Influence of Green Public Procurement

on Bids and Prices*

Work in progress

Sofia Lundberg♥

Per-Olov Marklund♦

March 29, 2016

Abstract

This paper assesses Green Public Procurement (GPP) as an environmental policy instrument, i.e. when authorities consider environmental requirements in the allocation of public contracts. Using a hedonic pricing approach and field data from Swedish cleaning service procurement auctions the potential impact of environmental requirements on bids and winning bids is analyzed. In brief, the results illustrate the importance of requirements that go beyond the existing standard in the market for control power. Six categories of environmental characteristics are identified and four of these are never significant. Requirements related to usage of chemical are associated with a price premium.

JEL: D44, H57, Q58

Key words: Auction, Bidding, Circular economy, Environmental policy, Hedonic pricing, Outsourcing, Public contracts, Public procurement, Purchasing, 2SLS

---

* Financial support from the Swedish Research Council is gratefully acknowledged. We would also like to thank seminar participants at the National Institute of Economic Research (NIER) and the Business School at Örebro University whose comments greatly helped to improve an earlier version of this paper.

♥ The Department of Economics at Umeå University, 901 87 Umeå, Sweden. E-mail: sofia.lundberg@umu.se. Phone: +46907865206.

♦ The National Institute of Economic Research (NIER), 103 62 Stockholm, Sweden. E-mail: pelle.marklund@konj.se. Phone: +4684535946.

1. **Introduction**

In this paper we empirically address Green Public Procurement (GPP) as an environmental policy instrument. GPP means that public authorities take environmental concern when using auctions to allocate contracts for goods, services, and works to private suppliers. The auction rule is multidimensional bidding with a price bid and quality offer.[1] The environmental performance of the potential supplier (or the product) is a part of the quality offer. The usage of GPP is a worldwide trend (Testa, et al. 2012), which continues to grow. The European Union and its Member States are very clear in their ambitions to implement GPP (Tukker, et al. 2008), and similar ambitions prevail in, e.g., the United States (Fischer 2010) and China (Qiao and Wang 2011).

The main argument to implement GPP is that the public sector is a significant buyer with market power,[2] which can be used to influence private producers and consumers to reduce their environmental impact. Besides claiming that GPP directly contributes to lower emission levels, it is argued that it triggers innovation and development of environmentally friendlier techniques and products (EC, European Commission 2008, 2011). The European Commission (2015) also highlights GPP as it can play a key role in the circular economy.

However, the implementation of GPP as an environmental policy instrument has weak scientific basis. It must be analyzed from the perspective of resources being scarce, and put into a larger context that also takes into account that the society has other options than GPP to reduce anthropogenic environmental impact. GPP represents a relatively new area of research (Testa, et al. 2012), but there are now a few theoretical studies in this field (Marron 1997, 2003, Lundberg, Marklund and Strömbäck 2015, Lundberg and Marklund 2011, Lundberg and Marklund 2013).[3] The results show that GPP works imperfectly as a policy instrument, not being cost-effective and objective effective. However, these studies need to be complemented by empirical studies, of which this paper is one of the very first.

---

[1] See e.g. (Che 1993) or (Nishimura 2015) for more on multidimensional auctions.

[2] There is no clear indication of the market share of the public sector. For example, according to European Commission (2008) the public sector in EU annually spends on average 16 percent of the GDP on procurement of goods, services, and works (EC, European Commission 2008). However, according to the European Commission (2015) the market share is nearly 20 percent.

[3] These papers are some of the very few that can be found within the field of environmental and natural resource economics. Other types of studies do not account for resources being scarce and typically reward the amount of GPP, i.e., the more the better. Such studies focus, e.g., on describing national GPP initiatives, providing guidelines, or GPP uptake (Lundberg, Marklund and Strömbäck, et al. 2015).

Our purpose is to empirically analyze whether GPP leads to an increase in bids. Higher bids indicate that it creates incentives for potential suppliers to undertake costly adjustments. The bid increase can then be interpreted as the price premium the procuring authorities are willing to pay in order to implement GPP.[4] Considering the environmental impact, if an adjustment cost can be identified it cannot be ruled out that GPP controls.

The fact that effective GPP may be associated with a cost to be borne by the public sector is often ignored when proponents argue in favor of GPP. In this paper we suggest a methodology to test whether it induce a cost, or a price premium. The methodology is general in structure and can in practice be based on data from any sector in any country.

There is quite an extensive literature on GPP that does not consider the economic perspective. For instance, studies are illustrating GPP initiatives e.g. (Swanson, et al. 2005, Geng and Doberstein 2008, Stage and Arvidsson 2012), providing guidelines e.g (Parikka-Alhola 2008, Tarantini, Dominici Loprieno and Porta 2011), reporting GPP uptake e.g. (Palmujoki, Parikka-Alhola and Ekroos 2010, Testa, et al. 2012), and deriving and analyzing design issues related to combinatorial auctions for sustainability in transportation e.g. (Basu, Bai and Palaniappan 2015) and scoring rules (Lundberg and Marklund 2011).

Empirical studies from an economics perspective are few. Simcoe and Toffel (2015) contribute to the field by an empirical analysis of green procurement spillovers in California cities. The authors investigate the influence of municipal procurement of the US Green Building Council's Leadership in Energy and Environmental Design (LEED) on the private sector. Based on their empirical analysis they find little, if any, evidence of the three mechanisms by which GPP is assumed to influence the private sector. They do find entry from new suppliers on markets where there is public LEED procurement policy. But, they find no evidence of increased local demand for LEED, decreased prices, or solving the coordination problem (i.e. demand increases due to increased supply or supply driven increased demand).

Another empirical study is Lundberg, Marklund, Strömbäck et al. (2015). Using field data from Swedish cleaning services (the same data as used in the current paper) they analyze the impact on potential suppliers' behavior. The result indicates at best only a weak impact. Their conclusion is that the use of GPP does not live up to its political expectations. One explanation

[4] It would be wrong to interpret the price premium as the price that the procuring authorities are willing to pay for reduced environmental impact. The reason for this is that the actual impacts of any GPP are unknown, both before and after the supplier has complied with the contract. At best the interpretation would be that the higher the price the greater the probability that GPP has contributed to reduced environmental impact.

for the weak impact would be that it does not control since suppliers already meet the requirements. A hypothesis is then that the price premium the public authorities pay for implementing GPP is low, or even zero. In this paper we test this hypothesis.

In order to test whether GPP gave rise to a price premium in the Swedish sector for internal regular cleaning services during 2008 to 2010, we adopt a hedonic price setting approach. The premise is that authorities conduct operations given a fixed budget. The reason for the price premium to be low or zero may then be that the public authorities lack willingness to pay for effective GPP due to scarce resources. If the ambition is to increase the consumption of environmental quality then consumption of any other quality, e.g., related to their operations, may have to be lowered.

We explicitly estimate two separate hedonic price functions (Taylor 2003), one that explains variation in all submitted bids and one that explains variation in only winning bids. The explanatory variables reflect environmental criteria stipulated by the contracting authorities in the call-for-tender. These criteria can be associated with the intrinsic environmental quality of the contract (the subject matter), as well of the potential suppliers' production processes. To isolate the impact from these variables a wide range of control variables are also included.

The choice to analyze the sector for internal regular cleaning service is based on it providing a good testing ground for GPP. It is a relatively easy service to contract for, it is not associated with severe capacity constraints, and it does not differ much in quality prior to the procurement process (Hyytinen, Lundberg and Toivanen 2015). This facilitates identification of the effects of different environmental criteria on the potential suppliers' bids. Another reason for using data from this sector is that the EU has identified cleaning products and services as one of about 20 prioritized sectors,[5] selected based on their scope for environmental improvement and impact on suppliers.

Generally, the result indicates that the environmental characteristics asked for in the call for tenders are not associated with a price premium. Environmental characteristics do not affect the winning bids, with the exception of requirements related to the usage of chemicals. These are requirements that, together with requirements related to vehicles, also affect all bids (the asking price).

[5] http://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm (2016-02-18).

The rest of the paper is organized as follows. The general principles of public procurement auctions and GPP, as a means to pursue environmental policy, are presented is Section 2. A hedonic price setting approach follows in Section 3. The empirical approach, the field data used in the regressions and descriptive statistics are found in Section 4, followed by a presentation of the results in Section 5. Finally, Section 6 summarizes and concludes the paper.

2. Green public procurement

Following the World Trade Organization's Government Procurement Agreement and EU procurement directives; in Sweden competitive sealed bidding is generally used when allocating public contracts. A call for tender is used to announce the auction and amongst other things it specifies the auction rules, supplier selection method (Dini, Pacini and Valletti 2006, Asker and Cantillon 2008, 2010, Bergman and Lundberg 2013), the technical characteristics of the product to be procured (the so-called subject matter), and any environmental requirements on the supplier or the product itself.[6] Several contracts (or lots) can be auctioned in one and the same procurement. Bidding is simultaneous but independent over contracts, meaning that separate bids are submitted on all or a subset of the contracts included in the same procurement. Each potential supplier is allowed to submit only one bid per contract. The winning bidder is paid in accordance with price offered in the tender.

Environmental policy by public procurement, i.e., GPP, is implemented when green criteria is part of the basis for the selection of supplier. Following Lundberg, Marklund, Strömbäck et al. (2015) we assess public procurement as defined by the EU procurement directives[7]: "…the measures implemented by a contracting authority with the aim of awarding a contract or concluding a framework agreement regarding products, services, or works" (Article 1),[8] and GPP as a situation in which contracting authorities take environmental considerations into account when buying products, services, or works (European Commission, 2008).[9] The procurement legislation within the EU and Sweden leaves the contracting authority a great deal of freedom in exactly how to design the auction and what environmental criteria to consider.

[6] This gives the procurement the character of a multidimensional first-price sealed bid auction (Che 1993).
[7] Directive 2004/17/EC of the European Parliament and of the Council of 31 March 2004 coordinating the procurement procedures of entities operating in the water, energy, transport and postal services sectors (30.04.2004)
Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts (30.04.2004)
[8] A contracting authority is a public body that is subjected to the European public procurement legislation.
[9] Note that this definition does not include auctions of nature conservation contracts, e.g., Latacz-Lohmann and Van der Hamsvoort (1997), Stoneham et al. (2003).

The criteria must, however, be linked to the subject matter of the contract and must comply with the general principles stipulated in the EU Directives (2004/17/EC and 2004/18/EC). The principles, which aim to promote an effective EU-wide and cross-border competition for public contracts and to prevent corruption, include equal treatment, transparency, non-discrimination, proportionality, and mutual recognition.

The environmental criteria can define what a product should be made of as well as targeting the production process itself. Potential suppliers may, therefore, have to change their production technology or the product itself to comply with the required environmental standard reflected in the criteria. Irrespective of the criteria addressing the production process or the product, they may target the use of resources or the negative effects of emissions (Lundberg and Marklund 2013).

Environmental criteria in GPP should be selected with reference to defined environmental quality objectives (Lundberg, Marklund and Strömbäck 2015). Furthermore, to have positive environmental impact: (*i*) Criteria must go beyond the current environmental standard of the products and/or technologies of the polluting firms; (*ii*) since there is an element of discretion associated with GPP,[10] at least one brown supplier must find it beneficial to undertake costly investments in order to adjust to the required environmental standard, and; (*iii*) the public sector must be willing to pay a price premium for the less polluting variant of the product.[11] This is illustrated in Figure 1.

[10] Potential suppliers who do not meet the required environmental or quality standards can avoid the cost of adjusting to the criteria by not participating in the procurement process.
[11] It is implicitly assumed that the subject matter of the procurement, i.e. cleaning services, can be produced in such a way that different suppliers offer services that are interchangeable in all dimensions except the environmental dimension.

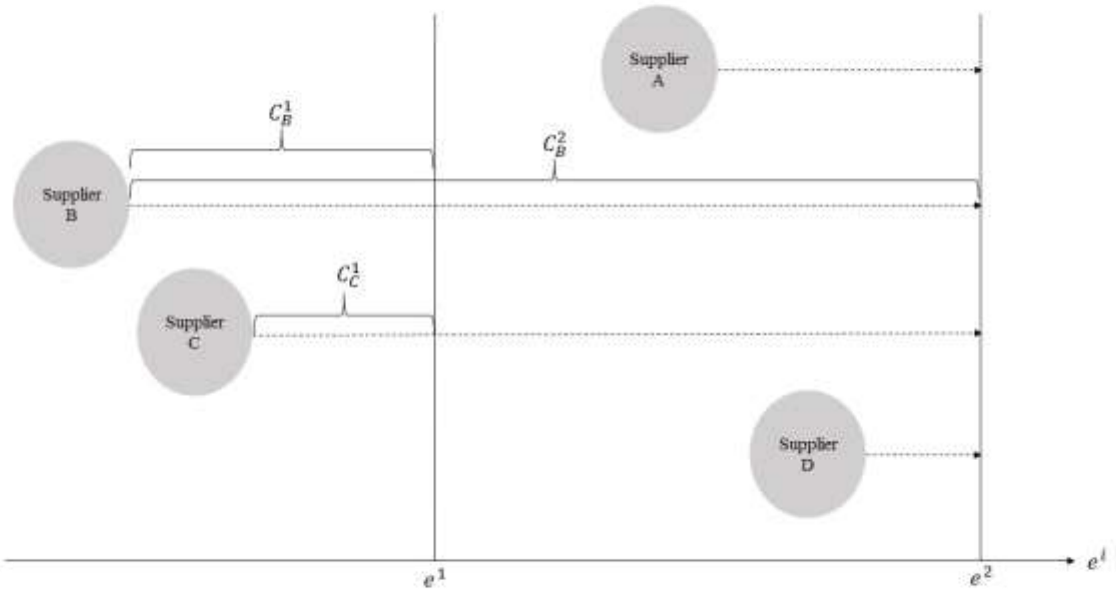


Figure 1. GPP in practice.

If the environmental standard required by the contracting authority corresponds to a vector of environmental characteristics, e^1,[12] potential suppliers A and D are defined as green. They already meet the standard and do not need to undertake any costly investments. However, if the authority raises the standard as to be reflected by the vector e^2 then all four suppliers A to D are considered to be brown. In this case the environmental criteria reflect a standard that goes beyond the products and/or technologies of all the potential suppliers. Then, if at least one of the suppliers decides to undertake costly investments in order to comply with the required standard, and to become an eligible bidder, GPP actually controls. The further a supplier j is from meeting the environmental standard the higher the cost, C_j, to adjust to the standard. For example, supplier B is considered as brown in relation to both levels of standards and, accordingly, has adjustments costs $C_B^1(e^1;T_B) < C_B^2(e^2;T_B)$, where T_B is the supplier B's production technology prior to any environmental adjustments. This means that the more stringent the required environmental standard is the larger adjustment cost will be passed on to the authority to pay as an environmental price premium.

Further, all things equal, the bids are assumed to be increasing in the adjustment cost and potential suppliers will enter the procurement auction if the expected pay-off from submitting

[12] Each characteristic could represent one of the sixteen environmental quality objectives established by the Swedish government, and that environmental measures should address. Each characteristic could also be seen as a specific environmental criterion, reflecting environmental quality of the subject matter.

a bid is non-negative when the cost of necessary adjustments is accounted for (Lundberg, Marklund and Strömbäck 2015).

In order to test the null-hypothesis, i.e., potential suppliers being defined as green when the authorities procuring internal regular cleaning services, we apply a hedonic price setting approach.

3. A hedonic price setting approach

Hedonic price setting relies on observing actual market behavior. As such, it is a revealed preference method. Prices of commodity characteristics are derived indirectly from price variation in commodity markets. Addressing environmental characteristics the hedonic method is commonly applied to the housing market e.g. (Malpezzi 2002, Kwong 2003). However, the method has been applied to a variety of characteristics on different markets (Taylor 2003).

In this paper it is suggested a reversed hedonic approach to test whether contracting authorities actually pay a price premium for implementing GPP. By reversed it is meant that the supplier is the bidder, not the consumer. The premium the authority pays for implementing GPP is determined by the winning supplier's cost to adjust to environmental criteria, which is added to the supplier's bid. By assumption, we treat this price premium as the contracting authorities' willingness to pay for implementing GPP. Our focus is to empirically determine if there is significant price premium paid for a number of different environmental characteristics.

Assume that the authority i is about to procure one unit of a commodity, Q, e.g., the subject matter, which in this case is internal regular cleaning services. By stipulating environmental criteria in the call for tender, the authority expresses ambitions for the subject matter to be encumbered with environmental characteristics, $e = e_{m=1},...,e_M$. Assuming perfect competition, the procurement auction will establish the price premium, $P(e)$. Assume also a composite factor, z, that represents all other goods, services, works, and characteristics relevant to the contracting authority. The factor z can be seen as the budget left over after having paid the environmental price premium.

Given the authority specific characteristics, α^i, the utility of consuming one unit of the subject matter Q is defined as:

$$U^i = \left(e, z; \alpha^i\right). \tag{1}$$

The authority maximizes utility in Equation (1) subject to the budget constraint:

$$B^i = z + P\left(e\right), \tag{2}$$

which clearly shows the trade-off between environmental characteristics and other types of characteristics and products the contracting authority needs in order to maintain the quality of its operation.

The price the contracting authority is willing to pay for any specific variety of environmental characteristics, while holding utility and the budget constant, is given by the payment function, θ^i. Rearranging Equation (2), assuming that $\theta^i \equiv P(e)$, and substituting into the utility function in Equation (1), then gives $U^i(\mathrm{e}, \bar{B}^i - \theta^i; \alpha^i) \equiv \bar{U}^i$. Then, by solving for θ, the authority's payment function is explicitly expressed as:

$$\theta^i = \theta\left(e, \bar{B}^i, \bar{U}^i; \alpha^i\right), \tag{3}$$

which is concave in environmental characteristics, e. i.e., the payment increases with these characteristics at a decreasing rate.

The hedonic price function reflects the equilibrium interactions between the contracting authority's payment function and the winning supplier's bid function. That is, when the price the authority is willing to pay for e_m at the margin, i.e., $\partial\theta^i / \partial e_m$, coincides with the winning supplier's marginal cost of delivering e_m, it defines the equilibrium price premium the authority is willing to pay for e_m, i.e., $P(e_m)$. This is illustrated in Figure 2, where the coordinate (P, e) is a point on the hedonic price function.

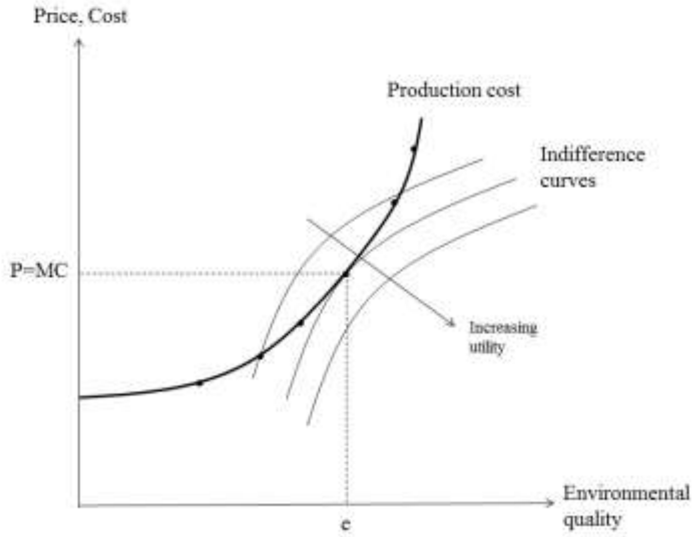


Figure 2. The auction outcome with perfect competition (Bergman and Lundberg 2013).

Theoretical research has previously pointed out that there may be a conflict between procurement legislation and the ambitions with GPP e.g. (Lundberg, Marklund and Strömbäck 2015). A major reason is that there is an element of discretion associated with GPP. If authorities specify environmental criteria that require potential bidders to major adaptions, with significant investment costs as a result, they have the option to refrain from entering the procurement auction. This means that the degree of competition between the potential bidders deteriorates and imperfect competition occurs. Consequently, the price premium related to the environmental criteria will be higher than illustrated in Figure 2, which reflected the authorities' original willingness to pay for implementing GPP.

The case with imperfect competition is illustrated in Figure 3 assuming only three potential suppliers. In the equilibrium the contracting authority's preferences match the production cost of the lowest bidder (supplier 3) who now makes a profit. Supplier 3 only has to bid slightly under the bid of supplier 2.

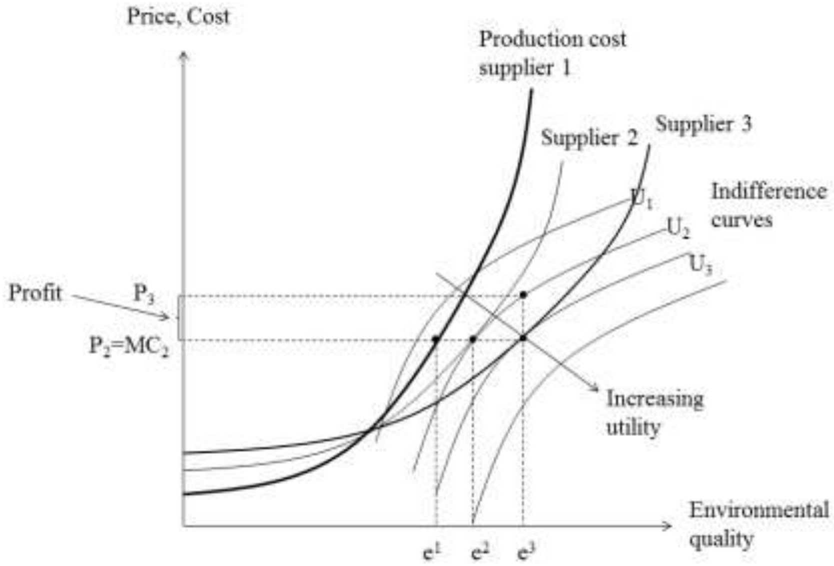


Figure 3. The auction outcome with imperfect competition (Bergman and Lundberg 2013).

The hedonic price function defines a set of price premiums the contracting authority pays for a varying bundle of environmental characteristics. Formally, it may be expressed as:

$$P^i = P\left(e_1, \ldots, e_m; \alpha^i, \beta^k\right) \tag{4}$$

To empirically estimate the hedonic price function requires information on the actual price the authorities pay for the subject matter of the procurements, environmental criteria stipulated by the contracting authorities, e, and relevant authority and supplier characteristics α^i and β^k, respectively. Using this information allows us to implicitly recover the price the procuring authority pays for stipulating any environmental criterion (Taylor 2003), as described in Figure 2.

4. **Data and empirical specification**

The empirical analysis is based on data consisting of internal regular cleaning service procurements from the years 2008 to 2010. The data was obtained from a national database in which call-for-tender notices are advertised in Sweden.[13] From procurement documents were extracted such as the call for tender, technical specifications, bid protocols including all submitted bids, records revealing the winning bidder, and variables on the procurement-,

[13] Visma Commerce AB.

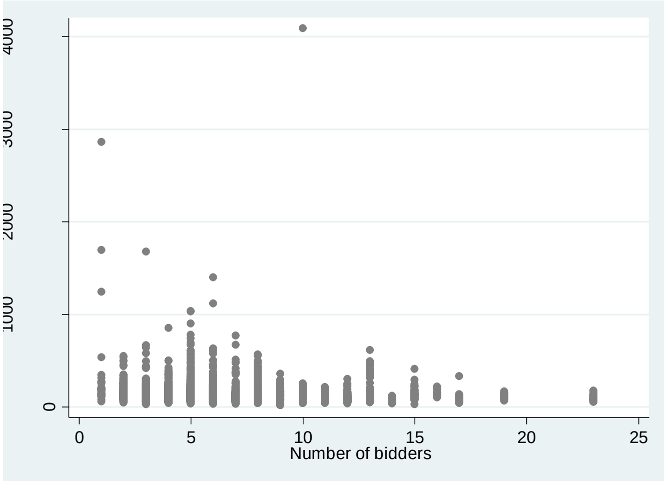
contract- and bid level. Complementary information about local market characteristics were collected from Statistics Sweden (SCB). In total the collected dataset consists of 340 procurement auctions comprising 709 contracts, on which a total of 4,143 bids were placed. Descriptive statistics are presented in Table 1, which includes the main variables that will be used in our empirical analysis.

Table 1. Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Bid price per square meter and year (SEK)	4,143	141.59	121.97	16.09	4,086.46
Winning bid, price (SEK)	709	119.46	79.64	16.09	1,239.68
Number of square meters	709	8,378.40	22,638.51	26.90	403,658.00
Number of contracts	340	2.26	4.38	1	51
Number of bidders (observed)	709	5.63	3.15	1	23
Firm size	4,064	8.78	4.09	0	16
Environmental Management System (EMS)	4,143	0.67	0.47	0	1
Eco labelling (ECO)	4,143	0.72	0.45	0	1
Vehicles (VEH)	4,143	0.12	0.32	0	1
Chemicals (CHEM)	4,143	0.70	0.46	0	1
Monitoring (MON)	4,143	0.09	0.29	0	1
Other environmental requirements (OTHER)	4,143	0.47	0.50	0	1
Financial status (FIN)	4,143	0.98	0.13	0	1
Limited liability insurance (INS)	4,143	0.92	0.26	0	1
Experience (EXP)	4,143	0.94	0.23	0	1
Performance (PER)	4,143	0.98	0.12	0	1
Social criteria (SOC)	4,143	0.44	0.50	0	1
Staffing (STAF)	4,143	0.93	0.25	0	1
School	4,143	0.31	0.46	0	1
Additional services (service)	4,143	2.24	1.21	0	4

The price bid and winning bid is measured as the annual price per square meter in Swedish krona (SEK),[14] and year standardized to a cleaning frequency of 260 days per year. The wide distribution in price is mainly explained by the type of facility to be cleaned. The number of contracts is the number of subcontract auctioned in one and the same procurement and it varies between 1 and 51. About 77 percent of the procurements are single contract auctions. On average almost six bids are received on each contract. We can observe a competitive effect on the bid, as illustrated in Graph 1.

[14] €1 = SEK 9.36, based on the exchange rate February 23, 2016.



Graph 1: Scatter plot of the number of bidders and bid per square meter to be cleaned.

In total 28 different environmental criteria were identified in the data. Following Lundberg, Marklund et al. (2015), to reduce dimensionality, these were, based on their description, aggregated into six category variables taking the value one if the requirement is stated in the call for tender: (*i*) The variable *Environmental management system* (*EMS*) condenses information on criteria that are related to environmental management systems, environmental certificates, and different ISO 14000 standards;[15] (*ii*) *Eco labeling* (*ECO*) concerns ecological labeling of cleaning products (e.g. the EU Ecolabel or equivalent); (*iii*) *Vehicle* (*VEH*) includes criteria stipulating emission standards for cars (e.g., Euroclass[16], fuel specifics, eco-driving, etc.); (*iv*) criteria that require the supplier to follow the Swedish Chemicals Agency B-list[17], the Swedish Environmental Code, the decree on Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH),[18] the Swedish Chemicals Agency Code of Statutes 2008, and similar regulations are classified as being *Chemical criteria* (*CHEM*); (*v*) *Eco monitoring*

[15] According to the web page for ISO, ISO 14001:2004 sets out the criteria for an environmental management system which also can be certified. It does not state requirements for environmental performance, but maps out a framework that a company or organization can follow to set up an effective environmental management system. It can be used by any organization regardless of its activity or sector. Using ISO 14001:2004 can provide assurance to company management and employees as well as external stakeholders that environmental impact is being measured and improved." http://www.iso.org/iso/iso14000.

[16] Within the EU, there are emission standards defining acceptable limits for exhaust emissions of different types of new vehicles (cars included) sold in the member states. These standards include emissions of nitrogen oxides (NOx), total hydrocarbon (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO), and particulate matter (PM). See the European Commission website: http://ec.europa.eu/environment/air/transport/road.htm.

[17] See the Swedish Chemical Agency website: http://www.kemi.se/.

[18] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC, and 2000/21/EC. http://ec.europa.eu/enterprise/sectors/chemicals/reach/index_en.htm.

(*MON*) covers requirements that signal that the authority intends to monitor or follow up that the required environmental standard is delivered; and finally (*vi*) other types of criteria, e.g., recommendations by the Swedish Environmental Management Council and allergy considerations, are included in the *Other eco demands* (*OTHER*) category.

Note that the *ECO* dummy variable is related to the usage of chemicals in the products used and although *CHEM* also relates to the usage of chemicals it is more process oriented and may require additional or changes in the competence and performance routine.

We can also identify 26 unique quality criteria that do not relate to environmental quality, e.g., those that relate to the performance of the cleaning service itself. The number of different quality criteria varies across procurements and range from 3 to 17 criteria. The 26 observed quality criteria were categorized into six quality variables: (*i*) *Financial status (FIN)* that relates to criteria with the goal of ensuring that the supplier's financial condition is solid (e.g., annual reports or information on turnover); (*ii*) *INS* that relates to the authority asking for relevant *insurance*; (*iii*) *EXP* that includes criteria demanding potential suppliers to prove them having relevant *experience* with similar assignments; (*iv*) *Performance plan (PER)* that refers to criteria that demand the potential supplier to provide an implementation plan, i.e., a description of how the cleaning service contract will be carried out; (*v*) *Social criteria (SOC)* that include criteria stipulating that the potential supplier needs to have collective labor agreements with the union, etc.; and finally (*vi*) *Staffing (STAF)* that includes criteria describing the qualifications of the employees.

In addition to the regular cleaning service, the contracting authority sometimes demands optional services (window cleaning, floor cleaning, periodical cleaning and provision of consumables) that require more resources and, therefore, might have an impact on the potential suppliers' bids. In the empirical model, optional services are measured as an index (*SERVICE*) by counting the number of these services included in each contract distributed between zero and 4. Furthermore, criteria regarding cleaning quality are to some extent facility type specific. To control for this in the empirical analysis we will include facility type fixed effects, with reference to schools in contrast to other type of facilities. About 31 percent of the bids are submitted on school contracts.

The firms, i.e., the bidders in our data are heterogeneous in size. Firm sixe (*SIZE*) is therefore controlled for, even though it is reasonable to presume that budget restrictions are soft and that all firms are equally likely to produce the requested quality (Hyytinen, Lundberg and Toivanen

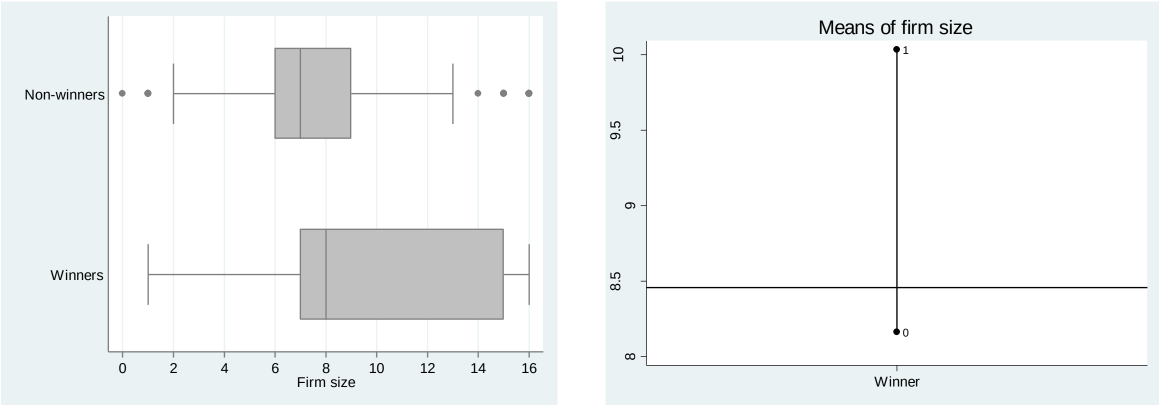
2015). It is measured by dividing the potential suppliers into 16 size classes with respect to the number of employees according to the official classification provided by Statistics Sweden (SCB).[19] This information has been transformed into a continuous variable. The continuous firm size variable is defined as the average value of the lower and upper bound of each size interval. The last size category is open ended. In the transformation this group was set as close as possible to the actually value based on public information. The average potential supplier is a firm with 20 to 49 employees.

Table 2. Submitted and successful bids by firm size (classification according to SCB)

Size class	No. of employees	No. of firms	No. of bids	No. of winning bids	Share of bids	Share of winning bids	Success ratio
1	0	31	76	4	0.02	0.01	0.05
2	1-4	54	145	2	0.03	0.00	0.01
3	5-9	30	141	26	0.03	0.04	0.18
4	10-19	34	195	9	0.04	0.01	0.05
5	20-49	52	432	27	0.09	0.04	0.06
6	50-99	35	535	110	0.12	0.15	0.21
7	100-199	24	787	119	0.17	0.16	0.15
8	200-499	18	799	102	0.17	0.14	0.13
9	500-999	4	411	39	0.09	0.05	0.09
10	1,000-1,499	3	3	2	0.00	0.00	0.67
11	1,500-1,999	1	6	0	0.00	0.00	0.00
12	2,000-2,999	2	15	0	0.00	0.00	0.00
13	3,000-3,999	3	3	0	0.00	0.00	0.00
14	4,000-4,999	1	2	1	0.00	0.00	0.50
15	5,000-9,999	7	718	220	0.16	0.30	0.31
16	10,000-	2	324	64	0.07	0.09	0.20
Total		301	4,592	725			

In total 301 unique bidders are identified in the data. The number of limited liability firms in class 10 and above is seven. The remaining twelve bidders are in-house production units that can participate in the auction as any other bidder. These units are not successful in their bidding, since the winners in classes 10 to 16 are found among the private firms. Based on Table 2 it is notable that 30 percent of all winning bids are place by some of the eight bidders with 5,000 to 9,999 employees. They submit only 16 percent of all bids. The average non-winning firm has between 200 and 499 employees, while a winning firm has based on the lower bound five times more employees. The difference is significant (t-value 11.37). This is illustrated in Graph 2.

[19] See Lundberg, Marklund, Strömbäck et al. (2015) for more details.



Graph 2: Box plot of firm size, Non-winning bids versus winning bids.

The empirical analysis aim at operationalize the e, α, and β parameters in Equation (4) and the functional form chosen is the semi-log (Taylor 2003) i.e., all continuous variables are in logs. Since there is reason to suspect the number of bidders to be endogenous, e.g., (Li and Zheng 2009, 2012) 2SLS regression is applied. The instrument variables are selected on the standard basis that these should be correlated with the endogenous regressor, at the same time being orthogonal to the errors. As instruments are used the unemployment rate and population density in the municipality where the contracting authority is located.

The effect of different environmental criteria on submitted bid prices and winning bids is tested, respectively. Three specifications are tested. Besides including the vector e in Equation (4), with the six environmental characteristics *EMS*, *ECO*, *VEH*, *CHEM*, *MON*, and *OTHER*, the base model includes control variables expected to influence the price, i.e., the number of bidders, the number of square meters to be cleaned, the number of contracts auctioned in one and the same procurement, a dummy accounting for the extra services and, finally, a dummy variable for the type of facility. In the second specification firm size is added to the control variables. The third specification additionally adds controls in terms of non-policy quality criteria related to the cleaning service (included in the *z*-vector in the contracting authority's budget restriction, Equation 2).

5. **Results**

The results from the regression based on all bids and winning bids are presented in Table 3 and 4, respectively. First stage regressions are found in Tables A1 and A3 in the Appendix. For comparison ordinary least square regressions are presented and found in Tables A2 (all bids) and A4 (winning bids).

Starting with the regressions results from the sample using all the bids (bid price or offered price) in Table 3, they show as expected, a clear competitive effect. For instance, Model 1 indicates that a one percent increase in the number of bidders leads to a 0.10 percent decrease in the bid price per square meter and year.

It is also evident that cleaning services are associated with economics of scale, a one percent increase in the square meters to be cleaned leads to a 0.15 percent decrease in the bid price. Scale opportunities seem also to be present over the number of contracts included in one and the same procurement. The bidders signal that a one percent increase in the number of contracts is associated with a 0.02 percent decrease in the bid price. Further, the bid prices signal that schools are more expensive to clean compared to other type of facilities and, asking for additional services will, as one would expect, result in a higher price offer.

Turning to the environmental characteristics a first conclusion is that requirements on well-established standards as environmental management system (*EMS*) and eco labelling (*ECO*) add nothing to the bid prices. Since we only observe bids placed by suppliers that comply with the environmental requirements we know that they at some point prior to the procurement auctions covered by our data have invested in environmental management systems and eco labelled products. Therefore, the non-significant coefficients indicate that the procurements in our data did not function as an instrument of environmental policy with respect to environmental management systems, eco labelling, monitoring (*MON*) and other environmental characteristics (*OTHER*).

Considering the worldwide recognition of environmental management systems based on ISO the non-significant impact from EMS might seem disappointing but, having in mind the literature review and empirical findings in Zobel (2016), not surprising. The same author mentions the new version of ISO 14001 introduced in 2015 to rely more on management by environmental objectives and assessment of performance and less on procedures, and therefore the potential to actually have environmental impact might increase (Heras-Saizarbitoriaa, Doguib and Boiral 2013). If so, based on newer data, in extension brown suppliers would have an adjustment cost with an upward effect on the bids, all things equal.

However, the results of Model 1 indicate that bidders do respond to the inclusion of requirements related to vehicles (*VEH*) or the routines related to the usage of chemicals (*CHEM*) by asking for a bid price premium significant at the 10 and 5 percent level, respectively. By adding requirements related to the vehicles the bid price increases with 4.5

percent. Requirements related to the usage of chemicals are associated with bidders asking, on average, for 3.6 percent more in payment. With reference to defined environmental objectives, these requirements may have gone beyond the environmental standard of the potential suppliers prior to the procurements. Hence, they were forced to costly adjustments in order to become eligible bidders, and which prompted them to ask for a price premium. These findings are stable for the inclusion of firm size. The coefficient for firm size indicates that bigger firms are able to bid lower. The latter finding is like most of the coefficients stable for inclusion of non-policy quality requirements with one exception; the coefficient for *VEH* is no longer significant.

In the first stage regressions, which are not reported, the coefficients for the instruments, population density and unemployment rate, are clearly significant. As expected the population density coefficient is positive and the coefficient for unemployment rate has the opposite sign.

Turning to the regressions based on the winning bids only and Model 1, the coefficient for competition and the number of square meters to be cleaned are still significant. Translated to a loss of one bidder the competitive effect corresponds to a price sensitivity of 17.8 percent and SEK 54,000 (≈ €5,770). Translated to a scale opportunities effect the price paid per square meter decreases with the number of square meters to be cleaned. The one percent increase in square meters corresponds to 84 square meters and a price premium of SEK 1,281 (≈ €137). Recall that the number of square meters per contract is 8,378.40 on average, with a total annual price of SEK 1,186 000 (≈ €127,000). Further, asking for additional services clearly comes with a price tag, as one would expect. Also, compared to other facilities it is more expensive to clean schools.

It seems as if the environmental characteristics asked for in the call for tenders in general are not associated with a price premium. Four out of six environmental characteristics do not affect the winning bids. There is one clear and one weaker exception, respectively. The clear exception is requirements related to the usage of chemicals, and the weaker one is environmental management system (only significant in model 3 and on the 10 percent level). Inclusion of chemical usage related requirements imposes on average a price premium of SEK 128,000 (≈ €13,675). The extra cost of doing so can for example be neutralized by attracting 2.3 additional bidders.

A potential explanation to the differences found between the effects on all bids versus on only the winning bids is found by looking at the second and third model specification, and specifically the firm size coefficient. As shown in Table 3, based on all bids this coefficient was clearly significant and negative. But, when it comes to winning bids only firm size seems to not matter. Winning bids is mainly placed by larger firms that constitute a relatively more homogeneous subsample compared to the group of small and medium sized firms that to a greater extent account for the non-winning bids. Larger firms constitute a group of firms that have stronger financial power and can be expected to be more likely to meet the environmental requirements prior to the procurements.

The findings from Tables 3 and 4 can be related to the illustration in Figure 1, and requirements that correspond to the environmental standard e^1. The outcome from the regression based on all bids can then be seen as binding vehicle and chemical requirements for supplier B and C (non-winning suppliers that most likely are small or medium sized firms) and non-binding vehicle requirements for the winner, supplier A or D (suppliers that most likely are large firms).

Based on the test statistics presented in Table 3 and 4, the instruments are concluded to be valid and strong. The Anderson canonical correlation statistic and the Sargan statistic indicate for all three model specifications that the null hypothesis cannot be rejected. This means that the instruments are independent from the unobserved error process and over-identification is not a problem. Furthermore, the instruments are, based on the first-stage regression outcomes presented in Table A1 and A3, valid and strong. The coefficients for population density and unemployment rate are clearly significant with expected signs.

Based on a Durbin-Wu-Hausman test (Davidson and MacKinnon 1993) it is not obvious that ordinary least regression estimates (Table A2 and A4) are consistent but for some models close to. The test has been performed based on the regressions using all and only the winning bids and for all three specifications, respectively. The findings presented in the Appendix supports the conclusions made based on 2SLS.

Table 5. Outcomes from the Durbin-Wu-Hausman test, *F* - values (*1*, *n-K-1*) and probability values for the regression results presented in Table 3 and 4.

	All bids			Winning bids		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
(*1*, *n-K-1*)	(1, 4130)	(1, 4022)	(1, 4016)	(1, 696)	(1, 689)	(1, 683)
F-value	0.29	0.74	2.45	0.15	0.44	0.45
Prob > *F*	0.590	0.388	0.117	0.703	0.507	0.504

Table 3. Results. 2SLS IV-estimation. All bids. Instruments: Population density & Unemployment rate.

	Model 1		Model 2 (Size)		Model 3 (Size & Quality)	
Log(Bid/sqm)	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std.err.
Log(Number of bidders)	-0.103***	0.029	-0.120***	0.034	-0.168***	0.036
Log(Number of square meters)	-0.155***	0.006	-0.146***	0.006	-0.150***	0.006
Log(Number of contracts)	-0.021***	0.006	-0.014**	0.006	-0.011*	0.006
EMS	-0.005	0.016	-0.017	0.016	0.008	0.017
ECO	0.016	0.018	0.012	0.018	0.005	0.018
VEH	0.045*	0.027	0.052*	0.027	-0.016	0.027
CHEM	0.036**	0.016	0.038**	0.016	0.054**	0.018
MON	0.010	0.025	0.007	0.025	0.038	0.026
OTHER	-0.018	0.016	-0.018	0.016	-0.012	0.015
SERVICE	0.083***	0.007	0.084***	0.007	0.107***	0.007
School	0.274***	0.016	0.272***	0.016	0.258***	0.016
Log(Firm Size)			-0.014***	0.004	-0.015***	0.004
FIN					-0.095*	0.056
INS					-0.381***	0.029
EXP					-0.034	0.032
PER					0.047	0.060
SOC					0.082***	0.016
STAF					0.128***	0.031
Constant	5.970***	0.070	6.001***	0.083	6.331***	0.121
Number of obs		4143		4036		4036
F-statistic		156.59		142.36		109.81
Prob > F		0.0000		0.0000		0.0000
Centred R2		0.30		0.30		0.33
Sargan		0.46		0.84		2.87
Chi2(1) P-value		0..5550		0.3607		0.0901
Anderson canonical correlation test		926.68		734.26		649.15
Chi2(1) P-value		0.0000		0.0000		0.0000

Table 4. Results. 2SLS IV-estimation. Winning bids. Instruments: Population density & Unemployment rate.

	Model 1		Model 2 (Size)		Model 3 (Size & Quality)	
Log(Winning bid/sqm)	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std.err.
Log(Number of bidders)	-0.235***	0.070	-0.275***	0.101	-0.295***	0.104
Log(Number of square meters)	-0.108***	0.015	-0.103***	0.018	-0.111***	0.018
Log(Number of contracts)	-0.026	0.016	-0.024	0.017	-0.036**	0.017
EMS	0.042	0.037	0.039	0.038	0.071*	0.038
ECO	0.059	0.040	0.048	0.041	0.022	0.041
VEH	-0.069	0.063	-0.053	0.072	-0.090	0.069
CHEM	0.106***	0.037	0.105***	0.038	0.081**	0.041
MON	-0.070	0.058	-0.068	0.058	-0.064	0.058
OTHER	-0.013	0.036	-0.009	0.036	0.005	0.036
SERVICE	0.111***	0.016	0.109***	0.017	0.119***	0.017
School	0.311***	0.038	0.308***	0.039	0.292***	0.038
Log(Firm Size)			-0.008	0.013	-0.009	0.014
FIN					-0.016	0.110
INS					-0.251***	0.079
EXP					0.069	0.079
PER					0.005	0.153
SOC					0.144***	0.036
STAF					0.078	0.063
Constant	5.415***	0.132	5.494***	0.195	5.664***	0.299
Number of obs		709		703		703
F-statistic		30.30		28.00		20.27
Prob > F		0.0000		0.0000		0.0000
Centred R2		0.35		0.35		0.37
Sargan		5.008		4.539		3.722
Chi2(1) P-value		0.0252		0.0331		0.0537
Anderson canonical correlation test		114.877		69.825		65.596
Chi2(1) P-value		0.0000		0.0000		0.0000

6. **Summary and conclusion**

Implementing Green Public Procurement (GPP) as an environmental policy instrument is a worldwide trend that continues to grow. However, the arguments behind the clear political ambition to increasingly expand the use of public procurement as a policy instrument do not rest on research findings. The economics literature on the subject is scarce, but the few existing theoretical studies are clear in their conclusions. GPP is not an efficient policy instrument, neither concerning costs nor effects.

Empirical studies based on economics are even scarcer. One of the few empirical studies is provided by Lundberg, Marklund, Strömbäck et al. (2015). They analyze the impact of authorities stipulating environmental criteria on supplier behavior in Swedish cleaning services using data from the years 2009 and 2010. They find at best a weak impact, which indicates that the criteria are too weak to actually force suppliers to costly environmental adjustments. This indicates that the environmental impact is small and may even be negligible. Based on this outcome a relevant hypothesis would be that the price the public authorities pay for implementing GPP is low, or even zero. In this paper, based on the same data as used by Lundberg, Marklund, Strömbäck et al. (2015), this hypothesis is empirically tested.

In brief, the results illustrate that to actually control it is important that contracting authorities make requirements in the call for tender that go beyond the current environmental standard in the market. This also means that the authorities should weigh the expected gains from effective GPP in terms of environmental improvement against expected losses in terms of reduced competition.

In the procurements studied here environmental requirements are quite common. Twenty eight different environmental criteria were identified in the field data, which were aggregated into six environmental characteristics. Four of these are not associated with a price premium, but requirements related to the processes associated with the usage of chemicals clearly are. In this latter case the contracting authorities pay a price for implementing GPP. Weaker but still, the results indicate the same thing for requirements related to environmental management systems (one out of three model specifications).

A policy implication of our findings is that for public procurement to have any environmental impact the requirements must, besides go beyond the current environmental standard in the market, target not only the winning bidder but also all non-winning bidders. Winning bids set the price premium the contracting authorities pays for implementing GPP. If there is a price the authorities, e.g., municipalities, need to either financing the price payments by increasing tax income or cutting costs elsewhere in their operations.

The fact that all potential bidders must be targeted brings to light that the timing of the call for tender is of importance. The timing must be of such nature that it gives potential suppliers enough time to adapt to the requirements asked for. In this context, bidders have two options. Either they consider that it is possible to adapt before the time for tender expires, and that the expected profit of doing so is non-negative, or they cannot adapt within the given time frame and therefore choose to deliver to market segments that do not demand the same stringent environmental standard.

Considering the worldwide popularity of GPP as an environmental policy instrument our research findings might be regarded as rather disappointing. Most of the previous literature on GPP that focuses on the potential environmental impact relies on case studies and statements from stakeholders. This study illustrates the need for more research and the importance of high quality field data and quantitative empirical methods to be used for evaluation of the environmental impact and the costs of GPP from an economics policy perspective. Having the politically extensive and high level ambitions for GPP in mind, this brings important knowledge that is crucial for the urgent need to reduce environmental and climate pressure. Putting too much faith into a barely evaluated policy instrument such as GPP runs the risk of leading to scarce resources being wasted, and environmental problems not being dealt with, which is not consistent with sustainability.

References

Asker, John, and Esthelle Cantillon. 2010. "Procurement when price and quality matter." *RAND Journal of Economics* 41 (1): 1-34.

Asker, John, and Esthelle Cantillon. 2008. "Properties of scoring auctions." *RAND Journal of Economics* 39 (1): 69-85.

Basu, R Jothi, Ruibin Bai, and PL K Palaniappan. 2015. "A strategic approach to improve sustainability in transportation service procurement." *Transportation Research Part E* 74: 152-168.

Bergman, Mats A, and Sofia Lundberg. 2013. "Tender evaluation and supplier selection methods in public procurement: An empirical analysis." *Journal of Purchasing and Supply Management* 19 (2): 73-83.

Che, Yeon-Koo. 1993. "Design competition through multidimensional auctions." *RAND Journal of Economics* 24 (4): 668-680.

Davidson, Russell, and James G. MacKinnon. 1993. *Estimation and Inference in Econometrics.* New York, New York: Oxford University Press.

Dini, Federico, Riccardo Pacini, and Tommaso Valletti. 2006. "Scoring rules." In *Handbook,* by Nicola Dimitri, Gustavo Piga and Giancarlo Spagnolo, 293-321. New York, NY: Cambridge University Press.

EC, European Commission. 2015. *Circular Economy Package: Questions and Answers. Fact Sheet.* December 3. http://europa.eu/rapid/press-release_MEMO-15-6204_en.htm.

EC, European Commission. 2011. ”GRÖNBOK – om en modernisering av EU:s politik för offentlig upphandling med sikte på en effektivare europeisk upphandlingsmarknad, KOM(2011) 15 slutlig.”

EC, European Commission. 2008. ”Offentlig upphandling för en bättre miljö. Meddelande från Kommissionen till Europaparlamentet, Rådet, Europeiska ekonomiska och sociala Kommittén samt Regionkommittén, KOM (2008) 400, slutlig.”

Fischer, Eric A. 2010. *Green Procurement: Overview and Issues for Congress. CRS Report for Congress, Congressional Research Service.* CRS Report for Congress, Congressional Research Service.

Geng, Yong, and Brent Doberstein. 2008. "Greening Government Procurement in Developing Countries: Building Capacity in China." *Journal of Environmental Management* 88: 932-938.

Heras-Saizarbitoriaa, Iñaki, Kouakou Doguib, and , Olivier Boiral. 2013. "Shredding light on ISO 14001 certification audits." *Journal of Cleaner Production* 51: 88-98.

Hyytinen, Ari, Sofia Lundberg, and Otto Toivanen. 2015. "Design of public procurement auctions. Evidence from cleaning contracts." SSRN: http://ssrn.com/abstract=2562840 or http://dx.doi.org/10.2139/ssrn.2562840 .

Kwong, Wing Chau. 2003. "A Critical Review of Literature on the Hedonic Price Model." *International Journal for Housing Science and its Applications* 27 (2): 145-165.

Latacz-Lohmann, Uwe, and Carel Van der Hamsvoort. 1997. "Auctioning Conservation Contracts: A Theoretical Analysis and an Application." *American Journal of Agricultural Economics* 79 (2): 407-418.

Li, Tong, and Xiaoyong Zheng. 2009. "Entry and competition effects in first-price auctions: Theory and evidence from procurement auctions." *Review of Economic Studies* 76 (4): 1397-1429.

Li, Tong, and Xiaoyong Zheng. 2012. "Information acquisition and/or bid preparation: A structural analysis of entry and bidding in timber sale auctions." *Journal of Econometrics* 168 (1): 29-46.

Lundberg, Sofia, and Per-Olov Marklund. 2013. "Green public procurement as an environmental policy instrument: cost effectiveness." *Environmental Economics* 4 (4): 75-83.

Lundberg, Sofia, and Per-Olov Marklund. 2011. "The pivotal nature of award methods in green public procurement." *Enviornmental Economics* 2 (3): 64-73.

Lundberg, Sofia, Per-Olov Marklund, and Elon Strömbäck. 2015. "Is Environmental Policy by Public Procurement Effective?" *Public Finance Review.* doi:10.1177/1091142115588977.

Lundberg, Sofia, Per-Olov Marklund, Elon Strömbäck, and David Sundström. 2015. "Using public procurement to implement environmental policy: an empirical analysis." *Environmental Economics and Policy Studies.* doi:10.1007/s10018-015-0102-9.

Malpezzi, Stephen. 2002. "Hedonic Pricing Models and House Price Indexes: A Select Review." In *Housing Economics and Public Policy: Essays in Honour of Duncan Maclennan.*, by Kenneth Gibb, 67-89. Oxford: Blackwell Publishing.

Marron, Donald B. 1997. ”Buying green: Government procurement as an intstrumen of environmental policy.” *Public Finance Review* 25 (3): 285-305.

Marron, Donald B. 2003. ”Greener public purchasing as an environmental policy instrument.” *OECD Journal of Budgeting* 3 (4): 71-102.

Nishimura, Takeshi. 2015. "Optimal design of scoring auctions with multidimensional quality." *Review of Economic Design* 19 (2): 117-143.

Palmujoki, Antti, Katriina Parikka-Alhola, and Ari Ekroos. 2010. "Green Public Procurement: Analysis of the Use of Environmental Criteria in Contracts." *Palmujoki A, Parikka-Alhola K, Ekroos A (2010) Green Public Procurement: Analysis of the Use of Environmental Criteria in Contracts. Review of European Community and International Law* 19 (2): 250-255.

Parikka-Alhola, Katriina. 2008. "Promoting Environmentally Sound Furniture by Green Public Procurement." *Ecological Economics* 68 (1-2): 472-485.

Qiao, Yuhua, and Conghu Wang. 2011. "Issues and challenges in implementing China's green public program." *Journal of Environmental Protection* 8 (2): 1034-1045.

Simcoe, Timothy, and Michael W Toffel. 2015. "Government green procurement spillovers: Evidence from municipal building policies in California." *Journal of Environmental Economics and Management* 68 (3): 411-434.

Stage, Jesper, and Anders Arvidsson. 2012. "Technology-neutral Green Procurement in Practice – An Example from Swedish." *Waste Management and Research* 30 (5): 519-523.

Stoneham, Gary, Vivec Chaudhri, Arthur Ha, and Loris Strappazzon. 2003. "Auctions for conservation contracts: an empirical examination of Victoria's BushTender trial." *Australian Journal of Agricultural and Resource Economics* 47 (4): 477-500.

Swanson, Mary, Arthur Weissman, Gary Davis, Mary Leet Socolof, and Kim Davis. 2005. "Developing Priorities for Greener State Government Purchasing: a California case study." *Journal of Cleaner Production* 13 (7): 669-677.

Tarantini, Mario, Arianna Dominici Loprieno, and Pier Luigi Porta. 2011. "A Life Cycle Approach to Green Public Procurement of Building Material and Elements: A Case Study of Windows." *Energy* 36 (5): 2473-3482.

Taylor, Laura O. 2003. *The Hedonic Method.* Vol. 3, in *A Primer on Nonmarket Valuation*, by Patricia A Champ, Kevin J Boyle and Thomas C Brown, 331-393. Dordrecht: Springer.

Testa, Francesco, Fabio Iraldo, Marco Frey, and Tiberio Daddi. 2012. "What factors influence the uptake of GPP (Green Public Procurement) practices? New evidence from an Italian survey." *Ecological Economics* 82 (2): 88-96.

Tukker, A, S Emmert, M Charter, M Vezzoli, E Sto, M M Andersen, T Geerken, U Tischner , and S Lahlou. 2008. "Fostering change to sustainable consumption and production: an evidence based view." *Journal of cleaner production* 16: 1218-1225.

Zobel, Thomas. 2016. "The impact of ISO 14001 on corporate environmental performance: a study of Swedish manufacturing firms." *Journal of Environmental Planning and Management* 1-20. doi:10.1080/09640568.2015.1031882.

Table A1. Results. First stage regressions. All bids. Instruments: Population density, Unemployment rate

	Model 1		Model 2 (Size)		Model 3 (Size & Quality)	
Log(Number of bidders)	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std.err.
Unemployment rate	-0.036***	0.003	-0.029***	0.003	-0.028***	0.003
Population desnity	0.000***	0.000	0.000***	0.000	0.000***	0.000
Log(Number of square meters)	0.052***	0.006	0.062***	0.006	0.062***	0.006
Log(Number of contracts)	0.037***	0.006	0.040***	0.006	0.050***	0.006
EMS	-0.261***	0.017	-0.249***	0.016	-0.237***	0.017
ECO	-0.015	0.018	-0.017	0.018	0.012	0.018
VEH	0.372***	0.028	0.361***	0.028	0.299*	0.029
CHEM	-0.005	0.016	-0.027	0.016	-0.032	0.018
MON	0.202***	0.024	0.210***	0.024	0.244***	0.024
OTHER	-0.149***	0.015	-0.146***	0.015	-0.141***	0.015
SERVICE	-0.099***	0.006	-0.087***	0.006	-0.075***	0.006
School	-0.010***	0.017	-0.022	0.016	-0.017	0.016
Log(Firm Size)			-0.049***	0.003	-0.047***	0.003
FIN					0.001	0.055
INS					-0.140***	0.029
EXP					-0.228***	0.030
PER					-0.110*	0.059
SOC					-0.022	0.016
STAF					0.176***	0.030
Constant	1.951***	0.060	2.098***	0.060	2.314***	0.095
Number of obs		4143		4036		4036

Table A2. Results. OLS regressions based on all bids.

	Model 1		Model 2 (Size)		Model 3 (Size & Quality)	
Log(Bid/sqm)	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Log(Number of bidders)	-0.089***	0.014	-0.094***	0.014	-0.117***	0.015
Log(Number of square meters)	-0.156***	0.006	-0.149***	0.006	-0.154***	0.006
Log(Number of contracts)	-0.022***	0.006	-0.014**	0.006	-0.013**	0.006
EMS	-0.003	0.016	-0.013	0.016	0.014	0.016
ECO	0.014	0.018	0.010	0.018	0.000	0.018
VEH	0.043	0.027	0.048*	0.027	-0.020	0.027
CHEM	0.037**	0.016	0.040**	0.016	0.058***	0.018
MON	0.007	0.024	0.002	0.024	0.026	0.024
OTHER	-0.016	0.015	-0.015	0.015	-0.006	0.015
SERVICE	0.085***	0.006	0.086***	0.006	0.110***	0.007
School	0.274***	0.016	0.273***	0.016	0.261***	0.016
Log(Firm Size)			-0.012***	0.003	-0.012***	0.003
FIN					-0.101*	0.056
INS					-0.371***	0.029
EXP					-0.021	0.030
PER					0.065	0.059
SOC					0.084***	0.016
STAF					0.115***	0.030
Constant	5.950***	0.057	5.953***	0.061	6.222***	0.097
Number of obs		4143		4036		4036
F-statistic		159.35		144.86		112.57
Prob > F		0.0000		0.0000		0.0000
R2adj		0.30		0.30		0.33

Table A3. Results. First stage regressions. Winning bids. Instruments: Population density, Unemployment rate

	Model 1		Model 2 (Size)		Model 3 (Size & Quality)	
Log(Number of bidders)	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std.err.
Unemployment rate	-0.035***	0.009	-0.017***	0.009	-0.015*	0.009
Population desnity	0.000***	0.000	0.000***	0.000	0.000***	0.000
Log(Number of square meters)	0.088***	0.015	0.102***	0.014	0.097***	0.014
Log(Number of contracts)	0.103***	0.018	0.088***	0.017	0.089***	0.017
EMS	-0.209***	0.047	-0.173***	0.044	-0.014***	0.044
ECO	-0.065	0.050	-0.084*	0.047	-0.072	0.048
VEH	0.392***	0.082	0.446***	0.076	0.389***	0.077
CHEM	0.017	0.047	0.005	0.043	-0.013	0.047
MON	0.073	0.071	0.066	0.066	0.074	0.067
OTHER	-0.094**	0.043	-0.076*	0.041	-0.062	0.041
SERVICE	-0.109***	0.018	-0.095***	0.017	-0.082***	0.017
School	0.021	0.048	-0.012	0.044	0.006	0.045
Log(Firm Size)			-0.087***	0.009	-0.087***	0.009
FIN					-0.008	0.126
INS					-0.217**	0.086
EXP					-0.174**	0.087
PER					-0.126	0.174
SOC					-0.083**	0.040
STAF					0.065	0.071
Constant	1.323	0.170	1.616***	0.161	2.011***	0.264
Number of obs		709		703		703

Table A4. Results OLS regressions based on winning bids.

	Model 1		Model 2 (Size)		Model 3 (Size & Quality)	
Log(Winning bid/sqm)	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Log(Number of bidders)	-0.210***	0.028	-0.210***	0.032	-0.227***	0.032
Log(Number of square meters)	-0.111***	0.013	-0.111***	0.013	-0.119***	0.013
Log(Number of contracts)	-0.029**	0.015	-0.029**	0.015	-0.041***	0.015
EMS	0.045	0.037	0.044	0.038	0.075**	0.038
ECO	0.057	0.040	0.048	0.041	0.022	0.042
VEH	-0.073	0.063	-0.074	0.065	-0.109*	0.065
CHEM	0.105***	0.038	0.106***	0.038	0.084**	0.041
MON	-0.070	0.058	-0.070	0.058	-0.067	0.059
OTHER	-0.011	0.036	-0.006	0.036	0.008	0.036
SERVICE	0.114***	0.015	0.115***	0.015	0.124***	0.015
School	0.311***	0.039	0.308***	0.039	0.294***	0.039
Log(Firm Size)			-0.001	0.008	-0.002	0.008
FIN					-0.021	0.111
INS					-0.234***	0.076
EXP					0.082	0.077
PER					0.021	0.153
SOC					0.139***	0.035
STAF					0.069	0.063
Constant	5.950***	0.123	5.400***	0.137	5.535***	0.234
Number of obs		709		703		703
F-statistic		34.26		31.13		22.74
Prob > F		0.0000		0.0000		0.0000
R2adj		0.34		0.34		0.36