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Green public procurement in the public transport sector

Jordi Rosell

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JEL Classifications: H57, L91, Q58

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1. Introduction

Urgent action is needed to address issues of climate change, biodiversity loss, water scarcity and the health impacts of pollution, among many others. Most of these environmental concerns are of a transboundary nature, and many are global in scope, but they can be addressed effectively if international cooperation can be secured in matters of environmental policy. In parallel with this, there are also actions that can be implemented by every public organization to mitigate the negative effects on the environment. Green public procurement (GPP) is one such policy tool, its strength being that it relies on neither third-party decisions nor third-party actors.

The quantity of recent publications dedicated to GPP is evidence that such practices are becoming more and more prevalent (Cheng et al., 2018) and an increasing number of these are taking a quantitative approach, thus addressing a historical gap in this research line. A good example of this current trend is provided by Yu et al. (2020) who conduct a European cross-sector analysis to demonstrate that the public transport equipment sector and the food sector are the main implementers of GPP. While the variation between organizations in the food sector with regard to their implementation of GPP is notable, in the public transport sector such differences are not so marked. Indeed, the latter provides researchers with the possibility of selecting organizations with the same mission and whose characteristics are largely comparable across countries while, in the food sector, the other front runner in terms of GPP adoption, organizational characteristics are more diffuse.

The transport sector has long been recognized as a major contributor to greenhouse gas (GHG) emissions and other pollutants in urban areas. The main environmental impacts attributable to public transport concern climate change, linked to tailpipe emissions; air pollution, caused by combustion engines and tire wear; noise pollution; and other emissions, resulting from electricity production for electric vehicles and associated impacts linked to battery production and disposal, among others. Local government and supramunicipal institutions have taken steps to address the issue and, progressively, public transport authorities seek to buy and deliver green transport services, wherever possible, including purchasing new buses; testing cleaner fuels and improving driving practices (Silva Cruz & Katz-Gerro, 2016). Increasingly public organizations are including the GPP practices of the public transport sector in their quality assessments and fomenting their adoption (Lindfors & Ammenberg, 2021). Moreover, strategic GPP use has a series of knock-on effects, for example, in the public bus sector it can stimulate the introduction of renewable fuels, among other innovations (Aldenius & Khan, 2017).

Analyzing GPP using survey data is a common practice (Brammer & Walker, 2011; Raj et al., 2020), and while differences in GPP have been reported between sectors in the same country (Etse et al., 2021) and between countries in the same sector (Chiarini et al., 2017), to date, no cross-country analysis of GPP adoption in one sector has yet to be undertaken. And, interestingly, all the indications are that the context seems to matter for the GPP adoption made by transport authorities (Aldenius and Khan, 2017; Aldenius et al., 2022). To address this research gap, this paper conducts a critical analysis of the differences in GPP adoption of the largest European public transport suppliers, a sector in which most organizations share the same internal factors as regards competences and mission. This means our primary focus can be on evaluating the impact of external factors on GPP adoption. More specifically, we conduct our analysis both before and during the COVID-19 epidemic, which allows us to determine how an external shock affects the green management practices of these organizations.

The rest of this article is structured as follows. The next section describes the data, methodology and variables employed. We then present our descriptive statistics and regression results, before discussing these outcomes in the next section. We conclude by considering aspects worthy of further research.

2. Material and methods

Data and Methodology

We draw on the Tenders Electronic Daily (TED) database, which contains all active calls for tenders published in the Supplement to the Official Journal (OJS) of the European Union. We select all active contract notices for these countries and contracts from countries in the European Free Trade Association (Norway, Iceland, and Liechtenstein) and from Switzerland. We consider a period that runs from 2010 to 2020, the last available year. The implementation of GPP has increased over time and although data are available from 2006, we have opted for this more recent year. On a cautionary note, results derived from the TED database should be interpreted with care given that missing data have been estimated at around 25% and because of the possibility of data misfiling, although TED personnel make every effort to correct the database. Moreover, observations below Directive thresholds tend to be misreported, since the reporting of contract notices by the contracting authorities is voluntary.

Essentially two criteria are employed when awarding a contract: the lowest price and the most economically advantageous tender (MEAT). Here, the lowest price criterion is excluded from our analysis since green criteria *per se* are not taken into account. If the contracting authority employs MEAT as its criterion for awarding a contract, the relative weight given to each of the criteria chosen to determine the MEAT (e.g. 50% price, 20% quality, 15% working conditions and 15% environmental characteristics) should be specified in the contract notice, contract document or, in the case of a competitive dialogue, in the descriptive document.

Our goal here is to establish an objective measure of GPP adoption across the actors in the EU's public transport sector. The general application of this methodology is outlined in Rosell (2021). However, briefly, we conduct a word search – in all official European languages – among all the awarding criteria contained in the contract notices in order to identify terms related to green award criteria. We focus specifically on the terms 'environment' and 'sustainable', but also include 'carbon footprint', 'life cycle assessment' (LCA), 'emission standards', 'carbon dioxide' and 'GHG', among other concepts. We should stress here that, as such, we cannot capture all aspects of GPP, for example, terms appearing elsewhere in the contract notices, such as the technical conditions and contract performance clauses. We exclude Greece and Bulgaria due to difficulties in detecting green words attributable to their respective alphabets. A number of papers have adopted the same approach. For example, Nemec et al. (2021) analyze the effects of including GPP in the contract awarding phase for SMEs in European Eastern countries; Krieger and Zipperer (2022) also focused their study on SMEs, though in this instance in Germany, to examine whether GPP served to trigger environmentally friendly product innovations; and, Badell and Rosell (2021) compared different levels of government, with a specific focus on EU institutions, to quantify their commitment to green policies. The last three studies all use the TED database while, Grandia and Kruyen (2020), conduct an exhaustive analysis of the Belgian case using the country's own national database.

Works, supplies or services that are the subject of procurement are acquired either by using one contract or by using a number of separate contracts or "lots", which may be awarded and performed by different economic operators. Since the majority of contract notices involve different lots, we have deleted those constituting more than one lot. The main reason for this is that larger contracts are more likely to include several lots, procedures are quite similar and, environmental award criteria are more common. After retaining just those notices comprising one lot (1,717,476), we are left with 1,013,282 contract notices corresponding to MEAT criteria. Recall, we have to exclude all the lowest price observations as no green award criteria can be detected. Of the remaining contract award notices, 12,364 correspond to the public transport sector. To conduct our analysis of the contracting authorities, we group contract notices for the same contracting authority. Some, however, were excluded on the grounds they have no urban mandate (e.g. Bus Eireann in Ireland and Skånetrafiken in the Skåne region in Sweden). Similarly, contracting authorities with fewer than a hundred MEAT contracts are excluded to ensure that GPP is representative. Thus, we are left with a total of 67 contracting authorities in a total of 19 European countries.

Empirical specification

We estimate two main equations given the dependent variable. Our first GPP dependent variable is at the contract level: a dummy that takes a value of one if the contract includes GPP among its awarding criteria, and zero otherwise. We estimate the following equation, in which each observation corresponds to one of the procurement processes described in the previous subsection for pooled data:

$$\begin{aligned} GPP\_contract = {} & \beta_0 + \beta_1 Bus\_vehicle\_acquisition + \beta_2 Tramway\_metro\_vehicle\_acquisition \\ & + \beta_3 Bus\_services + \beta_4 Time + \beta_5 Covid19 + \beta_6 GPA + \beta_7 Type\_of\_contract \\ & + \beta_8 Large\_area + \beta_9 Price + \beta_{10} Country + \varepsilon \end{aligned} \quad (1)$$

Our second dependent variable is the proportion of GPP in each authority and it is obtained by aggregating contract level data. Our model is:

$$\begin{aligned} & GPP\_proportion \\ & \quad = \beta_0 + \beta_1 Inhabitants + \beta_2 Number\_buses + \beta_3 Number\_tramways \\ & \quad + \beta_4 Number\_metros + \beta_5 CountryGPP\_prop + \varepsilon_{it} \end{aligned} \quad (2)$$

Dependent and explanatory variables

GPP contract is a dummy that takes a value of one if the contract includes GPP in its awarding criteria and zero otherwise. At the contracting authority level, we obtain the proportion of GPP over all MEAT contracts *(GPP proportion)*. These are the two main dependent variables.

Based on the literature review reported below and our search interest, and in line with their availability in the TED database and other databases, the following explanatory variables of the *GPP contract* dependent variable are incorporated.

- *Bus vehicle acquisition*: a dummy variable taking a value of one if the procurement process is related to a bus vehicle acquisition, and zero otherwise. We include common procurement vocabulary (CPV) codes 34120000 to 34121500 from the TED database.

- *Tramway/metro vehicle acquisition:* a dummy variable taking a value of one if the procurement process is related to a tramway or metro vehicle acquisition, and zero otherwise. We include CPV codes 34620000 to 34622300 from the TED database. We combine tramway and metro fleets in the same variable as the TED codes do not allow us to differentiate between them.
- *Bus services*: a dummy variable taking a value of one if the procurement process is related to bus service delivery, and zero otherwise. We include CPV codes 60100000 to 60112000 from the TED database.
- *Time:* a time trend variable to capture GPP. Time has had a positive impact on the number of studies examining GPP adoption (Cheng et al., 2018) and it has also had a positive effect on GPP adoption rates by contracting authorities (Rosell, 2021).
- *Covid19*: a dummy variable taking a value of one if the procurement dispatch date corresponds to the eleventh week of 2020 or later, and zero otherwise. The main criteria for selecting this week is subjective, that is, it corresponds to the first week that all European countries reported at least one confirmed case of COVID-19.
- *GPA*: a dummy variable taking a value of one if the contract is covered by a Government Procurement Agreement (GPA) and zero otherwise. The World Trade Organization (WTO) has been at the forefront of these global regulatory standards to ensure open, transparent and non-discriminatory procurement and value for money. When organizations procure under these principles, there is more probability of their adopting GPP practices (Yu et al., 2020).
- *Price*: contract value, in euros, without VAT, deflated to 2016 country prices. The consumer price index is obtained from the IMF. To avoid cases in which the contracting authority may have confused the contract value with the unit price, values below one thousand euros are omitted. This variable is in logarithms. A positive relation between price and GPP is expected in the regression (Renda et al., 2012; Yu et al., 2020; Rosell, 2021).
- *Type of contract*: a categorical variable that classifies whether the contract is a supply, works or service contract. Supply contracts include more GPP award criteria, whereas service contracts include more performance clauses due to contract duration and fewer GPP award criteria (Rosell, 2021).
- *Large area*: a dummy variable taking a value of one if the contract is tendered by one of the 67 public transport suppliers, and zero otherwise. Small municipalities procure less under GPP (Michelsen & Boer, 2009; Plaček et al., 2021) while in large and medium-sized municipalities, these differences are eroded (Rodriguez-Plesa et al., 2022)
- *Country effects*: each contracting authority operates in a specific country subject to the influence of economic, normative and other country fixed effects. For example, Italian organizations are more concerned with respecting mandatory laws compared to their UK counterparts (Chiarini et al., 2017). Indeed, in general, the literature highlights marked differences between countries (Cheng et al., 2018; Rosell, 2021).

As previously mentioned, when *GPP contract* information is aggregated as *GPP proportion*, we lose the information related to the contract. For the *GPP proportion* regression, therefore, we further include:

- *Country GPP effects*: each public transport contracting authority operates in a specific country and this, as discussed, has an influence on the contracting authority's decisions. Based on the total number of MEAT contract notices (1,013,282), we derive the country mean.
- *Inhabitants*: number of inhabitants in the city and surrounding municipalities in 2019. Obtained from Eurostat and transformed in logarithms.
- *Number of buses, tramways and metros*: obtained from the website of each public transport company supplier and corresponding to the last available report (2021). For buses, we count

the total number of buses, for tramways the total number of coaches and for the metro, the total number of convoys.

Finally, the following variables are included in the descriptive analysis.

- *City GPP effects*: each public transport contracting authority operates in a specific main city. Based on the total number of MEAT contract notices at the city level by local authority (50,337), we derive the city mean.
- *Bureaucracy:* a categorical variable taking a value from one to five in each country for 2019. Bureaucratic quality is obtained from the International Country Risk Group (Howell, 2011). The variable is based on expert views about the presence of regular, meritocratic recruitment and advancement processes, insulation from political pressure, and the ability to continue service provision during government changes (Howell, 2011). Better bureaucrats are less reluctant to implement GPP (Plaček et al., 2021).
- *GDP per capita:* this variable captures the level of development. The value is in euros for 2019, at market prices, adjusted at every country purchasing parity, in logarithms and is obtained from Eurostat.
- *Government expenditure:* this variable expresses total government expenditure as a percentage of country GDP for 2019 and is obtained from Eurostat. A more developed public sector should be associated with more GPP.
- *NO_2:* a more polluted city might be linked to a more aggressive GPP adoption or, equally, a less polluted city might be linked to more GPP due to more environmental awareness. As such, the expected sign of this variable is unknown. NO_2 is a pollutant linked to combustion engines. The value is the city average for 2019 as reported by the European Environment Agency.

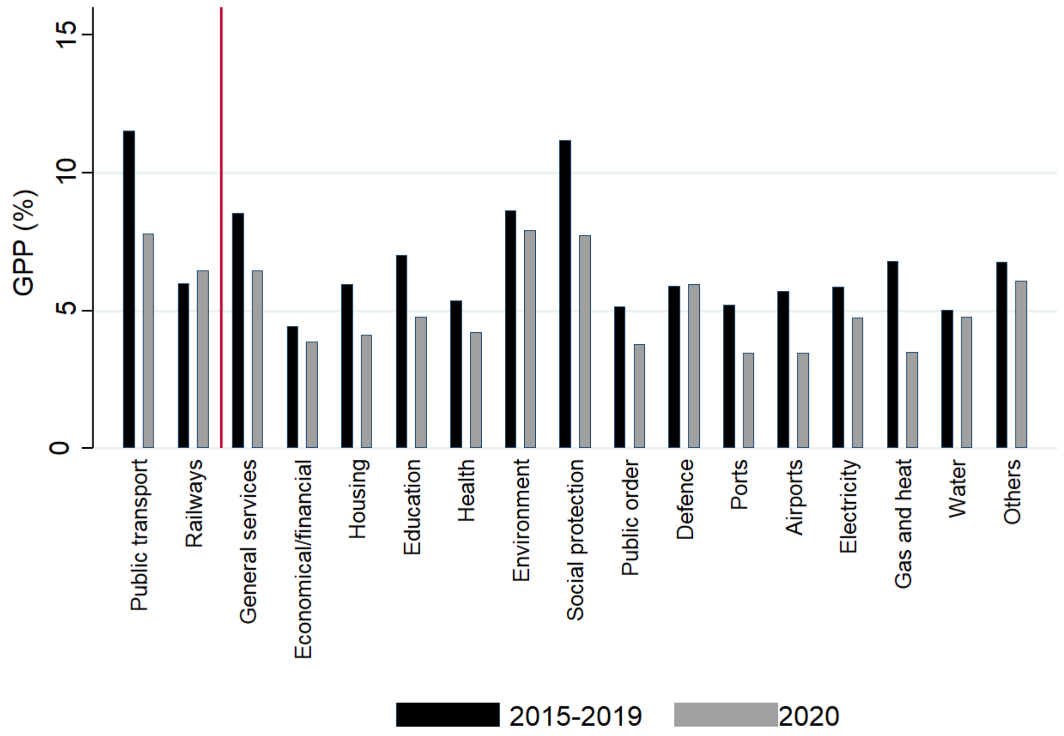
3. Results

Descriptive analysis

The public transport sector was the front-runner in terms of GPP adoption before the COVID-19 pandemic (11.5%) followed by the social protection sector (11.2%) (F

Figure 1). In the railway sector, the pre-COVID-19 GPP adoption rate stood at 6%. During the COVID-19 epidemic, GPP implementation fell markedly to 7.8% in the public transport sector, the largest drop in absolute values across all sectors and the second largest in relative terms. However, in the railway sector, a degree of growth was detected in GPP adoption during the pandemic, albeit quite small.

Figure 1. GPP adoption by sector before and during the pandemic



The GPP adoption rates also differ between different types of procurement in the public transport sector (

Table 1). In the case of the acquisition of bus vehicles, GPP stands at 23.6%; however, in the case of tramway/metro vehicles, the share falls to 14.5%. The results of a t-test reject the possibility that the GPP adoption rates of the two categories are the same (95% confidence level). Procurement processes of bus services have a GPP rate of 17.9%, a level that does not differ from that of the two vehicle procurement processes according to the t-test result. The public transport category, which includes all the other procurement activities conducted by a transport authority in this sector (that is, not including the previous three processes – i.e. bus acquisition, bus services and tramway/rail acquisition), has the lowest GPP adoption rate (8.6%) and, a t-test confirms that this value is lower than that of the other three categories at the 95% confidence level.

The difference between the GPP adoption rates of bus acquisitions and bus services appears to be in line with European institution recommendations, given that exhaust emissions criteria for bus service contracts are less exacting than those for new vehicle purchases (European Commission DG-Environment, 2011) and because most bus service contracts are awarded to companies with existing fleets purchased before the latest emissions requirements became mandatory. Moreover, the European institutions report that these criteria constitute award criteria, which means bus fleets and services can be compared, with more points being awarded to those deemed more environmentally friendly.

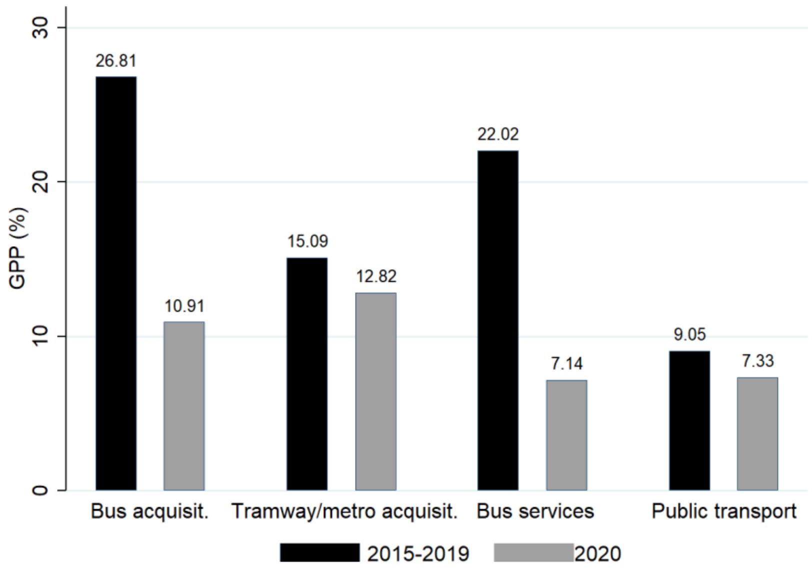
Table 1. GPP summary statistics by public transport subsector

Category (variable)	GPP Mean (%)	GPP Std. Dev. (%)	Obs
Bus vehicle acquisition	23.63	42.52	550
Tramway/rail vehicle acquisition	14.48	35.31	145
Bus services	17.88	38.45	151
Public transport	8.63	28.08	4,428

An analysis of how the COVID-19 pandemic has affected GPP adoption in these subsectors reveals marked drops in the rates for bus acquisitions and services (Figure 2). Note that GPP (%) is a proportion and not an absolute number of green procurement processes. If it were an absolute number, it would be plausible to think that the public transport authorities opted to postpone any decisions to acquire buses due to the reduction in passenger numbers during the COVID-19 lockdown. However, given that it is a proportion, it is more plausible to think that these authorities neglected the environment during the pandemic. Note that the reduction in GPP in the environment sector during the pandemic was smaller than that in the public transport sector (

Figure 1). In the case of tramway/metro vehicle acquisitions and public transport, although there was a fall in GPP during the pandemic, these figures are not significant according to a t-test mean comparison.

Figure 2. GPP adoption by public transport subsector before and during the pandemic



An analysis of supplier size shows that our 67 contracting authorities correspond to the largest available urban suppliers (compared, that is, to the other suppliers which we classify as small/ medium-sized). In the case of bus vehicle acquisitions, bigger cities use GPP more than their small/medium-sized counterparts (Figure 23), while in that of tramway/metro fleet acquisitions, GPP rates are lower than those of buses in both types of urban area while the difference in GPP rates between large and medium/small areas is not so great. Indeed, a t-test does not reject the null hypothesis that both are the same. In the case of tender processes related to bus concessions or services, we can only analyze small/medium-sized cities, since our contracting authorities are direct providers. In the last category, public transport, a t-test cannot reject the possibility that the GPP means for large and small/medium-sized areas are the same. Nevertheless, it should be stressed that ordinary procurement processes in the public transport sector present a GPP adoption rate of 8.6% (weighted average of 9.05 and 7.33% before and during pandemic, respectively, on Figure 2), which places this subsector ahead of most other sectors in

Figure 1. Given that the main procurement processes of a public transport supplier (i.e. vehicle acquisitions and service) should contemplate this environmental component, there is a positive effect on the other procurement process made by these authorities.

Figure 3. GPP adoption by public transport subsector in small/medium-sized and large areas

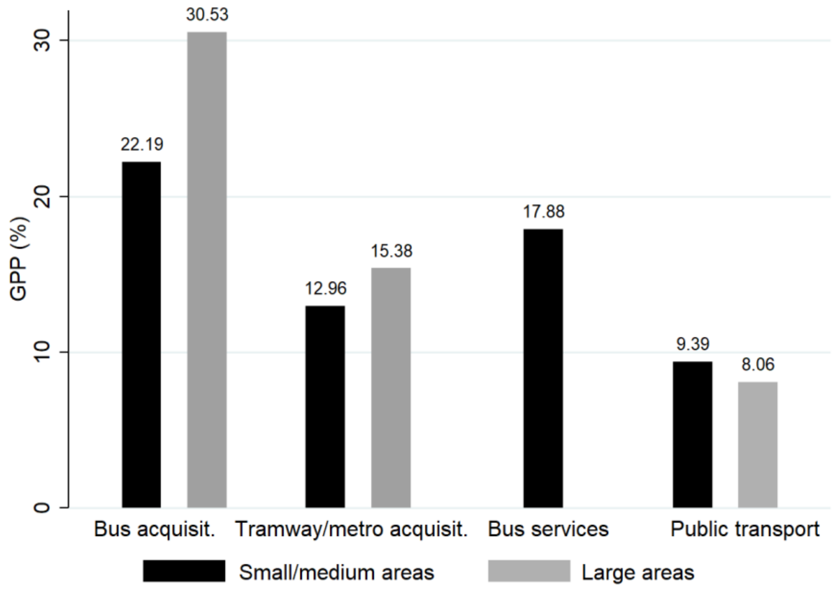
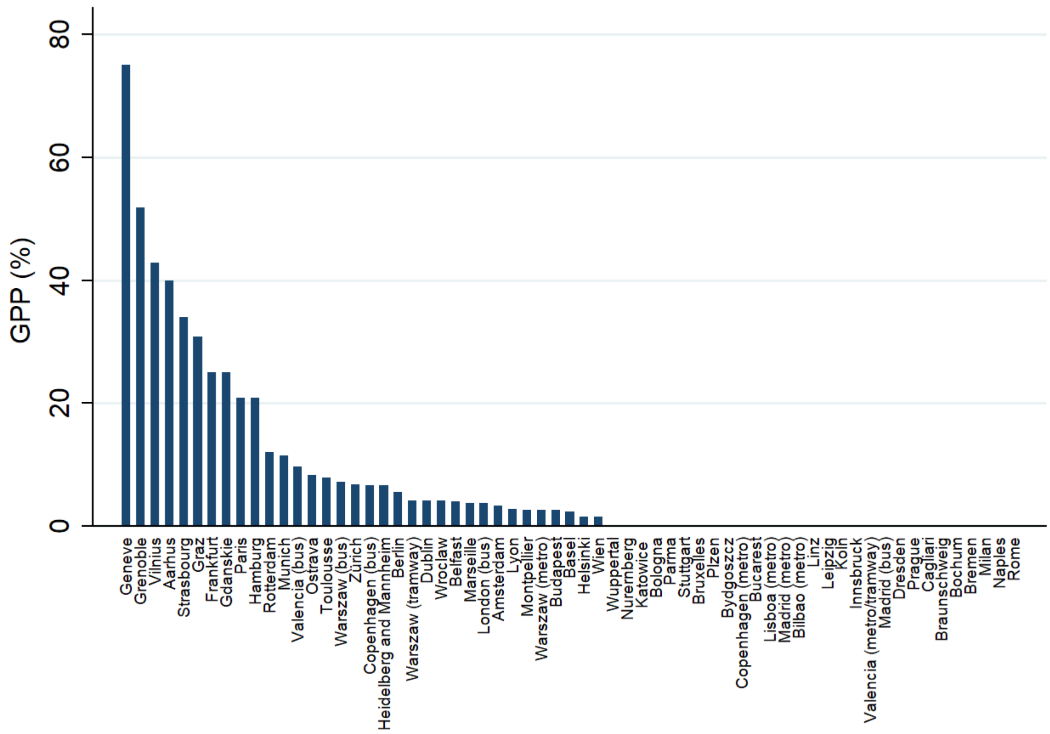


Figure 4 shows that the country of origin of the contracting authority influences the GPP rate. The top five public transport providers are based in Switzerland, France, Lithuania and Denmark. Rosell (2021) reports that Norway, France and Denmark are the leading three countries in terms of GPP implementation and that Switzerland has the largest fixed effects in relation to GPP implementation. So it seems that there is a relation between them.

Figure 4. GPP adoption by contracting authority



Thus, we need to consider which variables are related to this GPP adoption rate of the public transport suppliers. To do so, we analyze two additional GPP rate variables: one at the city level and one at the country level. Both are not only circumscribed to the public transport sector, but also take into consideration all other major sectors (e.g. health, education, social protection, etc.). We find that there is no relation between GPP at the supplier-city level, indicating a degree of independence between city and the public transport supplier in the case of GPP policy. However, as mentioned above, we find a positive, weak relation between the supplier and the country. As far as macroeconomic variables and quality of government are concerned, we find no relation between supplier and GDP per capita, government expenditure and level of bureaucracy. The same results hold for GPP at the city level; however, the relation between the macroeconomic variable and GPP at the country level is significant. This result is in line with Rosell (2021), in which GDP per capita and government size affect GPP adoption and the pairwise correlation is also significant. A country's level of bureaucracy is positively related to GPP adoption at the country level. The average yearly concentration of nitrogen dioxide at the city level is unrelated to the level of GPP adoption either by the transport authority or the city. All in all, the GPP policy of public transport suppliers presents an element of independence from macroeconomic conditions while GPP at the country level is more strongly influenced by these factors.

Table 2. Pairwise correlation between GPP and macro variables (67 observations)

	GPP supplier	GPP city	GPP country	GDP pc	Gov. expenditure	Bureaucracy	NO_2
GPP supplier	1.000						
GPP city	-0.049	1.000					
GPP country	0.237**	0.167	1.000				
GDP pc	0.163	0.096	0.467***	1.000			
Gov. expenditure	-0.096	-0.030	0.480***	-0.146	1.000		
Bureaucracy	0.035	0.108	0.288**	0.738***	-0.043	1.000	
NO_2	-0.116	0.196	-0.019	-0.157	0.058	-0.268**	1.000

* Significant at 10% level; ** at 5% level; *** at 1% level

Regression results

Our analysis of the logistic regression models from Equation 1 shows the significance of the likelihood-ratio chi-square test at the 1% level for all specifications (Table 3). This is computed by comparing a model that has no independent variables (i.e. it has the constant only) with a model that does. These tests convey evidence against the intercept-only model and in favor of the model with explanatory variables. The best model is the one with the lowest Akaike information criterion (AIC). Based on these results, model six, which includes all variables and country fixed-effects, is the one in which the AIC is minimized, making it our preferred model. However, it should be noted that when we include the *Price* variable, the number of observations is reduced by half, making, in this instance models four and six, our preferred models.

Bus vehicle acquisition is positive and significant, which indicates a greater probability of GPP in a bus vehicle acquisition process than in a general procurement process in the public transport sector. Indeed, the odds-ratio is between six and seven times more for specifications four to six. A procurement process for a bus service is likewise associated with a greater probability of GPP than a general procurement process in the public transport sector. Specifications four and five indicate that there is 4.5 to 4.7 times more probability of GPP in a bus tendering process. However, when we control for contract price (specification six), there is 8.5 times more probability of GPP. In general, all three variables remain stable to the addition of our explanatory and control variables. And, these results are in the same direction than previous descriptive statistics.

As far as the control variables are concerned, *Time* has a positive effect on GPP adoption; however, during *Covid-19* time, there is a reduction in GPP. More specifically, the odds of GPP during the COVID-19 epidemic are 36-45% lower than in 2010, *ceteris paribus*. This result is stable over the specifications. Likewise, contracts signed in pro-competitive and open environments (i.e. *GPA*) do not seem to impact GPP adoption, except in the case of specification six. We are less likely to find GPP in service contracts than in goods contracts, while there is a greater probability of GPP in works contracts than in goods contracts. Another possible effect appears to be related to size: large public transport suppliers in large urban areas tend to implement more GPP processes than their smaller counterparts. Note that the *Large area* dummy variable is not significant for specification five and only positive and significant at the 10% level for specification six. This means there is no clear evidence here of size playing an important role in the GPP adoption of public transport agents. Finally, the higher the value of the contract (*Price*), the more likelihood there is of finding GPP.

Table 3. GPP contract level logistic regressions

Dependent variable: GPP contract	Specif. 1	Specif. 2	Specif. 3	Specif. 4	Specif. 5	Specif. 6
	Coeff. (St.Err.)	Coeff. (St.Err.)	Coeff. (St.Err.)	Coeff. (St.Err.)	Coeff. (St.Err.)	Coeff. (St.Err.)
Bus acquisition	1.187*** (0.1138)	1.970*** (0.1528)	2.002*** (0.1541)	1.965*** (0.1710)	1.997*** (0.1747)	1.897*** (0.2542)
Bus services	0.836*** (0.2190)	1.061*** (0.2363)	1.060*** (0.2598)	1.501*** (0.2692)	1.539*** (0.2715)	2.158*** (0.4027)
Tramway/rail acquisition	0.584** (0.2420)	1.049*** (0.2587)	1.035*** (0.2379)	1.056*** (0.2693)	1.051*** (0.2693)	0.492 (0.3999)
Time			0.172*** (0.0558)	0.191*** (0.0565)	0.192*** (0.0566)	0.196** (0.0803)
Covid-19			-0.590*** (0.1704)	-0.613*** (0.1726)	-0.613*** (0.1726)	-0.391* (0.217)
GPA				-0.007 (0.1264)	-0.003 (0.1266)	-0.403** (0.1844)
Type of contract (Goods)						
Works				0.477*** (0.1430)	0.481*** (0.1428)	0.388* (0.1987)
Services				-0.454*** (0.1415)	-0.459*** (0.1416)	-0.695*** (0.2018)
Large area					0.091 (0.1073)	0.275* (0.1516)

Price (log)						0.092** (0.0327)
Constant	- 2.360*** (0.0535)	- 2.377*** (0.3219)	- 350.2*** (112.7)	-387.9*** (114.1)	- 390.5*** (114.2)	-399.9** (162.1)
Country effects	No	Yes	Yes	Yes	Yes	Yes
Observations	5,274	5,153	5,153	5,114	5,114	2,720
McFadden's R^2	0.029	0.113	0.116	0.131	0.131	0.168
Likelihood ratio chi-square test (p-value)	104.7 (0.00)	398.5 (0.00)	411.4 (0.00)	461.1 (0.00)	461.9 (0.00)	306.5 (0.00)
AIC	3473.4	3192.0	3183.1	3113.6	3114.9	1580.7

*** p<.01, ** p<.05, * p<.1

In

Table 4, we estimate the proportion of GPP within each public transport supplier. These regressions include just 67 sixty-seven observations, which raises certain doubts about their reliability. However, the joint significant test (Wald test) rejects the null hypothesis (at between the 10 and 5% levels) that the model is not significant. For this reason, therefore, we keep this regression as simple as possible and only regress variables related to the size of the city or the company. Heteroscedasticity is detected, so we use robust standard errors in our estimations. Including country GPP performance increases the model's explanatory power. Thus, there is a positive relation between the proportion of GPP in a country and the GPP adoption by a transport supplier, driven mainly by the country's current situation or specific national policies on GPP. *Inhabitants* is negative and significant, which indicates that public transport providers in large agglomerations are less likely to procure using green award criteria. When we include the size of the company, our results are mixed. For example, a larger number of tramways is associated with less GPP implementation. In the case of the size of the bus fleet, the evidence is unclear, indicating that larger companies are less likely to use GPP; or, in the case of specification four, the evidence is unclear when we combine number of inhabitants and fleet size. Similarly, the size of the metro fleet does not influence the proportion of GPP. Thus, a clear result emerges from these regressions: larger companies in larger urban agglomerations are not associated with the implementation of higher GPP rates. In fact, there is some evidence that points in the opposite direction: that is, neither increasing company size nor larger urban areas favors GPP implementation. At first sight, this result seems to contradict Aldenius et al. (2022) who find that GPP is more likely in larger areas. However, the latter restrict their study to Sweden and include just three large cities: Stockholm, Gothenburg and Malmö. Here, our sample includes all of Europe's cities, which accounts for the different outcomes reported.

Table 4. Estimation of GPP proportion by authority with country effects

Dependent variable: GPP supplier	Coeff. (St.Err.)	Coeff. (St.Err.)	Coeff. (St.Err.)	Coeff. (St.Err.)
GPP country	0.743* (0.4443)	0.736* (0.4266)	0.736* (0.4424)	0.725* (0.4300)
Inhabitants		$-1.3\cdot10^{-6}$ ** ($4.7\cdot10^{-7}$)		$-1.8\cdot10^{-6}$ *** ($6.3\cdot10^{-7}$)
Number buses			-0.001** (0.0004)	-0.001 (0.0005)
Number tramways			-0.108** (0.0050)	-0.011** (0.0049)
Number metros			0.002 (0.004)	0.007* (0.0038)

Constant	2.278 (2.143)	4.025* (2.315)	4.212 (2.561)	5.350** (2.614)
Observations	67	67	67	67
R^2	0.056	0.084	0.08	0.109
Wald test (p-value)	2.8* (0.099)	3.7** (0.030)	2.08* (0.094)	2.71** (0.028)

*** p<.01, ** p<.05, * p<.1

We replicate the regressions in

Table 4 substituting the GPP country variable with the GPP city variable. We find that the sign and significance for all the common variables are maintained; however, the GPP city variable is not significant in any of the specifications (

Table 5). This indicates that city GPP rates do not impact the GPP adoption of public transport suppliers, and that the latter present a degree of independence in relation to the city's GPP policies. It is also worth stressing here that some of these specifications suggest that the model is not significant and that the explanatory power is weakened when substituting country GPP effects with city GPP effects. All in all, these results confirm that GPP country effects are more important than GPP city effects.

Table 5. Estimation of GPP proportion by authority with city effects

Dependent variable: GPP supplier	Coeff. (St.Err.)	Coeff. (St.Err.)	Coeff. (St.Err.)	Coeff. (St.Err.)
City GPP	-0.081 (0.1109)	-0.057 (0.1119)	-0.088 (0.1141)	-0.066 (0.1146)
Inhabitants		$-1.3\cdot10^{-6}$ ** ($5.2\cdot10^{-7}$)		$-1.9\cdot10^{-6}$ *** ($6.3\cdot10^{-7}$)
Number buses			-0.001*** (0.0003)	-0.001 (0.0007)
Number tramways			-0.011** (0.005)	-0.011** (0.0007)
Number metros			0.003 (0.004)	0.007* (0.0038)
Constant	6.719*** (2.089)	8.293*** (2.607)	8.634*** (2.868)	9.604*** (3.133)
Observations	67	67	67	67
R^2	0.002	0.031	0.028	0.057
Wald test (p-value)	0.53 (0.471)	2.98** (0.058)	2.17* (0.089)	1.47 (0.211)

*** p<.01, ** p<.05, * p<.1

4. Discussion

The public transport sector is one of the leaders in GPP implementation, a situation that can be attributed to two main causes: First, its efforts to address its role as an intensive polluter and, second, the market availability of environmentally friendly products for the public transport sector. The lack of availability of such products deters local governments from engaging in higher levels of GPP (Dimand, 2022). However, in the public transport sector, these products (e.g. bus fleets with renewable fuel) have been available since 2010 (Xylia & Silveira, 2017), the date from which we initiate our analysis. Clearly, a wide product market facilitates GPP implementation.

In larger metropolitan areas, GPP is more common. This result is in line with Aldenius et al. (2022), who find that GPP for the bus sector is more common in the tendering of larger areas and within cities in Sweden than it is in the country's regional bus provisions. European Commission DG-Environment (2011) recommends stricter environmental measures for urban areas and public transport suppliers are, as we report, tending to adhere to these recommendations. Furthermore, we find evidence that the level of GPP implementation is higher in those public transport subsectors whose ecological footprint tends to be larger. A diesel bus fleet, for example, cannot be compared to a hybrid or natural gas fleet, or to an electric fleet. Indeed, on tramway or metro systems, which are essentially electric powered, the lower level of GPP implementation can be explained by the fact that their pollution levels are lower. This explains why GPP managers dedicate more of their efforts to implementing GPP in activities whose impact is greater and where market availability of environmentally friendly products is higher, such as the bus sector. Here, our results that point to higher rates of GPP in relation to bus acquisitions in larger cities might be driven by these same factors.

Yet, this conclusion does not hold for Europe's biggest cities: London, Milan, Paris and Madrid, for example, are not front-runners in terms of GPP implementation. Given that we know that there tends to be a higher rate of GPP with size, it would appear that there is a certain size at which suppliers are likely to adopt GPP but, accordingly, once this critical size is reached, a larger size does not, as we report here, result in a greater probability of GPP. Indeed, public transport suppliers have a considerable degree of independence when it comes to implementing GPP and the city framework does not influence their level of GPP implementation. Here, we need to consider the importance played by the specific characteristics of public transport contracting units, where an organization's technical capacity and strategic leadership have been reported as being the main drivers of GPP adoption in local government (Dimand, 2022). Top management support, green training to increase awareness and corporate social responsibility are three key internal company factors that favor GPP (Liu et al., 2020). Boruchowitch and Fritz (2022), moreover, report that GPP boosts a supplier's reputation and attractiveness. And, thus, the qualities of the contracting unit, are, from our point of view, the main drivers of the GPP implementation of public transport suppliers, which seem to operate with a certain independence from the city level.

It is, however, irrefutable that GPP practices in the public transport sector fell during the pandemic, or more specifically during the course of 2020. This study has not conducted a survey among those responsible for such decisions to determine their exact motives and such an analysis awaits future research. However, were we to speculate on the causes, it would be easy to imagine that the decline was attributable to reasons of urgency in the procurement process. A contracting authority in the health sector is likely to have made environmental concerns a lower priority during the pandemic, in its need to provide medical equipment immediately. However, the same levels of urgency can hardly be said to have applied to the public transport sector. So why were buses purchased or bus concessions tendered with lower rates of GPP in 2020? Do green procurement processes represent more of a challenge for managers and at a time of great uncertainty (as was the case in 2020), did they prefer to include easier criteria? This, however, seems unlikely given that once these criteria have been included, maintaining their implementation does not constitute any greater additional effort on the part of managers.

5. Conclusion

In recent decades, GPP practices have expanded in many countries. Yet, detailed knowledge of the level of GPP implementation remains scarce, because of difficulties in monitoring these procurement activities. One of the sectors in which GPP adoption is most common is that of public transport, which, nevertheless, is one of the main polluters as measured by various environmental indicators, with a particular impact on urban areas. Public transport providers are broadly comparable across cities, given that most share the same mission and engage in the same activity. In this paper, we exploit this characteristic and compare the largest European public transport providers. Drawing on the TED database, we analyze 1,013,282 contract notices in a cross-sector comparison. For the public transport sector, we dispose of a subsample of 5,274 observations covering the largest 67 European public transport suppliers.

The public transport sector, together with that of social protection, is the front-runner in GPP implementation. Within this sector, GPP adoption is higher in relation to bus acquisitions than it is in relation to tramway/metro acquisitions. We detect an increase in GPP adoption in the whole sector over time; however, during the COVID-19 pandemic, there was a marked decline in GPP practices in bus acquisitions and bus service tendering compared to GPP rates in tramway/metro acquisitions.

European, large urban, public transport suppliers are front-runners in GPP adoption, while their medium-sized/small city counterparts lag behind. Yet, in this group of front-runners, larger public transport suppliers implement less GPP. This group of suppliers tends to operate with a degree of independence from the GPP policies of the city they supply; however, country conditions are found to impact on their adoption of GPP.

The outcomes of our study have a number of managerial implications. First, based on our empirical results, our study suggests that the absence of a relationship between GPP adoption at the city level and the local public transport provider offers an opportunity whereby intrinsic motivation and leadership in a contracting unit can boost GPP adoption, despite the fact that the local or regional authorities have no intention of adopting GPP. And, second, the monitoring of procurement units should be seen as a benchmark to encourage these units to include more GPP practices in their activity. This tool could be extended to organizations beyond the public transport sector and need not only be limited to environmental criteria, but could also adopt a more social orientation, that is, targeting sustainable and, even, circular public procurement. So, this study also has implications beyond GPP. As suggested, circular procurement, currently in an emerging phase, can benefit from the results of this study to take the next step toward becoming a reality in the circular economy (Sönnichsen and Clement, 2020; Ali and Appolloni, 2022) and, moreover, the scale of GPP implementation in the public transport sector should facilitate the adoption of life cycle costing (De Giacomo et al., 2018).

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