

OBJECTIVE EFFECTIVENESS OF GREEN PUBLIC PROCUREMENT

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ABSTRACT. Advocates of green public procurement (GPP) argue that the public sector, by its purchasing power, can influence production and consumption to become more environmental friendly. The purpose of this paper is to assess GPP as an environmental policy instrument and its ability to contribute to environmental objectives being achieved. Central to the analysis is to what extent polluting firms choose to invest in green technology, i.e., participate in the procurement auction. Introducing a privately known adjustment cost, new insights are gained regarding bidders' entry decision and its effect on objective effectiveness. Theoretically, GPP is found to be objective ineffective in general and give rise to an *environmental policy paradox*.

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1. INTRODUCTION

Advocates of green public procurement (GPP) argue that the public sector, by its purchasing power, can influence production and consumption in society to become more environmental friendly. The specific purpose of this paper is to assess GPP as an environmental policy instrument in terms of its ability to contribute to environmental objectives being achieved exactly. Reducing emissions too little or too much in comparison to a welfare optimally set target is a socially inefficient outcome, and therefore by definition leads to welfare losses. Starting from a sustainable and welfare theoretical perspective, the main objective of this paper is to analyze GPP in terms of objective effectiveness, i.e., its potential to accurately contribute to the achievement of specific environmental policy objectives.

Recently, GPP have politically and formally been emphasized as a policy instrument, which can be exemplified by the European Commission (2010) defining GPP as a process where public authorities take environmental concern when allocating public contracts. Within the EU, the first steps towards GPP and the “EU 2020” strategy, where GPP is pointed as an instrument to achieve environmental objectives (European Commission 2010a: 10, 14, 15), was taken in year 2001 (Gothenburg European Council, 2001). In year 2003 the Member States of the EU was encouraged to develop National Action Plans (NAPs) on GPP, and today most of them have done so (European Commission, 2003). Internationally there is a similar trend. Alongside with multilateral trade agreements within the WTO the Government Procurement Agreement (GPA), containing GPP paragraphs, was initiated and signed in year 1994.† In addition to this, authorities and politicians around the world argue in favor of public procurement as a means to achieve social objectives, such as

† The Government Procurement Agreement (GPA) is a plurilateral agreement negotiated alongside multilateral trade agreements within the WTO. The European Community (27 member states), Hong Kong (China), Iceland, Israel, Japan, Korea, Liechtenstein, (the Netherlands with respect to) Aruba, Norway, Singapore, Switzerland and the United States of America has to date signed the GPA.

environmental sustainability. Other objectives under concern are labor standards, employment and civil rights (McCrudden, 2004). This paper will however only focus on the environmental dimension. Obviously, worldwide there are strong forces promoting the implementation of GPP, yet there are hardly any peer-reviewed scientific findings in support.

Environmental policy instruments are commonly classified as “economic” or “command-and-control” instruments, e.g., taxes or quantity rationing, respectively. What type of instrument to use in a certain situation is not always obvious from a welfare perspective, and depending on situation some instruments may be preferred to others. As implemented in practice, GPP may be seen as belonging to the command-and-control class of instruments.

Lundberg and Marklund (2012), and Lundberg et al. (2009), concludes that when evaluated according to cost-effectiveness, economic policy instruments such as taxes are preferred to GPP. However, the choice of environmental policy instrument can also be based on other criteria, such as its effectiveness of contributing to the achievement of environmental objectives in society (e.g. Hanely et al., 2007). It is therefore of high relevance to post the question whether GPP may serve as an objective effective environmental policy instrument.

A distinction between standard literature on environmental regulation and the GPP context outlined here is how firms’ alternative option is defined. While, e.g., a tax is mandatory, a potential bidder’s adoption to GPP-criteria is contingent on its decision to submit a bid. Therefore it seems at odds to believe that the only relevant option for the firm is to exit the market and go-out of business. Instead, an equally relevant option here would be to engage in other markets with less stringent criteria, including other governmental purchase, i.e. business as usual. As a policy instrument, public procurement is hence potentially weaker than taxes, subsidies, regulations and tradable permits although basically any form of environmental regulation can lead to entry barriers (see e.g. Heyes, 2009, for a survey).

In a partial market equilibrium framework Marron (1997) shows that GPP will most likely be objective ineffective under most

circumstances. The fundamental reason for his conclusion is that GPP hardly have an effect on total production but merely focus on the substitution effect between products of different environmental tractability. By extending the work of Marron (1997) we analyse the incentive structure of GPP and its impact on the entry decision of potential bidders. In this paper it is argued that the idea of using GPP as an environmental policy instrument builds on the ambition to provide incentives for green investments by all potential bidders and hence not only the winner of public contracts. Induced market capacity of producing green products will have an indirect effect via the composition of products of different environmental tractability being supplied in a market. Consequently, the effect of GPP on bidders' behavior has the potential to go beyond the specific purchase made by the government. Furthermore, investments are modeled as adjustment costs, privately known to each potential bidder which of course can be avoided by not participating in the procurement auction. Ex ante the procurement auction, potential bidders are assumed heterogeneous in their production technology resulting in different adjustment costs. In addition, adjustment costs are treated as exogenously given as they are associated with the process of becoming eligible bidders. This provides new insights regarding bidder's entry decision in GPP auctions and adds to the literature regarding costly investments and models in which firms under the threat of regulation voluntarily invest in greener technology (e.g. Urpelainen, 2011).

The majority of production literature regarding investment incentives in procurement auctions refers to costly- but production cost decreasing investments in production (e.g. Piccione and Tan, 1996; Arozamena and Cantillon, 2004; Gong et al., 2011). Common to these studies are that private information regarding bidders cost for completing the contract is endogenously determined by the level of investment. Their modeling approach, however, does hardly apply to GPP directly since investments in green technology divert resources from production. In the latter case, bidders face exogenous costly- and potentially production cost increasing investments in green technology in order to become an eligible bidder.

Rather, the entry decision of potential bidders is endogenized with respect to an exogenous level of GPP. Based on the derived model for entry, GPP's potential to be objective effective is analyzed. The results indicate that GPP will most likely be objective ineffective as an environmental policy instrument.

Besides the studies mentioned above there seems to be paucity in the research literature where GPP from a welfare economic perspective is addressed as a policy instrument. As such the current paper contributes to the existing literature. In D'Amato (2006) the organization of the public sector is concluded to be important for the outcome of public procurements with environmental concern. The environmental quality is found to be lower in a decentralized organization characterized by non-cooperation between the procurement and environmental expertise compared to a centralized organization. Otherwise it seems as the common approach is synonymous to regard GPP as an established environmental policy instrument where public authorities should implement it because they can and the main focus is on the potential benefits of GPP (e.g. Sterner, 2002; Erdmenger, 2003; Cerin, 2006; Thomson and Jackson, 2007; Bolton, 2008; Geng and Doberstein, 2008; Parikka-Alhola, 2008; Qiao and Wang, 2011) or the frequency of GPP in terms of usage rates in published call for tenders (Kippo-Edlund, et al., 2005; Nissinen et al., 2009; Palmujoki et al., 2010). The usage rate is commonly defined as the share of public procurements with any form of environmental concern. As pointed out by Lundberg and Marklund (2011) award methods and scoring rules[‡] play a central role in the functioning of GPP as an environmental policy tool. A high usage rate as a measure of GPP success has the disadvantage of the risk of mistaken green washing for contribution to reduced environmental burden.

The remainder of this paper is organized as follows. Institutional settings and principles of GPP are presented in Section 2 which departs from EU legislation. The findings, however, are valid for

[‡] Examples of scoring rules in public procurements with environmental concern are found in case studies by e.g. Arvidsson and Stage (2012) and Parikka-Alhola and Nissinen (2012).

any kind of GPP implementation. This is followed by Section 3 that includes a presentation of how to approach environmental policy instruments in general. Section 4 introduces an adjustment associated with GPP and its effect on firms' decision to enter the procurement auction. Section 5 provides a theoretical analysis of GPP and its potential to achieve environmental objectives. Meanwhile, the assumptions made are discussed and the main finding of the paper is basically found to be robust for alternation of the assumptions. Section 6 concludes the paper.

2. INSTITUTIONAL ENVIRONMENT

We assess GPP as defined by the EC[§] and public procurement as defined by the EU procurement directives.** Following the GPA and EU procurement directives, competitive sealed tendering is in general used to allocate public contracts. GPP can be performed by the use of (i) qualification criteria on the supplier or the subject matter, e.g. technical and/or professional ability and technical specifications, (ii) bid preference program (e.g. Hubbard and Paarsch, 2009; Kranokutskaya and Seim, 2010), and (iii) contract performance clauses or a combination of these (e.g. Marron, 1997; Palmujoki et al., 2010). Environmental consideration in public procurement can be of various strength; ranging from lax to stringent.

The bidding is initiated by a publication of a call for tender. It specifies among other things the characteristics of the product to be procured and contract conditions. The call for tender also includes technical

[§] Green public procurement means that public purchasers take environmental consideration when buying products, services or works. (COM(2008) 400)

** "Public procurement means 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 13)". Directive 2004/17/EC and Directive 2004/18/EC. Note that this definition does not include auctions of tradable permits (see, e.g., Tietenberg, 2003) and nature conservation contracts (see, e.g., Latacz-Lohman and van der Hamsvoort, 1997; Stoneham et al., 2003; Cattaneo et al., 2007).

specifications and the rules of the game such as criteria and principles for bid evaluation. The bid evaluating process can be characterized by a two-step procedure. The first phase consists of qualification followed by a bid evaluation phase.^{††} In the first step each bid is evaluated against the exclusion criteria and qualification criteria specified in the call for tender.^{‡‡} Bidders that fulfill the requirements are qualified to the second and final step in the evaluation process. Here, the contract is awarded according to either lowest bid or economically most advantageous tender (EMAT) principle.

The award principle must also be specified in the call for tender. If lowest bid is the award method of choice, allocation of contracts is relatively straightforward. The contract will be allocated to the bidder who offers to complete the contract to the lowest price, given that the exclusion and qualification criteria for both the subject matter and bidder are met. This gives the procurement auction the character of the classical first-price sealed bid auction (Vickrey, 1961). In contrast, EMAT implies that the award method will be based on a predetermined scoring rule including price and other award criteria (e.g. Dini et al. 2006; Asker and Cantillon, 2008, 2010; Bergman and Lundberg, 2011; Lundberg and Marklund, 2011). Consequently, the bid in a general EMAT-setting consists of price and other award criteria related to e.g. aspects of quality and environmental consideration, which gives the procurement the character of a multidimensional auction (Che, 1993). The award method is for

^{††} The two-step procedure, consisting of a qualification phase followed by a bid evaluation phase, is from the perspective of potential bidders a simultaneous process. A submitted bid include prices and the outcome of the qualification phase is made public at the same time as the outcome of the bid evaluation phase. This is somewhat different from, e.g., Texas Department of Transportation highway mowing auctions where the outcome of the qualification phase is known to the bidders prior to them submitting their price bids (see Li and Zheng, 2007).

^{‡‡} Exclusion criteria deal with circumstances such as bankruptcy, serious misconduct, unpaid taxes, or social security contributions that normally cause contracting authorities not to do any business with it. For instance, tenders that repeatedly breach environmental law can be excluded on the grounds of grave professional misconduct (2004/17/EC and 2004/18/EC).

simplicity reasons here assumed to be lowest price.^{§§} Further, in the remaining text other quality aspects but environmental will not be regarded. Environmental quality can in addition to the environment be climate and energy related.

Although the procurement auction is regulated by law it leaves the contracting authority a lot of freedom in exactly how to design the bid evaluation process, and what environmental qualification- and award criteria to consider. The qualification criteria, award method, and contract conditions must, however be published in the call for tender and follow some basic rules. Environmental criteria (qualification- as well as award criteria) must respect the principles of equal treatment, transparency, non-discrimination, proportionality, and mutual recognition, given by the EU directives. As a consequence, potential bidders meet identical environmental criteria in the call for tender. Also, the criteria must be linked to the subject matter of the contract. The criteria may include clauses that oblige bidding bidders to change their production technology in order to meet the public procurement requirements. The EU Directives (2004/17/EC and 2004/18/EC) allows public authorities to define what a product is made of as well as how it is made in the technical specification. In practice the use of GPP address, e.g. environmental management systems, references proving sustainability, certificates, standards, biodiversity, emissions to air or water, energy or water consumption, chemical consumption and waste generation (European Commission, 2004). From here onwards, GPP will be used as the common name for all types of green criteria.

3. ENVIRONMENTAL POLICY INSTRUMENTS

From a welfare and sustainable point of view, it is important to compare GPP to other economic and command-and-control instruments. The choice of which instrument to choose can be based on the extent to which they meet a number of evaluating criteria. In Hanley et al. (2007) four criteria are discussed: *(i)* Efficiency, *(ii)* Effectiveness, *(iii)* Equity, and *(iv)* Flexibility. Briefly, equity is about

^{§§} The assumption of lowest price as the award method will not alter the qualitative conclusions made about the environmental objectiveness of GPP.

environmental policy measures may redistribute costs and benefits in society. Flexibility addresses issues such that the ability of environmental policy adapting to changes in economic, technological, and environmental conditions. (see, e.g., Hanley et al., 2007 for an introduction to these criteria). GPP and efficiency (cost-effectiveness) is discussed in Lundberg et al. (2009), GPP and objective effectiveness is the focus of the current paper, whereas equity and flexibility is left for future research.

Efficiency (*i*) refers to the ability of environmental policy reaching the environmental objective at the lowest possible cost. For a uniformly mixing pollutant a cost-effective result could be achieved by establishing a per-unit tax; a single tax rate for all sources of emissions (Baumol and Oates, 1971, 1988).***.††† The tax rate should be set according to the marginal environmental damage cost. Cost-effectiveness is discussed in a GPP context in Lundberg et al. (2009): They conclude that GPP in general is not a cost-effective environmental policy instrument, compared to economic instruments. Rather, in practice GPP is more comparable to command-and-control instruments, such as technology control and emission quantity rationing. However, Lundberg et al. (2009) did not categorically dismiss the possibilities for GPP serving as an environmental policy instrument with reference to other criteria, e.g., objective effectiveness.

Effectiveness (*ii*) refers to the accurateness of which environmental policy contributes to the achievement of environmental objectives. Even though economic instruments, as e.g., per-unit taxation on emissions, may be referred to as being cost-effective, they are not necessarily having an effective impact on the environment. One major

*** The environmental damage from a uniformly mixing pollutant is independent of location of the polluting source. By assuming uniformly mixing pollutants we can disregard spatial considerations. One example is greenhouse gases (GHGs).

††† Cost-effectiveness is here entirely associated to private resource cost minimization in reducing emissions. Then, if cost-effectiveness is the only criteria to consider (assuming objective effectiveness, equity and flexibility) private resource cost minimization coincides with social resource cost minimization.

problem is that the regulatory authority, e.g., implementing an environmental policy tax scheme, has limited information about firms' emission reduction costs. Accordingly, the authority does not know, ex ante, how large reduction in emissions a given unit tax rate will lead to in total. Hence, it is likely that non-optimal tax rates are set in practice, and the policy fails to accurately achieve the environmental objective. If the tax rate is set too low the environment suffers additional damages that would not have arisen if more objective effective policy measures had been used from the start. Consequently, environmental objectives can be achieved at a lower total net cost to society by using a cost-ineffective but objective effective policy instrument.

The nature of GPP makes it reasonable to classify it as an administrative or quantitative environmental policy instrument. Potential bidders must, as previously mentioned, in order to become eligible bidders fulfill certain environmental requirements that either targets the process or emissions associated with production or consumption or both. If the production process is in focus the requirements targets the producer (provider) of the product while requirements directed towards the consumption places the environmental responsibility upon the public sector's own consumption. If the requirements are production process oriented then externalities are targeted while consumption orientation targets the usage of resources (see Lundberg and Marklund, 2012). Administrative and quantitative policy instruments are often referred to as command-and-control instruments.

An important difference between traditional environmental policy instruments, e.g., taxes (economic) or standards (command-and-control), and GPP is the element of discretion. The potential bidder can avoid the cost of adjusting to the GPP criteria by not entering the procurement auction. As such, the understanding of the functioning of GPP as an environmental policy instrument and objective effectiveness demands insights in how GPP affects the entry decision of potential bidders. This is discussed in the next section, where a one-stage model is proposed for modeling the entry decision.

4. THE ENTRY DECISION

When assessing whether GPP is an objective effective environmental policy instrument the number of participating bidders is most relevant. This number is determined by the firms' decision of entering the procurement auction or not. The entry-decision of a profit maximizing and risk neutral potential bidder is simple in the case of no entry costs; participate if the expected pay-off is non-negative. However, if GPP criteria are imposed and firms therefore have to adjust in purpose of becoming an eligible bidder an additional cost has to be considered in the entry decision. From now on this particular cost is termed cost of adjustment.

Furthermore, following from the assumption of potential bidders being heterogeneous in environmental performance ex ante the procurement auction, they face different adjustment costs. This systematic cost differential is transmitted to the joint production cost function of each potential bidder. Whenever such cost differential is common knowledge, bidders' beliefs are referred to as being asymmetric (Maskin and Riley, 2000b). Consequently, the cost of adjusting to GPP, here denoted CA_i for $i = 1, \dots, N$ potential bidders, is modeled to statistically determine the joint distribution of bidder i 's cost of completing the contract of a procurement auction. Asymmetries are thus captured by the assumption that the bidders' cost of completing the contract is drawn from a distribution being conditioned on CA_i .

In explicitly modeling the entry decision, assuming the number of potential bidders $N \geq 2$, we follow mainly Arozamena and Cantillon (2004), and Maskin and Riley (1996, 2000a). Bidders' participation and bidding behavior is modeled as the standard *Bayesian Nash Equilibrium*, where the cost of bidders fulfilling the contract, c_i , is assumed being an independent private cost parameter (IPCP) drawn by bidder i from a conditional stochastic distribution $F_i(c; CA)$ with the commonly known support $0 \leq \underline{c}_i \leq \bar{c}_i$. It is furthermore assumed that both the bidders' preferences and their probability distributions satisfy the necessary and sufficient equilibrium conditions so that the bid functions $b_i = b_i(c_i; CA_i)$ are unique and strictly increasing in c_i

(Athey, 2002). Conditional on entering the procurement auction, the realized profit for bidder i , with a given cost c_i and a bid of b_i , is given by:

$$\pi_i(b_i, c_i; CA_i) = \begin{cases} b_i - c_i & \text{if } b_i < b_j \text{ for all } i \neq j \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

The realized profit in Equation (1) is restricted to be non-negative, i.e., bidder i never bids less than its reservation price. To see this, let $\underline{b}_i(c_i; CA_i)$ be bidder i 's reservation price if c_i is drawn from distribution F_i . Then it is readily confirmed that the reservation price coincide with bidder i 's cost by setting $\pi_i(\underline{b}_i, c_i; CA_i) = 0$. This is useful when defining the entry condition by identifying potential bidders' with cost draws sufficiently high for deciding not to enter the procurement auction.

Before defining the entry condition, the equilibrium bid function must be specified. For convenience the inverse bid function is our point of departure:

$$\phi_i(b) = b^{-1}(b_i(c_i; CA_i)) \quad i = 1, \dots, N \quad (2)$$

where $b_i(\cdot)$ is bidder i 's equilibrium bid as a function of its cost to fulfill the contract. Given its competitors' bidding behavior, bidder i 's optimization problem is to maximize its expected profit according to:

$$\max_b \pi_i(b_i, c_i; CA_i) \prod_{j \neq i} (1 - F_j(\phi_j(b))) \quad (3)$$

where $\prod_{j \neq i} (1 - F_j(\phi_j(b)))$ is the probability that a bid of b from bidder i is the lowest. Expected profit thus consists of a markup times a probability of bidder i winning the contract. Provided that the cost asymmetry among bidders is not too pronounced in terms of differing support, $0 \leq \underline{c}_i \leq \bar{c}_i$, Maskin and Riley (1996, 2000a) have shown that there exist a unique equilibrium in this environment. Following Arozamena and Cantillon (2004), and Maskin and Riley (2000b), the corresponding first order condition of bidder i 's maximization problem

is obtained by taking logarithms of Equation (3) and then differentiating by b , which gives:

$$\sum_{j \neq i} \frac{F'_j(\phi_j(b))\phi'_j(b)}{1 - F_j(\phi_j(b))} = \frac{(\frac{\partial}{\partial b} \pi_i(b, \phi_i(b)))}{\pi_i(b, \phi_i(b))} \quad i = 1, \dots, N. \quad (4)$$

The equilibrium inverse bid functions, corresponding to the system of differentials in Equation (4), are evaluated at b for all bids that satisfy lower and upper boundary conditions, i.e., $\forall b \in [l_i, u]$. In each bidder type, b_i , the lower boundary is endogenously determined by setting $F_i(\phi_i(l_i)) = 0$. However, in the analysis of potential bidders' entry-decision, the upper boundary condition, u , is of primary interest. Suppose that for each bidder type the upper support of the bid distribution can be described by an N -tuple of bid functions such that for any highest cost \bar{c}_i ; $\underline{b}_1(\bar{c}_1; CA_1) \leq \underline{b}_2(\bar{c}_2; CA_2) \leq \dots \leq \underline{b}_N(\bar{c}_N; CA_N)$. If the assumption of single crossing property holds and there are asymmetries in bidders' types, Maskin and Riley (1996), have shown that for two bidders the highest possible winning bid u is unique and satisfies:

$$\underline{b}_1(\bar{c}_1) \leq u \leq \underline{b}_2(\bar{c}_2) \quad (5)$$

Consequently, bidders with a cost realization above the threshold, i.e., $(c_i; CA_i) > u$, have no incentive to enter the auction by bidding its cost, since they have zero probability of winning. Furthermore, this also means that if there are no entry costs, a bidder with a realized cost at the threshold is indifferent whether to participate or not, with a bid of:

$$\underline{b}_i(c_i; CA_i) = c_i = u. \quad (6)$$

Here, asymmetries in the cost distributions of potential bidders arise due to the conditioning on GPP requiring necessary investment in

*** This result can readily be extended to the case of entry costs (in terms of e.g. preparation of bid documents, process of learning the private cost parameter and so on).

environmental friendlier technology, whereby lowest possible equilibrium winning bid, $b_i = l_i$, need not be common to all bidder types. Common to all types, however, is the highest possible equilibrium winning bid threshold, $b_i = u$. As shown in Equation (5), this threshold will uniquely determine who will not carry out this particular investment and, accordingly, do not enter the auction. Hence, incorporation of entry decisions will induce bidders with sufficiently high cost draws to not enter the auction since their probability of winning the contract is zero.

Referring the discussion above to GPP, a general conclusion would be that potential bidders with relatively low initial environmental performance are more likely to stay out of the procurement auction. This effect will be more pronounced as the stringency of GPP increases.

To sum up, in this section we have shown that crucial to potential bidders' entry decision and, therefore, the objective effectiveness of GPP, is the commonly known asymmetry in bidders' distributions from which they draw the parameter that reflects the cost of fulfilling the contract. This cost asymmetry is modeled as being contingent on differences in the cost of adjusting to GPP criteria.

In the next section we look closer at GPP and its prerequisites of working as an objective effective environmental policy instrument, given potential bidders being heterogeneous in environmental performance.

5. GPP AND OBJECTIVE EFFECTIVENESS WITH ASYMMETRIC BIDDERS

For GPP to work as an environmental policy instrument it obviously needs to have actual positive impact on the environment. Therefore, it is important that the practice of GPP attracts brown firms, i.e., firms that actually need to adjust to GPP criteria and as discussed in the

previous section have a positive adjustment cost.^{§§§} For analytical purposes we assume that all potential bidders are brown ex ante the procurement auction, i.e., the GPP criteria are binding for all bidders. Furthermore, we assume that there is no environmental policy instrument in effect, i.e., there is no environmental policy pursued ex ante the GPP auction. ****

As in Lundberg and Marklund (2012), GPP is studied as an environmental policy instrument that can be used to bring environmental pressure to bear on potential bidders.^{††††} In this case, the purpose of practicing GPP should not primarily be to reduce produced quantities of marketable products that are the origin of emissions, but to contribute to these emissions being reduced. This means that the purpose of practicing GPP is rather to contribute to firms producing less emission per unit produced marketable good, i.e., the improvement then basically relates to improved environmental performance in firms' production processes, which is consistent with the theoretical discussion in previous section. Here we assume that performance may be improved by firms investing in environmentally friendlier technologies, consistent with the characteristics of GPP as an environmental policy instrument that specifies technological requirements (see Lundberg and Marklund, 2012).^{††††}

^{§§§} Concluding whether a firm is green (or brown) in perspective of welfare and sustainability is difficult. However, here we simply regard firms that are already satisfying the GPP criteria as green ($CA_i=0$) and firms that do not as brown ($CA_i>0$).

^{****} The assumptions of all potential bidders being brown and no environmental policy ex ante the procurement auction will not alter the analytical conclusions made. Assuming away any other instrument than GPP as an option of environmental policy will not make GPP easier from an effectiveness point of view.

^{††††} Lundberg and Marklund (2012) provide an illustrative sketch on different ways of using GPP.

^{††††} Environmental productivity may also be increased by input substitution in the production process. However, disregarding the possibility of input substitution will not alter the analytical conclusion made.

Furthermore, we adopt a principal-agent approach when analyzing GPP as an environmental policy instrument. The principal, e.g., representing politicians at the municipal or county level, decides whether GPP to be implemented or not. The principal is assumed to have a certain environmental objective of reducing the externality corresponding to a specific quantity for a given time period. The civil servant (the agent) optimally sets a level of GPP for the environmental objective to be met. The agent, however, is assumed to have incomplete information about environmental performance of potential bidders. This mimics the decentralized structure of GPP in practice.

Next we explicitly provide a theoretical discussion on heterogeneous firms and their asymmetric costs of adjusting to GPP criteria. It is reasonable to think of GPP stringency being crucial to adjustment costs.

5.1 GPP stringency and cost of adjustment

Following Lundberg and Marklund (2012), assume an economy where $i = 1, \dots, N$ heterogeneous firms produce a marketable product, Q , totally amounting to $q_Q = \sum_{i=1}^N q_i$. The production of Q simultaneously generates emissions of an undesirable by-product, Z , totally amounting to $z_Z = \sum_{i=1}^N z_i$. All N firms are assumed to be potential bidders when putting GPP into practice. Also, consistent with theoretical discussion on entry decision in previous section, N is assumed known to the agent and treated as exogenously given.

Given that the agent is about to procure the quantity $q^{PP} \leq q_Q$ of the marketable good, the principal has decided that GPP is to be practiced in purpose of improving environmental quality in society. Specifically, the environmental objective is set to a sustainable level of total emission corresponding to z_Z^* and, accordingly, the total reduction needed in society is $\Delta z_Z = z_Z - z_Z^*$. For that reason, the agent implement GPP to meet the environmental objective set by the principal by specifying criteria in the call for tender that address the N potential bidders' production processes. In practice the agent must translate the principal's objective Δz_Z , or z_Z^* , to correspondingly

needed environmental criteria. Not violating the non-discriminatory and equal treatment principles of the EU procurement directives, we assume that she specifies a certain technology requirement that all N potential suppliers need to meet in purpose of qualifying as a bidder.

Assuming that the number of potential bidders, N , is known to the agent and that all potential bidders commit to a procured quantity, q^{PP} , allows the agent to set the level of technology, T^* , to be met by each bidder i in accordance to the function: §§§§.*****

$$T^* = g(z_Z^*, N) \quad (7)$$

Given q^{PP} , T^* is to be seen as an indicator of environmental performance, or productivity, at the firm level that is a function of the environmental objective set by the principal and the number of potential bidders, with the first order conditions $T_{z^*}^* \geq 0$ and $T_N^* \leq 0$. Obviously, in practice the agent face a challenging problem of finding the level of T^* that assures all the potential bidders to achieve an emission level ex post the procurement auction that, taken together, sum up to the environmental objective set by the principal. That is, if all N potential bidders actually enter the procurement auction then $z_Z^* = \sum_{i=1}^N z_i$ is fulfilled. For further analysis, here we make the very strong assumption that the agent actually succeeds.

§§§§ We assume that bidder i produces at least q^{PP} after the procurement auction. However, if all N potential bidders adjust to the environmental requirements of the GPP and one of the bidders actually produces more than q^{PP} after the auction, delivering to other buyers, the total amount of emission reduction will exceed the environmental objective set by the principal. Given that the objective, z^* , is set optimally in a welfare perspective, this is not an objective effective outcome and resources are wasted. Clearly, the technology set, T^* , is not optimal from a welfare point of view.

***** The potential bidders meeting exactly the same technological requirement resulting in $T^* = T^*$, do not necessarily turn them into a homogenous group of firms ex post the procurement auction. Rather, the firms become more homogenous in $(q_i - z_i)$ -space. In practice the requirements most likely address certain parts of the production process, and do not completely redesign the production process.

The GPP requirement, T^* , in Equation (7) can be seen as a minimum requirement level of environmental performance that each firm must fulfill to be an eligible bidder. This will affect the firms as potential bidders differently due to them being heterogeneous in their environmental performance, T_i , ex ante the procurement auction. Specifically, for all $i = 1, \dots, N$, the technological change necessary to become an eligible bidder is:

$$\Delta T_i = T^* - T_i \quad \text{and} \quad \Delta T_i \neq \Delta T_j \quad \text{if} \quad T^* > T_i \text{ then } \Delta T_i > 0 \quad (8)$$

A higher T_i is equivalent to a higher environmental productivity, i.e., a greener technology. The greener technology ex ante the procurement auction the less technological units, ΔT_i , bidder i has to invest in to achieve the technological level, T^* . This environmental heterogeneity among potential bidders will impose different adjustment costs as follows:++++

$$CA_i = g(T_i; T^*) \quad i = 1, \dots, N \quad (9)$$

Given the level of required technology, T^* , this function is assumed to be twice continuously differentiable with the following properties:

$$\frac{\partial CA_i}{\partial T_i} = MCA_i \leq 0, \quad \frac{\partial^2 CA_i}{\partial T_i^2} \geq 0, \quad (10)$$

where MCA_i is the marginal adjustment cost. Note that the conditions given in (10) imply that the adjustment cost in Equation (9) is convex in ΔT_i (Equation (8)).++++

++++ Adjustment costs may be seen in terms of investment costs, also including installation and learning costs. For a bidder, changing the technology generates disruption cost during installation and costly learning must be incurred as the structure of production may have been changed. Adjustment cost might also be irreversible absent secondary market of technology products (Barnett et al., 1999).

++++ If deciding to enter the procurement auction, the bidder must sink an irreversible and completely relation-specific adjustment cost.

Referring back to the discussion in Section 4, asymmetry in bidders' beliefs of ex ante environmental performance, $T_i \neq T_j$, is captured by the assumption that the bidders' cost of completing the contract is drawn from different conditional distributions, $F_i(c_i; CA_i)$. As a result, bidders' with relative high initial environmental performance (high T_i and low CA_i) stochastically dominate low performing bidders (low T_i and high CA_i) in a first order stochastic dominance sense according to the following definition (Arozamena and Cantillon, 2004):

For a given GPP-criteria and $CA_i < CA_j$; $F(c_i; CA_i) > F(c_j; CA_j)$, $i \neq j$, and

$$\frac{F'(c_i; CA_i)}{1 - F(c_i; CA_i)} > \frac{F'(c_j; CA_j)}{1 - F(c_j; CA_j)} \quad (11)$$

for all c where these expressions are well defined. §§§§§

Conditioning on any minimum level of cost, the stochastic conditional dominance in Equation (11) implies that $F(c_j; CA_j)$ is more likely to yield a higher cost than $F(c_i; CA_i)$ for all c on the interior of their common support, i.e. the cost distributions of high performing bidders' are shifted to the left of low performing bidders. Hence, bidders with relative high initial environmental performance have a competitive advantage over bidders having low initial environmental performance.

Summarizing the results so far, in Section 4 we showed that crucial to potential bidders' entry decision and, therefore, the objective effectiveness of GPP, is asymmetries in bidders' distributions from which they draw the parameter that reflects the cost of fulfilling the contract. This cost asymmetry is modeled as being contingent on differences in the cost of adjusting to GPP criteria. In this section we have further emphasized the role of differing adjustment costs, under the additional and reasonable assumption that GPP induced costs increase at an increasing rate as GPP stringency increases.

In the next section we explicitly address the question whether GPP may work as an objective effective environmental policy instrument in

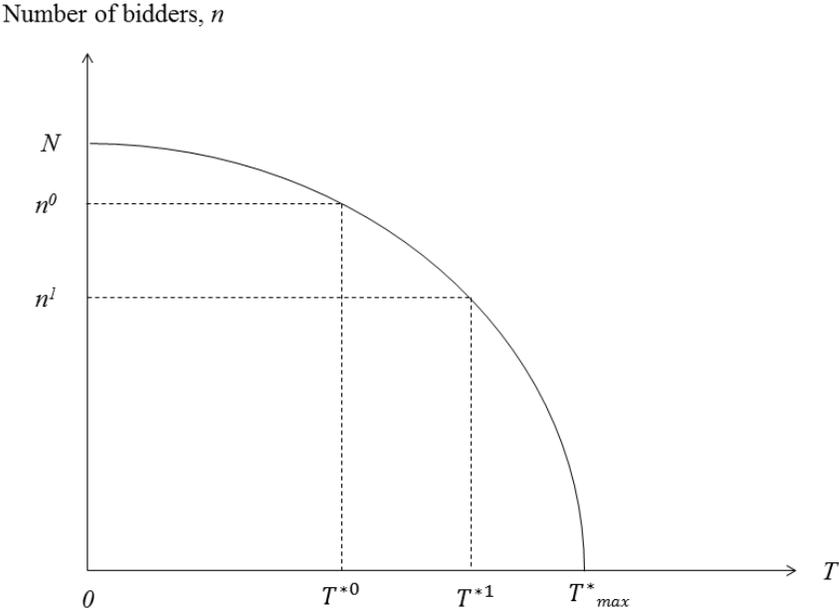
§§§§§ Compare the expression in Equation (4).

an environment characterized with asymmetric adjustment costs, increasing at an increasing rate as GPP requirements are strengthened.

5.2 Is GPP an objective effective environmental policy instrument?

Given that the principal has set the environmental objective to z_Z^* , suppose that the agent choose the GPP level, T^* , according to the expression in Equation (7), presumably binding for all N potential bidders. For firms to become eligible bidders they are required to adjust their production process according to Equation (8), in which Equations (9) and (10) establish the convex shape of the adjustment cost CA_i . Referring to Section 4 and the discussion on firms drawing production costs from distributions contingent on CA_i , and Equation (5) showing that potential bidders drawing costs above the threshold, i.e., $(c_i; CA_i) > u$, will not adjust, convex adjustment cost will have crucial importance for the functioning of GPP. That is, the more stringent GPP the more potential bidders will, at an increasing rate, not enter the auction, all other things being equal. Accordingly, the relationship between the number of actual bidders and GPP stringency can be described as in Figure 1.

Figure 1. Relationship between number of actual bidders and stringency of GPP.



In fact, as illustrated in Figure 1, GPP stringency comes with a “crowding-out” effect that gives rise to an environmental policy paradox. To see this, the agent implementing the GPP stringency, T^{*0} , will cause $N - n^0$ potential bidders not to enter the procurement auction. As the agent decides the GPP stringency given the expectation of N bidders entering the auction, this will lead to emission reductions that are too low compared to the environmental objective, z_Z^{*0} . However, for the sake of argument, assume that the agent knows beforehand that $N - n^0$ potential bidders will drop out given the GPP stringency level, T^{*0} , and therefore instead put further pressure on the remaining n^0 expected bidders, let us say T^{*1} .

However, in this case totally $N - n^1$ potential bidders will drop out. As a consequence, even more bidders will not enter the auction and, as $T^{*1} > T^{*0}$ and $N - n^1 > N - n^0$, the emission reduction will be even lower. That is, the more stringent GPP the more the environmental objective will be missed.

Given the concave relationship between the number of actual bidders and GPP stringency in Figure 1, the number of participating bidders will dwindle at an increasing rate as GPP gets more stringent. Consequently, the society's environmental objective, z_Z^{*0} , will never be achieved by GPP. Consequently, GPP is, given the assumptions made, not an objective effective environmental policy instrument.

The fundamental reason why GPP may be regarded as being an objective ineffective environmental policy instrument is mainly due to a combination of: (1) The cost of adjusting to GPP is assumed to increase with GPP stringency at an increasing rate and more importantly; (2) as the adjustment cost put bidders' with high environmental performance on a relative competitive advantage it might deter low performing bidders from entering the GPP auction. The intrinsic entry decision is the fundamental reason to why GPP may be regarded as being objective ineffective compared to other types of environmental economic and command-and-control policy instrument. A simple numerical example that illustrates this environmental policy paradox is given in Appendix A.

Finally, to find out whether GPP have less positive effects on the environment as it becomes more stringent (a negative relationship between the number of actual bidders and GPP stringency as shown in Figure 1), or whether there is no effect at all is an empirical question. A positive relationship between the number of bidders and GPP stringency would be an XXX result. It indicates that...

To summarize the findings, let's return to some of the assumptions underlying the conclusion that GPP is not an objective effective environmental policy instrument. The assumptions made were: heterogeneous potential bidders, incomplete information about potential bidders' technology (i.e. production costs), privately known costs, convex adjustment costs and no other active policy instrument with the same environmental objective in target.

The alternative to assuming potential bidders to be heterogeneous in their production technology is them being homogenous. This would of course be easier as the adjustment cost would be equal to all bidders and the fact that they face the same requirements in the same procurement auction (i.e. contract notice) would no longer be a problem. But for GPP to be objective effective requires that the agent has complete information about potential bidder's technology and that all of them adapts and enters. This takes us to the second assumption that information is incomplete. If the agent has complete information about potential bidders' production technology and they are heterogeneous the main principles of the EU procurement directives will most likely deter an objective effective outcome. Some potential bidders will still find the adjustment cost too high and either go-out of business or engage in other markets with less stringent criteria, including other governmental purchase.

The assumption of privately known costs for completing the contract (including the cost of adjustment) is conventional in the literature concerning procurement auctions and appears to be a reasonable starting point. Other cost structures including e.g. affiliation or uncertainty would just add complexity to the analysis and not increase the likelihood of GPP being objective effective.

The result that GPP will deter entry at an increasing rate is not contingent on the assumption of convex adjustment cost. As shown in the Appendix, assuming a linear relationship will not affect this conclusion. Furthermore, assuming concavity is not realistic – if adjusting becomes less expensive the browner the firm is how come brown firms are still observed?

Finally, assuming GPP to be the only policy instrument with a specific or several objectives in target is a simplifying assumption. Adding tools aiming to contribute to the same objective would only complicate the analysis. If there are existing tools GPP would have to be tailored to complement these which are a delicate matter. The main conclusion would however still be valid. Conclusively, it seems as the finding that GPP is an objective ineffective environmental policy instrument would survive alternating the assumptions made.

6. COMMENTS AND CONCLUSIONS

Worldwide there is a strong tendency for governments implementing GPP as a policy instrument in purpose of achieving environmental objectives. In comparison to other economic and command- and controls instruments, the key factor to why GPP is not objective effective is that it is voluntary from the perspective of potential bidders. While, e.g., a tax is mandatory, the potential bidder's adoption to a certain GPP-level is contingent on its decision to submit a bid. A binding GPP-level naturally gives rise to an adjustment cost for potential bidders which might deter potential bidders from entering the bidding process.

In contrast to Marron (1997) we argue that GPP provide incentives for green investments by all potential bidders, not necessarily only the winning bidder. Nevertheless, a potential bidder i with relatively high *ex ante* environmental performance is assumed to have a competitive advantage over low performing bidders. Bidder i 's conditional distribution of realized cost is hence stochastically determined by its initial environmental performance, e.g. degree of environmental productivity. So, under the assumptions of the model, potential bidders with relatively low initial environmental performance is more likely to draw a private conditional cost parameter larger than a uniquely determined threshold cost, and as such, do not enter the procurement auction. This finding has direct consequences for the objective effectiveness of GPP since the incentive scheme will target bidders with high initial environmental performance due to their low adjustment costs. In fact, any optimal level of GPP-criteria will give rise to a crowding out effect resulting in under investment in greener technology. Given the convex relationship between GPP-criteria and adjustment cost, the number of bidders that enters the procurement auction will dwindle at an increasing rate as environmental requirements get more stringent. Less obvious but potentially significant is the tendency of regulatory controls to discourage otherwise eligible bidders from taking risks and bearing costs uniquely associated with public contracting.

Based on our findings, the only prospect for GPP serving as an environmental policy instrument is when the green requirements are binding for at least one potential bidder. Accordingly, the stringency of

GPP must increase gradually over successive rounds, which in fact is the rationale for the non-dynamic one period game stated here. This analysis can be extended by considering the effect of increased bidder heterogeneity in successive GPP-auctions with gradually increased stringency. Another issue to be studied is the strategic price effect of decreased competition over successive round and how it might counteract with the threshold value, u , i.e. the entry decision of potential bidders.

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