that part of the effect goes through ESIF co-funding. The top line in Figure 2 shows the predicted probabilities of GPP uptake, based on a univariate probit model that does not control for ESIF. The lower line in Figure 2 is based on a bivariate probit model that controls for ESIF. The difference between the lines illustrates that prior GPP experience has an indirect effect on GPP uptake, increasing the contracting authority's chances to obtain ESIF co-funding.

The direct effect of prior GPP experience, aside from ESIF, is positive but small; Figure 2 shows that the predicted value of GPP uptake is 0.8% when the contracting authority took up GPP in none of its tenders and 11.2% when the contracting authority took up GPP in all its tenders¹⁶ in the previous budget year. On average, contracting authorities took on GPP in about 3.7% of their tenders in the previous budget year (see Table 2a), meaning that the direct effect of prior GPP experience is near trivial for the average contracting authority.

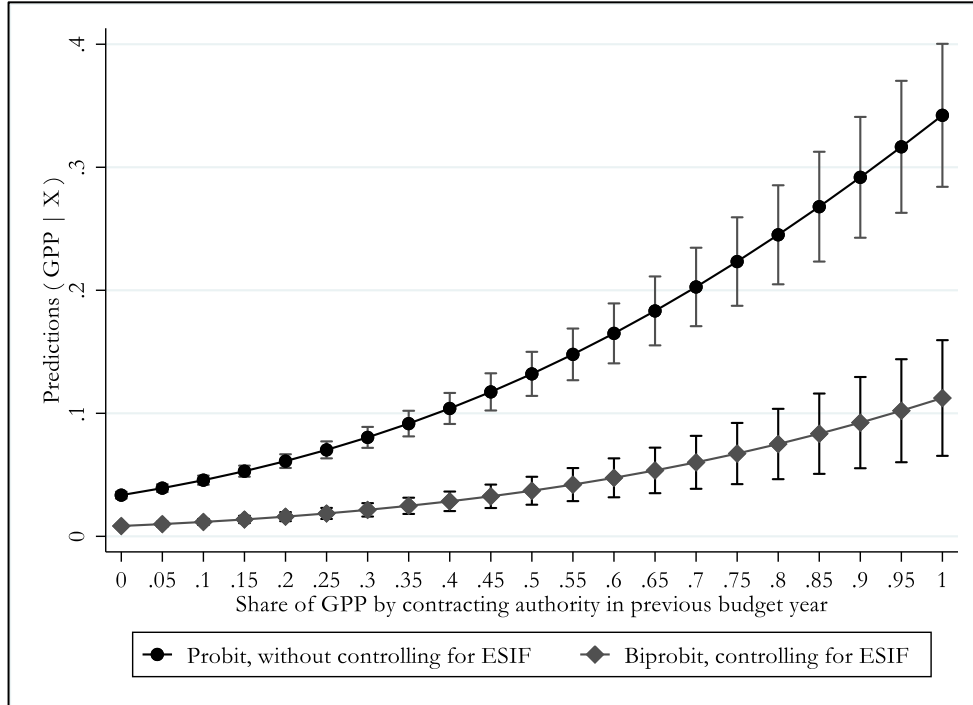


Figure 2 Predicted values for GPP uptake in tenders at different levels of prior GPP experience of the contracting authority in previous budget year, with 95% confidence intervals. Estimates are based on regression equation (4)

¹⁶ In practice, the contracting authorities that have taken up GPP in all tenders in the previous budget year are assumedly mainly small authorities that have posted only one tender which is green. We excluded observations where $GPP\ Experience = 100\%$ and find that the results are robust (results not shown).

The justification of the bivariate probit model is that *ESIF* cannot be used as a control variable in a univariate probit model without creating a ‘bad control problem’; ESIF co-funding may be the result of prior GPP experience. The results in Table A4 of the Appendix (and Section 5.1) show that prior GPP experience is indeed positively and significantly related to ESIF co-funding. The bivariate probit model controls for *ESIF*, including its positive correlation with prior GPP experience, thereby working around the bad control problem.

6. 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 public projects to stimulate growth in the less economically developed regions of Europe. Analysing nearly all public tender notices in the Czech Republic from 2006 to 2019, we find that ESIF co-funding increases the uptake of GPP by 2.7 percentage points, after we account for (un)observed selection effects. Next, by studying two exogenous policy changes, we explore through which mechanisms ESIF stimulates GPP uptake and find that GPP uptake responds significantly to changes in co-funding availability in certain areas, but not to overall ‘greener’ ESIF policy objectives that advocate for GPP. Combined, these first two results confirm the hypothesis that ESIF affects GPP uptake and provide mixed support for the assumed policy change effect. Finally, our results show that, aside from ESIF co-funding, GPP uptake increases only slightly with the contracting authority’s prior GPP experience. This confirms our second hypothesis, although the effect size is also small.

Our findings show that ESIF co-funding has a positive effect on GPP uptake. However, we consider the effect limited in proportion to the recourses spent through ESIF. In our dataset, 30% of procurement tenders receive ESIF co-funding. If we suppose that each ESIF co-funded tender were made green because of ESIF conditions (perhaps being green is a pre-condition to obtain the co-funding, imposed by the managing authority) and there were no spill-over effects to other contracts, then our estimate would be closer to 30% (i.e., ESIF co-funding would increase the GPP uptake probability of a tender by 30% on average). Meanwhile, our estimate is only 2.7 percentage points. This illustrates that the additionality of ESIF in terms of GPP uptake is limited. An explanation for the limited additionality of ESIF, as suggested by the theoretical model, is that the benefits of ESIF for GPP may not outweigh the perceived additional risk and cost of GPP. We indeed find that GPP uptake responds to increases in co-funding availability, which suggests that

contracting authorities take up more GPP when the potential benefits of co-funding are higher. This finding also aligns well with the theoretical model.

In addition, the relative advantage of GPP over non-GPP projects may be limited by the extent to which co-funding is available for non-GPP projects. GPP is recommended by the ESIF guidelines and is not a strict condition for co-funding. Member States are evaluated based on their progress in the thematic areas that are laid down in the Partnership Agreement with the EC. Hence, the managing authorities in the Member States may allocate co-funding for non-GPP projects that can be related to the objectives of the Partnership Agreement. As such, the incentives that ESIF provides for the general objectives of sustainable development, net environmental benefits and GPP seem overshadowed by the incentives for specific types of projects in thematic areas. This prioritization of specific thematic areas might provide an explanation why we find no increase of GPP uptake after the transition period among ESIF co-funded tenders; the use of thematic areas and a Partnership Agreement has been consistent over time.

Moreover, we demonstrate that selection effects are an explanation why the additional effect of ESIF on GPP uptake is limited. The results show that part of the relation between ESIF and GPP can be explained by prior GPP experience and other unobserved selection effects, meaning that, to some extent, co-funding is allocated to tenders that a priori have a higher probability for GPP take up. This is also consistent with our theoretical model.

The first main implication of this study accordingly concerns the role of the ESIF allocation mechanism to stimulate GPP uptake. Our results imply that the provision of financial support from ESIF in specific areas could act as an incentive for contracting authorities to adjust their preparations to meet these conditions. This behaviour is explained by the theoretical model and also appears rational, as it enables contracting authorities' realization of the projects at significantly lower costs. Our results suggest that contracting authorities may allocate their internal resources (e.g. relevant GPP experience) or prioritize projects to secure ESIF co-funding and optimise their budgets. Policies that incentivise GPP only for specific programs, projects or public sector domains may thus create a substitution effect that lowers the priority given to GPP in areas without incentives. Therefore, we argue that policy makers aiming to mainstream GPP would benefit more from more systemic drivers that cover procurement as a whole and not specific projects. For instance, GPP could become an eligibility condition for a

Member State or region to receive ESIF co-funding. For example, the horizontal sustainable public procurement policy of the Dutch central government applies to all tenders and has led to a large increase of GPP uptake (van Berkel & Schotanus, 2021). Meanwhile, the use of GPP has become compulsory in the Czech Republic in 2021; procurers can only apply ‘non-green’ procurement when they have a sufficient justification. Future research could study to what extent this regulatory reform affected GPP uptake and the role that ESIF plays. Moreover, we highlight that there is a pressing need for future research on environmental outcomes and the effectiveness of GPP overall, as GPP uptake itself is not the desired final outcome.

The second main implication of this study relates to the importance of GPP experience (or knowledge). The extant literature highlights relevant GPP experience as one of the main barriers of GPP uptake (Cheng et al., 2018; Chiappinelli, 2022). Likewise, GPP-related training and information provision are among the most used measures worldwide to stimulate GPP, while economic incentives are among the least used (UNEP, 2022). Meanwhile, this paper points out that the effect of GPP experience itself is small in the Czech Republic (and limited compared to that of economic incentives – in this case ESIF co-funding). Our findings imply that GPP experience might be insufficient to mainstream GPP uptake, especially in the absence of institutional incentives or other clear drivers for GPP. Accordingly, we emphasize that policy makers should make sure to place GPP experience on the list of potential GPP barriers (not drivers) that impede GPP uptake, depending on the institutional drivers and conditions that are present.

Likewise, we stress that scholars should take care to regard GPP experience as a barrier to GPP uptake, in interaction with other factors. So far, few studies (apart from (Zhu et al., 2013)) distinguish the interaction dynamics between drivers and barriers (Behraves et al., 2022). Studies that show the importance of the effects of relevant GPP knowledge and experience on GPP uptake (Testa et al., 2012, 2016) should be generalized only conditional on by the institutional drivers for GPP, that typically differ across countries and regions, or legal regimes (Shadrina et al., 2022).

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, 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 financial

means was the strongest driver of the direct effect in our study, we have not included the ESIF monitoring and governance structures in our analysis. Future work is encouraged that looks into the governance of ESIF co-funding in more detail.

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Appendix

Table A1 Hits per search term in the dictionary underlying GPP, with and without ESIF co-funding.

	With ESIF co-funding	Without ESIF co-funding
Environment*	30	59
Sustain*	62	115
Ecolog*	312	411
Emiss*	267	84
Reduce_emiss*	163	9
Pollut*	48	34
CO2	35	15
NOX	32	8
PM10	3	0
PM2_5	1	1
Toxic	4	12
Hazardous	97	272
Vegetable	54	48
Waste_sort*	35	59
Organic*	21	27
Chemic*	155	553
Biodeg*	56	18
two_side_print*	1	0
Titanium_dioxide	1	2
Water_sav*	0	2
Gas_sav*	1	1
Fuel_sav	5	12
Reduc*_energ*	1,106	78
Insulat*	1,762	735
Dimming	0	1
LED	77	187
ISO14001	2	20
EMS	0	2
FSC	0	1
Recycl*	96	43
Recharg*	7	11
Endur*	1	1
Durab*	3	2
Demont*	4	36
Rehab*	215	148
Life*	181	253
Renew*	21	13
N [tenders]	54,855	128,879

Table A2 Marginal effects of ESIF on GPP based on univariate probit estimation of regression equation (1), Q3 2006 – Q2 2019

	{1}	{2}	{3}	{4}	{5}	{6}
<i>ESIF</i>	0.060*** (0.004)	0.056*** (0.004)	0.056*** (0.003)	0.053*** (0.004)	0.054*** (0.004)	0.044*** (0.004)
<i>GPP Experience</i>						0.113*** (0.008)
<i>Time FE</i>	No	Yes	Yes	Yes	Yes	Yes
<i>Contracting auth. FE</i>	No	No	No	Yes	Yes	Yes
<i>Industry FE</i>	No	No	Yes	No	Yes	Yes
Pseudo R ²	0.0457	0.0512	0.0839	0.0676	0.0951	0.1180
Wald χ^2 (df)	233 (1)	517 (24)	1374 (37)	775 (38)	1552 (51)	1763 (51)
N [tenders]	174,569	174,569	174,569	171,705	171,705	136,942

Notes: Standard errors in parentheses, clustered at the level of the contracting authority in all estimations. *GPP* indicates that the tender contains at least one green search term. *ESIF* indicates if a tender is ESIF co-funded. *GPP Experience* is the share of tenders containing a green search term, done by the contracting authority in the previous budget year. *Time FEs* include controls for seasonal effects per month and budget year fixed effects. *Contracting auth. FE* include controls for the type of organisation, whether its location is in Prague and whether it does few or many tenders. *Industry FE* is a set of dummy variables that controls for the industrial category of the tender based on CPV codes. *** p<0.01, ** p<0.05, * p<0.1

Table A3 Maximum likelihood of ESIF on GPP based on bivariate probit estimator, Q3 2006 – Q2 2019

	{1}			{2}		
	<i>GPP</i>		<i>ESIF</i>	<i>GPP</i>		<i>ESIF</i>
	ME	ML	ML	ME	ML	ML
<i>ESIF</i>	0.020*** (0.002)	1.087*** (0.318)		0.0267*** (0.002)	1.812*** (0.117)	
<i>GPP Experience</i>	0.034*** (0.004)	1.264*** (0.139)	0.606*** (0.110)			
<i>TransitionPeriod</i>			0.105*** (0.0249)			0.390*** (0.030)
<i>Time FE</i>		Yes	Yes		No	No
<i>Contracting auth. FE</i>		Yes	Yes		No	No
<i>Industry FE</i>		Yes	Yes		No	No
Wald χ^2 (df)		7,624 (102)			958 (2)	
Murphy's Rao χ^2 (9)		542***			38***	
ρ [rho]		-0.348*			-0.709***	
N [tenders]		136,942			174,569	

Notes: Standard errors in parentheses, clustered at the level of the contracting authority in all estimations. Results in this table are based on the estimation of regression equations (2) using a bivariate probit estimator. The left side of the columns present the marginal effects on *GPP*, based on the right side of the column. The statistical significance of rho indicates that the error terms of the both equations are correlated, which suggests that the variable *ESIF* is endogenous, justifying the use of a bivariate probit model over univariate models. A significant test statistic of Murphy's Rao specification indicates that the bivariate probit model is misspecified, meaning that the error terms of *ESIF* and *GPP* are not jointly normally distributed. The estimates on *ESIF* in the right half of the column of each estimation are maximum likelihood estimates that cannot be interpreted as marginal effects, but show only the sign and significance of independent variables on ESIF co-funding. *** p<0.01, ** p<0.05, * p<0.1

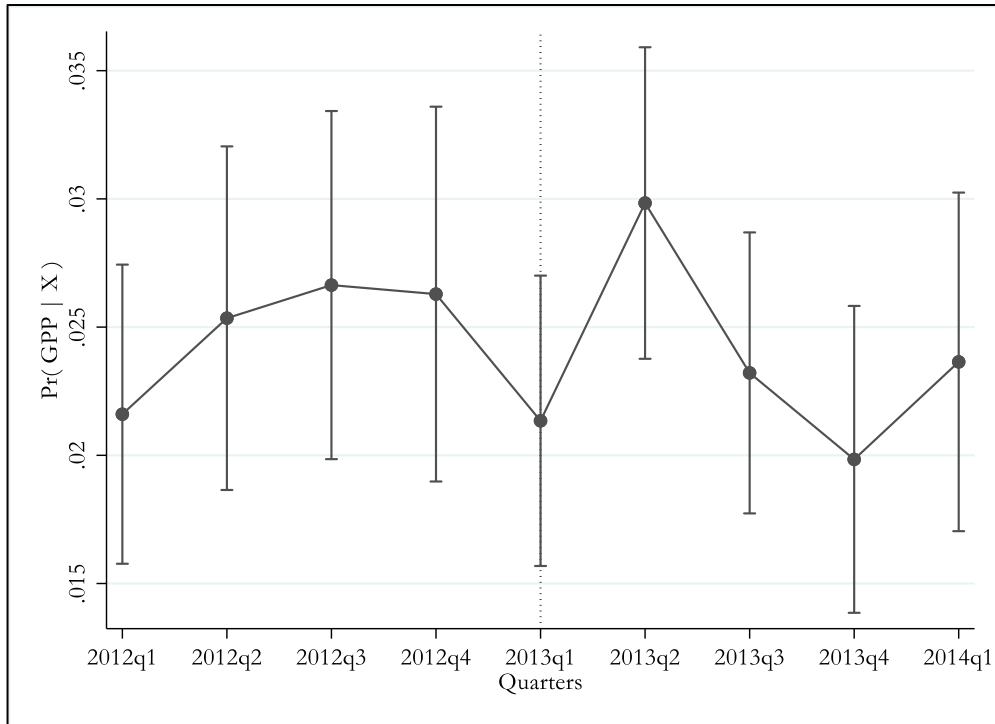


Figure A1 Predicted values for GPP per quarter with 95% confidence intervals, based on probit model estimation of regression equation (1) without time controls. Dotted line indicates start of policy change

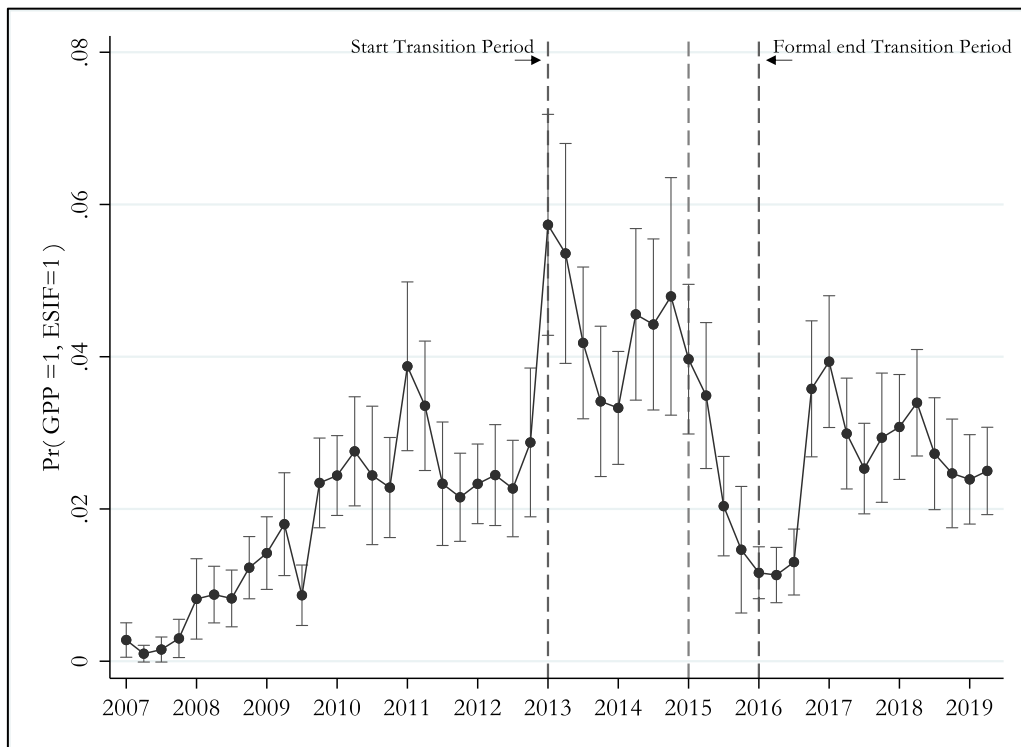


Figure A2 Predicted marginal effect of ESIF co-funding on GPP per quarter with 95% confidence intervals, based on bivariate probit model estimating $(\text{GPP} = \text{ESIF} + \text{Quarter_dummies} + e, \text{ESIF} = \text{Quarter_dummies} + u)$

Table A4 Maximum Likelihood estimates of prior GPP experience on GPP, based on bivariate probit model (4) Q3 2006 – Q2 2019

	GPP	ESIF
<i>ESIF</i>	1.044*** (0.347)	
<i>GPPExperience</i>	1.280*** (0.145)	0.605*** (0.109)
<i>Time FE</i>	Yes	Yes
<i>Contracting auth. FE</i>	Yes	Yes
<i>Industry FE</i>	Yes	Yes
Wald χ^2 (df)	7,489 (101)	
ρ [rho]	-0.323	
N [tenders]	136,942	

Notes: Standard errors in parentheses, clustered at the level of the contracting authority in all estimations. The estimates are maximum likelihood estimates that cannot be interpreted as marginal effects, but show the sign and significance of independent variables. *GPP* indicates that the tender contains at least one green search term. *ESIF* indicates if a tender is ESIF co-funded. *GPP Experience* is the share of tenders containing a green search term, done by the contracting authority in the previous budget year. *Time FEs* include controls for seasonal effects per month and budget year fixed effects. *Contracting auth. FE* include controls for the type of organisation, whether its location is in Prague and whether it does few or many tenders. *Industry FE* is a set of dummy variables that controls for the industrial category of the tender based on CPV codes. *** p<0.01, ** p<0.05, * p<0.1