"Towards a Measurement of the Benefits from Electronic Solutions in Government Procurement: Some Evidence from Brazilian Data"

by

Gian Luigi Albano[1], Ph.D.

27th March 2013

Table of Contents

[1] Email: gla@gianluigialbano.com or gl.albano@mclink.it.

1. Introduction

E-procurement is widely considered as a tool with important potential to deliver significant benefits to Governments. E-public procurement (for simplicity e-procurement henceforth) can streamline and accelerate public purchasing, benefiting both public purchasers and suppliers along the way. It can lead to more efficient procurement administration resulting in cost and time savings. When coupled with the development of centralized purchasing bodies - that is, bodies that perform a subset of the procurement phases on behalf of other public administrations - e-procurement can provide a way to optimise these efficiencies further, integrating resource-consuming support functions (*i.e.*, legal, product specific, statistical and economic) and delivering savings due to economies of scale and skill specialisation.

By automating and strengthening the flow of information about individual tender opportunities, e-procurement can help reach a wider audience and provide greater publicity, thus leading to increased participation by economic operators and, as a consequence, increased competition. E-procurement could also promote cross-border procurement, not just through greater publicity of contracts, but also by enabling a certain degree of language independence (through the use of e-Catalogues for example) and standardising certain practices. Equally, e-procurement presents an opportunity to introduce more rigor within procurement systems, providing ways to apply more objectivity in selecting suppliers and increase transparency thus contributing to better governance. Ultimately, it has the potential to result in better value for money for the taxpayer, which in the current financial climate could be very crucial for maximising the potential of constrained resources. E-procurement systems have already proved useful in speeding up the expenditure of public procurement budgets and therefore to increase the efficiency of the whole process.

Although there exists an almost unanimous consensus on e-procurement delivering sizeable benefits to both the demand and the supply side of the procurement market, little evidence has been produced to confirm such a conjecture. Worse, many researchers seem to be convinced that solid evidence could be grounded on surveys mainly relying on the interviewees' *perceptions* of benefits from e-procurement.[2] To our knowledge, benefits have never been measured[3] by relying on field data, that is, on data from real public procurement transactions. Since electronic solutions can be adopted at different stages of the procurement process, it seems wise to classify the benefits from e-procurement into two broad families: those stemming from a *lower transaction costs* and those from *enhanced competition*. In this paper, we focus on the latter class and attempt at designing a simple empirical strategy to measure the resulting benefits. We implement this strategy on a set of procurement processes (mainly simple IT equipment) that took place in Brazil in 2008/09/10. Our empirical analysis delivers two fundamental messages. First, consistently with our intuition, relying on electronic tools at the competition stage (that is, using e-auctions) increases the level of competition with respect to auctions in which bidders have to be physically present in the same room. Secondly, a quite more surprisingly, a higher level of competition in e-auctions, as measured by the number

[2] See section 3 below.
[3] A partial exception is represented by Singer et al. (2009). See the section on the related literature.

of active bidders, does *not* generate statistically significant *higher savings*. However counterintuitive, we provide an explanation as why this might be the case by exploiting some basic results from auction theory.

The paper is organized as follows. In section 2 we provide an operational definition of e-procurement and explain the qualitative features of our empirical strategy to assess its main benefits. In section 3 we review the most closely management and economics literature. In section 4 we describe the data coming from public procurement processes carried out in Brazil. Section 5 contains the main econometric analysis and section 6 concludes.

2. The main benefits of e-procurement

While a certain degree of consensus around the concept of "public procurement"[4] seems to exist, the same cannot be said for "e-procurement". While broad reference to the "use of electronic means" in frequently made, we can safely state that e-procurement refers to the process of replacing paper based procedures with ICT based communications and processing throughout the procurement cycle. Moreover, because of the use of electronics means innovative purchasing solutions can be adopted.

E-Procurement thus consist the introduction of electronic processes to support the different phases of a procurement process – publication of tender notices, provision of tender documents, submission of tenders, evaluation, award, ordering, invoicing and payment. The process is illustrated graphically in figure 1. It does inspire one major observation that will be instrumental for the remainder of our analysis. At its simplest, we can define a procurement process as an "e-procurement" process whenever *at least one phase* is conducted by using electronic means. Consequently, the potential benefits stemming from e-procurement will depend crucially on the particular phase(s) where the ICT solutions have been implemented.

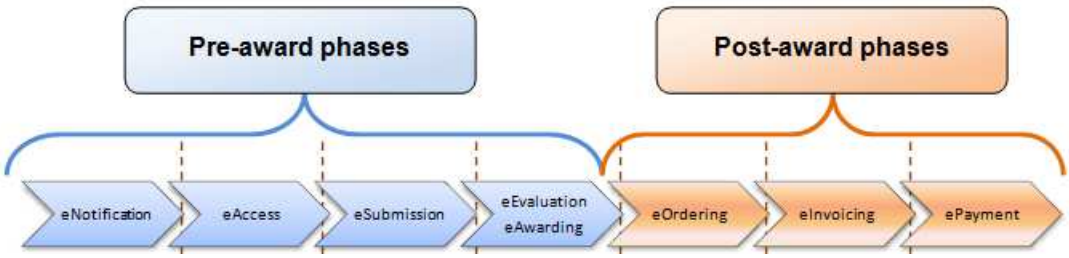


Figure 1: Overview of possible phases in an e-procurement process[5]

[4] Public procurement is the process whereby the public sector, that is, national, regional and local government and certain utilities, awards contracts to companies for the supply of goods or services, including building and construction works.

[5] The figure is taken from "Study on the evaluation of the Action Plan for the implementation of the legal framework for electronic procurement (Phase II) - Analysis, assessment and recommendations", Siemens, 2010.

Since ICT solutions can in principle be applied to different phase of the procurement process, the resulting benefits are likely to depend on which particular phases are concerned. Broadly speaking, though, the potential benefits from e-procurement can be bundles in three main groups.

1. **Benefits from reduced transaction costs**. They would include the net gain from investing and maintaining a portal for publication rather than having buyers pay for publications in official gazettes; running an e-auction rather than a paper-based (or physical one); electronic invoicing and payment rather than the traditional ones. All these benefits mainly focus on the demand side of the public procurement market. However, firms, and specifically small and medium enterprises, also reap some of the benefits stemming from more standardized (e-)processes, representing lower participation costs and, ultimately, lower barriers to entry in the procurement market.
2. **Benefits from enhanced competition**. These benefits stem from two channels. Publishing calls for tenders on a portal (e-notification) allows public buyers to reach a wider set of potential participants *regardless* of whether bids are submitted electronically or not. Alternatively, when an e-auction is used for awarding a public contract, *regardless* of whether publication is electronic, competing firms need not gather in the same *physical* place. In both circumstances, a higher number of potential bidders drives the level of competition up which benefits public buyers through lower prices. Moreover, a higher potential participation makes, all things being equal, collusive agreements less stable, thus, again, lower awarding prices.
3. **Benefits from enhanced integrity of procurement processes**. Corruption - that is, any misuse of entrusted power for private gain - is increasingly recognized as a major problem in public procurement and, more generally, in public as well as in private organizations. It is a widely shared view that discretion in decision making lies at the root of corruption in public procurement. Because it relies mainly on objective dimensions and on traceable procedures, e-procurement may become instrumental to lower discretionary power thus reducing the risk of corrupt practices.

2. A Step towards a New Methodology to Estimate (some of) the Benefits from E-procurement

2.1 The Transaction-Cost Argument

Since transaction costs arise at any stage of the procurement process benefits from introducing electronic solutions should in principle be evaluated along the procurement cycle. However, casual observation reveals that most of the e-procurement reforms in the last couple of decades aimed mainly at streamlining all phases until the award of a public contract. Consequently, if we limit our attention to the pre-award phases the discounted value of the costs, $C_{\text{e-proc}}$, to be borne for setting up and managing an e-procurement system might be written as follows:

$$C_{\text{e-proc}} = I_0 + (H_0 + M_0 + U_0) + \delta(H_1 + M_1 + U_1) + \ldots + \delta^{\text{T}}(H_{\text{T}} + M_{\text{T}} + U_{\text{T}}) \qquad (1)$$

where

I_0 = value of the up-front (time 0) investments (technology and human resources) mainly related to setting up an e-procurement platform; and then for each period t = 0, 1, …, T

H_t = value of the FTEs for operating the platform

M_t = maintenance costs of the platform

U_t = costs borne by the users of the platform (related to publishing, running an e-auction, training etc.)

T = number of years considered as the relevant time horizon for the initial investment

δ = discount factor which is inversely related to the relevant market interest rate *I*, that is,

$$\delta = 1/(1 + i).^{6}$$

Under a traditional public procurement system transaction costs are mainly variable costs borne for carrying out the process until the contract award. That is, when looking at T-period time horizon, the discounted value of the costs, C_{trad}, can be simply written

$$C_{trad} = (HH_0 + F_0) + \delta(HH_1 + F_1) + \ldots + \delta^T(HH_T + F_T) \quad , \qquad (2)$$

where

HH_t= value of the FTEs for carrying out the procurement process

F_t = value of non-human costs for awarding the contract (i.e. costs for publishing in official gazettes, administrative costs etc). Thus in principle an e-procurement system is welfare improving if and only if

$$\boldsymbol{C_{eproc} - C_{trad} < 0}.$$

2.1 The Enhanced-Competition Argument

By reducing barriers to entry in the public procurement market, e-procurement enlarges the set of potential participants thus triggering, in principle, tougher price competition. However, once an e-procurement system is in place or when electronic solutions are implemented at least for the awarding stage market outcome do have a different nature than under the non-electronic regime. Thus in order to estimate the benefits of e-procurement we should compare market outcomes when electronic tools are used with those arising when electronic tools are not used. In other terms we need a (solid) counterfactual argument. A potentially appealing argument hinges on the observation that in some countries public procurement regulation allows public buyers to award contracts for similar goods/services by using either an e-auction or a traditional auction, the latter requiring bidders to be *physically present* in a predetermined place. Then a simple estimate of whether e-procurement is effective in enhancing competition would consist in testing whether the difference in any period *t* (say, a year)

[6] If T = 10 years, the relevant market interest rate might be the yield of government's 10-year bonds.

$$S^t_{eproc} - S^t_{trad}$$

is significantly different from zero, where

S^t_{eproc} is the amount of savings generated in period *t* by using e-auctions and S^t_{trad} is the amount of savings generated in period ***t*** by using traditional ("physical") auctions, while controlling for a list of variables that would certainly include products'/services' (minimal) technical specifications, reserve prices, number of units bought, public buyer's characteristics (e.g. central vs. local government) and participation requirements (possibly via the initial estimated value of the contract).

In some circumstances, though, e-procurement reforms do not leave public buyers with any other option than using e-auctions (or any other ICT-based competitive procedure). When this is the case, e-procurement represents a structural break so that evaluation of savings can only be carried out by using different one point in time only, namely the moment when certain goods/services are bought by using an e-auction rather than a traditional auction. To put simply, suppose that public buyers used to buy a class of laptops by using a traditional auction until year t, and moved to e-auctions in year t+1. Thus there exists only one point in time in which comparing savings under the two different regimes may represent a meaningful exercise, namely the difference between achieved savings in time t+1 and time t. Comparing, for instance, savings in time t+10 and savings in time t would require comparing outcomes concerning completely different objects.

2.2 On the Measure(s) of Savings

In the previous section we have laid out the basic methodology for comparing savings from competitive procedure under two alternative scenarios, namely the traditional (non-electronic) "physical" tendering and the electronic auction. Such an exercise is in fact trickier than it looks like at a first sight as it relies on our ability to construct a measure of savings. The question then become how we estimate "savings" from using a competitive procurement procedure? Should we always expect *positive* savings?

Auction theory[7] teaches that competition might make the buyer better off with respect the most easily available outside option, consisting often in negotiating a deal with a local, possibly well known, supplier. By attracting new bidders competition should in principle yield lower purchasing cost than a private deal with the local supplier. Basically, by moving from one-to-one to a one-to-many market interaction, the buyer can exploit a higher bargaining power. The number of new bidders is mostly determined by level of (in)efficiency of the local supplier, that is, how costly is the buyer's outside option: the more inefficient the local supplier (implying a higher purchasing cost for the buyer) the higher the number of potential new bidders.

Thus a first definition of (absolute) savings would consist in *the (absolute value of the) difference between the outcome of a competitive bidding and the cost of the negotiation with the most easily available supplier*. The definition leaves some leeway in defining the outside option. From a practical viewpoint, it might consist in the price charged by any incumbent firm that used to supply non-competitively local buyers or the "average" posted price available on the local market. The choice of the benchmark price is crucial in that it

[7] See, for instance, Krishna (2009).

affects the measurement of the "performance" of any given competitive procedure. All else being equal, doubling the cost of the outside option doubles the value of achieved savings!

When knowledgeable to evaluate the cost of the outside option public buyers may decide to commit to a *reserve price*, that is, a ceiling to any offer they are willing to consider. When commitment is firm, a public buyer rejects any tender higher than the reserve price. By setting a reserve price *strictly* lower than the outside option a buyer bears the risk of not trading with any firm since it is possible that all potential participants (estimated) costs for carrying out the procurement task(s) are higher that the reserve price. However, under a set of circumstances, such a strategy may yield the buyer higher savings by inducing tougher competition among those firms that turn out to be efficient enough to participate in the competitive tendering.[8] In this case, the relevant measure of (absolute) savings would consist in the (absolute value of the) *difference between the outcome of a competitive bidding and the reserve price*. When public procurement is (at least partially) centralized though a central procurement agency/body awarding contracts on behalf of other public buyers, the reserve price can be meaningfully set at the level of the average purchasing price that public buyers can achieve without using the central procurement agency's *frame* contracts.

We are then in a position to draw two main conclusions. First, the logic for benchmarking the outcome of a competitive process against a particular outside option may depend on different institutional details. Second, because the value of the outside option does affect the measurement of savings, public buyers may be tempted by inflating artificially the former in order to raise the performance of the competitive process.

3. Related Literature

A growing literature between management science and the theory of organizations provides analyses of real cases studies of ineffective or harmful implementations of e-procurement solutions. The table below classifies the main implementation problems in 9 different families and the list of most closely related research works.[9]

Nature of the Problem	Description	Partial or full discussion provided by
Fragmented understanding of technological dynamics, implementation and spotty legislative support	E-procurement means different things to different stakeholders. Systems are implemented in a localized manner. There is limited organizational or national integration or legislative coordination.	Hawking et. al (2004), Andersen (2004), Gichoya (2005), Henriksen and Mahnke (2005), Preuss (2007), Hardy and Williams (2008), Bof and Previtali (2007), Varney (2011), Mota and Filho (2011), Hui et al. (2011), Hoque et al. (2011)

[8] This is a classical, albeit somewhat counterintuitive, result in auction theory that goes under the name of the *exclusion principle*. See Krishna (2009).

[9] The classification is borrowed from Roman (2012).

Technology's "halo" effect, lack of technological "know how" and financial constraints and waste	The expectation that it is sufficient to implement the technology and the benefits "will come". Implementing e-procurement without providing the supportive context is unlikely to lead to desired outcomes. Limited understanding of technological effects coupled with lack of experience in the matter cause great financial waste and strategic disappointments	Andersen (2004), Hawking et. al (2004), Gichoya (2005), Henriksen and Mahnke (2005), Bof and Previtali (2007), Hardy and Williams (2008), Varney (2011), Mota and Filho (2011), Hoque et al. (2011)
Incompatibility of platforms or managerial/philosophical strategies	E-procurement systems are often incompatible with other digital platforms used by organizations or with older e-procurement software.	Croom (2000), Andersen (2004), Gichoya (2005), Varney (2011), Karjalainen and Raaij (2011), Hoque et al. (2011)
Interrupted (punctuated) implementation: Or the need for maintaining dedication and learning beyond first stage adoption	As it is the case with the majority of ICT use in government, e-procurement adoption is undertaken in spurts. At this point in time, there is an obvious shortcoming in continuous support and dedication to the idea. Early failures stymie future investments or transformational changes.	Andersen (2004), Varney (2011), Mota and Filho (2011)
Internal customer satisfaction and maverick purchasing	If the e-procurement software is found to be inadequate for organizational needs and not representative on the decisionmaking dynamics within the agency - procurement specialists will "go around" the system. Thus, any benefit from e-procurement will be lost since the system's use is rather trivial.	Croom and Johnston (2003), Brandon-Jones and Carey (2010), Mota and Filho (2011), Varney (2011), Karjalainen and Raaij (2011)
Resistance to technology and cooptation.	Organizations often resist the changes associated with e-procurement adoption. Without a proper approach and managerial support the system will be resisted and sabotaged or passively co-opted.	Hawking et. al (2004), Croom and Johnston (2003), Brandon-Jones and Carey (2011), Mota and Filho (2011), Hoque et al. (2011)

Complexity, uncertainty, ambiguity and network-driven contractual instability	Public procurement is probably one of the most complex areas of public administration. Within the context of increasing reliance on contracts and networks matters, matters become even more complicated. The governance complexity and instability make effective e-procurement (transformative procurement in general) challenging and at times even technologically prohibitive.	Croom (2000), Andersen (2004), Enquist, Johson and Camén (2005), Henriksen and Mahnke (2005), Enquist, Brown, Potoski and Van Slyke (2006, 2007, 2009), Varney (2011), Enquist, Camén and Johnson (2011), Entwistle (2011), Peck and Cabras (2011), Hoque et al. (2011)
Biased data or "dead end" collection	Either due to financial and knowledge constraints, strategic focus or organizational and legislative design - the data and insights garnered by employing e-procurement are not used. When such data are considered, it is often the case that it's done in a biased manner.	Andersen (2004),Gichoya (2005), Hardy and Williams (2008)
Developers are not "public" ready, oriented or reasonably priced	The platforms available on the market are either primarily oriented for the private sector or are not sufficiently sophisticated to address the complexity and network-driven needs of a public entity.	Andersen (2004), Hawking et. al (2004), Bof and Previtali (2007), Varney (2011)

The most relevant paper for our purposes is Singer et al. (2009). The authors estimate the enhanced competition effect generated by public buyers using the Chilecompra's electronic platform which arguably allowed a higher number of firms to compete for public contracts. By assuming certain properties of the statistical distribution of submitted bids, the authors are able to estimate the additional savings stemming from a more intense participation. However, unlike the methodology that can be applied in the Brazilian system as explained in the next sections, in the Chilean case one cannot observe the counterfactual of public buyers *not* using an electronic tendering procedure. Thus the authors are bound to ask individual public buyers how many additional competing firms they have been observing since they started using the Chilecompra's platform. Although it is very hard to figure out a different way to capture the enhanced-competition effect, it remains nonetheless true that such methodology definitively introduces a potentially interfering dimension of subjectivity in the savings estimation technique.

4. Toward a Measurement Strategy: Public Procurement Data from Comprasnet Brasil

4.1 Data description and polishing procedure

The database employed contains data on several types of tenders, including RFQs, calls for bid and auctions. The period of reference covers three years, from 2008 to 2010. The object of the tenders includes standardized goods, such as notebooks and related accessories, hardware and office material. The quantities supplied vary from tender to tender. As to the buyers, the public authorities involved are divided, according to a territoriality criterion, into local, state and federal authorities.

Moreover, an ID variable is provided, which identifies each single participant to the tender, the number of placed bids and their related value. Finally, we have reported, per unit of product, both the value of the awarded contract and the reference price fixed by the public authority, on which the percentage discount is computed.

In order to perform the empirical analysis on the procurement market of Brazil, we rearranged the available raw data through the following steps:

1. we kept the electronic and physical auctions, which are the main focus of our work;
2. we excluded the auctions for which the awarded value of the contract was above the fixed reference price, in order to avoid biases in the discount analysis;
3. we did not take into account the auctions reporting a zero value of the bid, since this value is probably due to a measurement error.

Moreover, comparing the database with the official publications available on the website www.comprasnet.gov.br , we encountered that, in certain cases, the value of the awarded contracts and the reference price were reported either on a per unit basis or on the total value of the contract without specifying a unique criterion of classification. Thus, we decided to consider the total value of the awarded contract and, taking into account the percentage discount given in each tender, estimated the total value of the reference price. These two variables – total value of the awarded contract and of the reference price – will be employed in our empirical analysis.

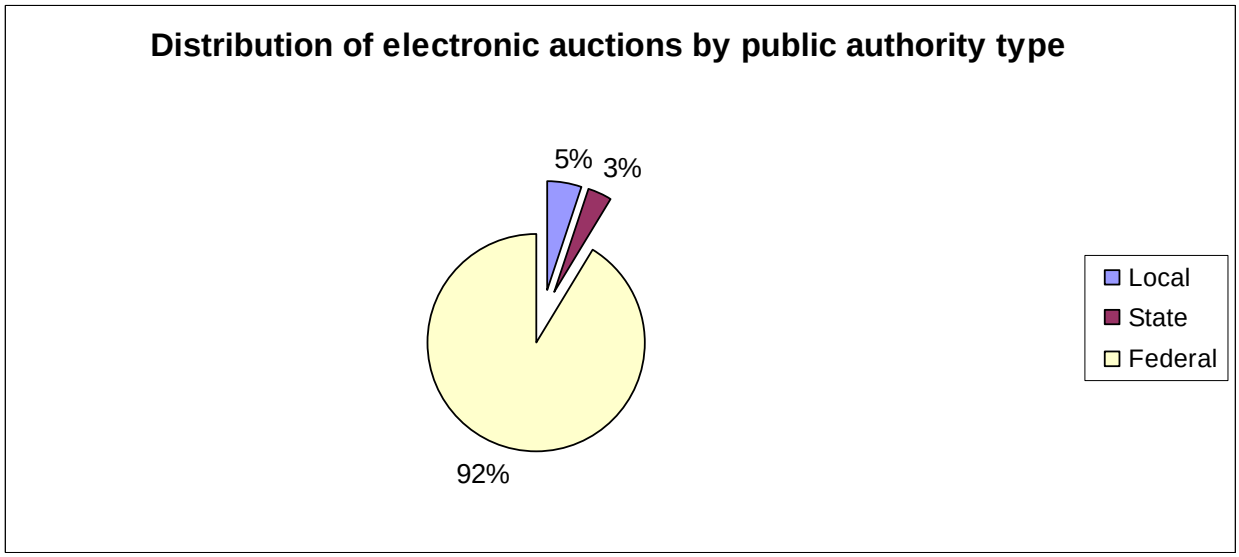
4.2 Descriptive Statistics

The new database, resulting from our polishing procedure, is composed of both *physical* and *electronic* auctions. The original aim was to compare these two classes in order to detect any significant difference, in terms of amount of discount and degree of competition, associated with the passage from a physical to an electronic auction market. Unfortunately, the physical auctions correspond approximately to 1% of our sample. Thus, due to a very low degree of representativeness, it is impossible to investigate the phenomenon through a reliable empirical analysis.

Electronic Auctions

The sample of electronic auctions is composed of 2785 tenders, divided into three categories - local, state and federal authorities - depending on the territorial jurisdiction of the purchasing public authorities.

Graph 1 below illustrates that the largest part of the contracts (92%) are awarded by state authorities, followed by local (5%) and federal (3%) authorities.



Graph 1: Distribution of electronic auctions by public authority type

Furthermore, we take into account two main variables of interest, corresponding to the two main aspects of our investigation: we have a variable *'perc_discount'*, which specifies the value of the discount obtained as the difference between the awarding price and the reference price; we then consider, as a proxy of the degree of competition, the variable '*numb_part'*, which counts the total number of participants per each tender.

Regarding the first variable, the average discount obtained is around 32% as reported in the table below. The table also shows that the average discount value is higher for state authorities, while it decreases slightly for local and federal: it could be inferred, then, that a contract subscribed by the authority with an intermediate territorial jurisdiction results to be somehow more attractive to the firms participating at the auction.

Table 1: Summary statistics for percentage discount obtained

	MIN	MAX	MEAN	MEDIAN	Q1	Q3	ΔQ3-Q2	STD. DEV.	N
Total	**0,0**	**99,8**	**32,1**	**30,8**	**12,6**	**49,4**	**36,8**	**22,5**	**2785**
Local	0,0	98,8	31,6	29,4	12,4	49,3	36,9	23,5	143
State	0,0	88,4	33,0	30,7	19,9	49,6	29,8	20,2	97
Federal	0,0	99,8	32,1	30,9	12,4	49,4	37,0	22,5	2545

Concerning the variable '*numb_part*', as it is evident in both Table 2 and Graph 2, the distribution of the number of participants is pretty right-skewed, with a mean of about 14 participants and a median of 12 at each auction. Furthermore, there seems to be relatively less participation in the e-autions run at the federal level. This can be explained by factors such as capacity and distribution network constraints, or significant transportation costs that suppliers may have to face in order to serve a widespread territory like the Brazilian one.

Graph 2: Distribution of the number of participants

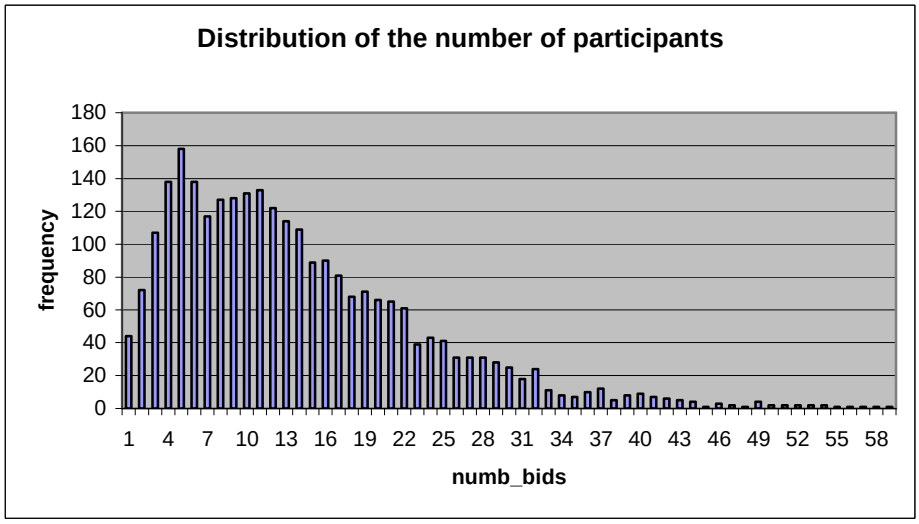


Table 2: Summary statistics for number of participants

	MIN	MAX	MEAN	MEDIAN	Q1	Q3	ΔQ3-Q2	STD. DEV.	N
Total	**1**	**114**	**14,3**	**12**	**7**	**19**	**12**	**9,9**	**2785**
Local	1	55	15,4	13	8	21	13	10,4	143
State	1	57	15,6	13	8	20	12	10,4	97
Federal	1	114	14,2	12	7	19	12	9,8	2545

In Table 3, we indicate the different reference prices. The mean value in the whole sample is around 8,000 Brazilian Real (approximately 4,465 USD at the exchange rate of Dec 3, 2011) , with a median of roughly 1,300 Brazilian Real. Unexpectedly, a negative relationship emerges between the contract value and the level of centrality of the purchasing authority: most valuable contracts are awarded at a local level.[10]

Table 3: Summary statistics for the value of contracts

	MIN	MAX	MEAN	MEDIAN	Q1	Q3	ΔQ3-Q2	STD. DEV.	N
Total	**0**	**1,182,400**	**8,444**	**1,351**	**90**	**4,205**	**4,115**	**39,768**	**2,785**
Local	13	589,030	21,479	3,332	425	10,271	9,846	75,357	143
State	3	214,909	12,069	2,200	178	6,400	6,222	31,659	97
Federal	0	1,182,400	7,573	1,150	84	3,900	3,816	36,947	2,545

Table 4: Correlation analysis by public authority type

CORRELATION	Total	Local	State	Federal
discount(%) - numb_part	0.23	0.26	0.11	0.23
numb_part – contr_value	0.18	0.40	0.04	0.17
discount – contr_value	0.12	0.09	0.21	0.13

Finally, we performed a correlation analysis between the three variables considered above. There exists a positive (though weak) correlation between the variables *perc_discount* and *numb_part*, less pronounced for auctions with state authorities. Moreover, there is a positive correlation between the number of participants and the value of contracts (especially strong for contracts subscribed with local authorities). The same positive relationship is detected between the value of contract and the total discount.

[10] We are considering, the values in the national currency (Brazilian Real). Later on, in addition to the national currency, we will seldom provide the counterfactual value in US dollars, considering the exchange rate at the 1st January 2011. 1 Brazilian Real = 0,60$

Another interesting descriptive statistic may be the one related to the number of bids of the winning suppliers. As we can see, referring to the mean value, more bids are needed to subscribe contracts with state and federal authorities, while a relatively lower degree of "effort" is required for local authorities. In any case, it is impossible to reach a unique conclusion, since the median values are very similar through the entire sample.

Table 5: Summary statistics for the number of bids of the winning suppliers

	MIN	MAX	MEAN	MEDIAN	Q1	Q3	ΔQ3-Q2	STD. DEV.	N
Total	**1**	**231**	**16.0**	**9**	**3**	**21**	**18**	**19.4**	**2785**
Local	1	112	14.9	7	2.5	21	18.5	18.8	143
State	1	92	16.3	7	2	25	23	20.2	97
Federal	1	231	16.1	9	3	21	18	19.4	2545

Physical Auctions

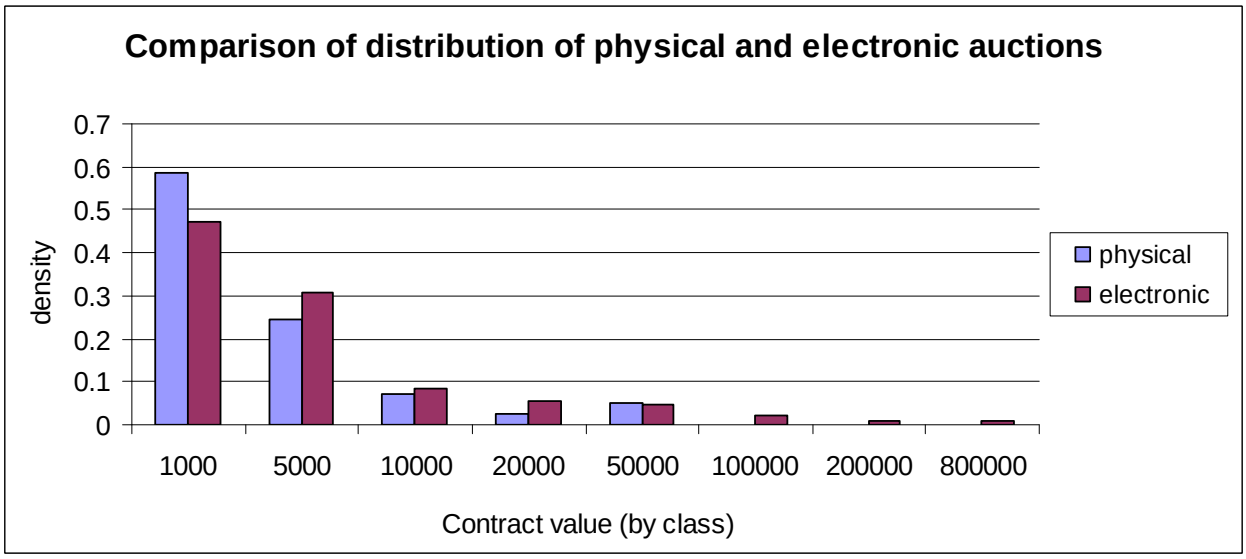
As mentioned above, our sample contains a very low percentage of physical tenders (around 1%), with respect to the total sample. It is therefore impossible for us to further investigate the phenomenon through a complete empirical analysis. As a consequence, we will adopt a generic framework providing a comparison of the descriptive statistics referred to the physical and electronic auctions.

Let us start from the distribution of the 40 physical tenders included in our sub-sample. Graph 3 illustrates the distribution of the physical and electronic auctions in the sample. As we can see, the density is higher for small values and decreases for higher values[11] of the contracts. Despite the different number of observations in the two samples, the distribution is very similar, suggesting that a comparison in term of descriptive statistic is possible[12].

Graph 3: Comparison of distribution of physical and electronic auctions

[11] In the Graph, the values are given in the national currency (Brazilian Real). In US dollars, the values go from 600$ to a maximum of 480,000$, considering 1 Brazilian Real = 0,60$ at the 1st January 2011.

[12] In this case, we are not considering the division for territorial purchasing authorities, since all the physical auctions provided are at a federal level.



We can now concentrate our analysis on the percentage discount deriving from the electronic and physical auctions. In this case, since the two distributions are similar, we will not mention the discount value in Brazilian Real, because the expected results would be similar. In Table 6 we have the number of participants, the value of the contracts, and the percentage discount. It is evident that the physical auctions attract a lower number of participants, roughly through looking at the mean value. Thus, lower transaction and participation costs are very likely to play a key role in the participation of the electronic market. The value of the contracts, on the other hand, are very similar, as for the percentage discount. This result, at first sight, may seem controversial, but it can be explained as a benefit deriving, for what concerns the physical auctions, from the direct negotiation between suppliers and public authority. Indeed, many physical auctions have just one participant, which is consistent with the hypothesis described above

Table 6: Comparison between physical and electronic auctions

	Number of participants	Contract value	Discount(%)
physical	2.9	3362	31.2
electronic	13.86	3417	32.0

The next step of our brief analysis is to compare the variables concerning the percentage discount and the value of the contract by fixing the mean value of the participant. This was done by randomly re-sampling the observations. As we can see in the next graph, it is evident that the difference between the two types of auctions increase considerably.

Table 7: Comparison between physical and electronic auctions (fixing the average value of the number of participants)

	Number of participants	Contract value	Discount(%)
physical	2.9	3362	31.2
electronic	2.9	1514	16.2

In conclusion, the limited analysis described above cannot be held as fully reliable, due to the low representativeness of the physical auctions. A larger number of physical tenders would (have) allow(ed) for a more robust empirical analysis. For instance, it would be instructive to broaden the analysis on the correlations between the (low) degree of competition and the physical tenders' exogenous characteristics (value of the reference prices, territorial jurisdiction) in order to compare the marginal and total effects with respect to electronic auctions.

In the next section, we will construct and discuss our econometric model by restricting our analysis to the sub-sample of electronic auctions.

5. The Econometric Model

Our aim is to investigate the correlation between the average discount value - estimated as the difference between the awarding price and the fixed reference price - and other covariates referred to some characteristics of the tender. *This first step will be useful to understand which may be the optimal participation pattern, that is the number of participants that maximizes the discount value per tender.*

5.1 List of variables

Let us now list our variables, starting from the response variable.

- *"Perc_discount":* This variable refers to the percentage value of the discount expressed in Brazilian Real.
- *"Numb_part":* This variable refers to the number of participants for each tender. It will stand as the most important independent variable in our model. The correlation between this and the discount variable will give us the amount of discount increase that derives from the participation of one more participant. We will also use the quadratic term – "*Numb_part2*" – to identify the marginal impact of competition.
- *"Local/State/Federal":* These represent three dummy variables, which refer to the territorial jurisdiction of the purchasing authorities. Our reference dummy will be the local level.
- *"Numb_bids":* This variable accounts for the number of bids of the winning suppliers.

- *"Numb_bids_others":* This variable reports the average number of bids of all the participants other than the winner.
- *"Contr_value"* : This variable indicates the value of the contract of each tender.

The econometric model that we will estimate is the following:

$$perc\_discount = constant + numb\_part + numb\_part^2 + state + federal + numb\_bids + numb\_bids^2 + numb\_bids\_others + numb\_bids\_others^2 + contr\_value$$

In order to have immediate and intuitive results, we implemented a simple robust OLS model, without investigating the model specification. The latter could be promptly implemented in case of further analysis of the data.

5.2 Results

Five models are estimated using the model introduced above. In the first model, we look at the impact of the number of participants on the (percentage) discount obtained. We then add public authority dummies (*local*, *state*, *federal*), the value of the contracts (*contr_value*), and the number of bids of the winner (*numb_bids*) and the other participants (*numb_bids_others*).

Table 8: Estimation results (base model)

	(1)	(2)	(3)	(4)	(5)
numb_part	0.56***	1.40***	1.40***	1.32***	1.28***
	(12.74)	(11.07)	(11.07)	(10.38)	(9.95)
numb_part2		-0.02***	-0.02***	-0.02***	-0.02***
		(-6.89)	(-6.89)	(-6.40)	(-5.91)
State			-0.04	-0.36	-0.61
			(-0.01)	(-0.12)	(-0.20)
Federal			-0.78	-1.02	-1.47
			(-0.40)	(-0.52)	(-0.76)
numb_bids				0.12***	0.28***
				(4.59)	(4.49)
numb_bids2				-0.00**	-0.00**
				(-3.16)	(-3.14)
numb_bids_others				0.06	0.07
				(0.75)	(0.47)
numb_bids_others2				-0.00	-0.00
				(-0.28)	(-0.23)
contr_value					-0.00**
					(-2.00)
Constant	23.40***	17.46***	18.16***	16.75***	16.42***
	(30.47)	(15.60)	(8.35)	(7.62)	(7.39)
R - squared	0.055	0.073	0.073	0.085	0.089
Adj. R-Squared	0.055	0.073	0.072	0.083	0.086
N	2785	2784	2784	2783	2783
Prob>F	0.00	0.00	0.00	0.00	0.00

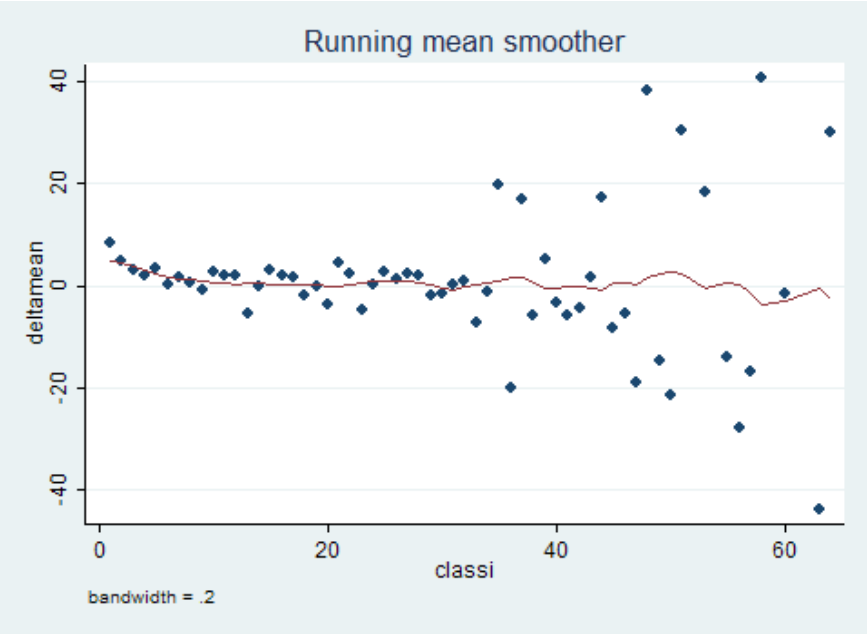
In column (1), there is a positive impact of the number of participants: the greater is the degree of competition, the larger is the discount obtained. Although the coefficient is statistically significant and goes in the expected direction, it is very low in magnitude. Thus, it is reasonable to believe that participation and discount are non-linearly related and, in order to further investigate the phenomenon – that represents the main goal of this work – we add, in Column (2), the square of the variable *numb_part*. Both coefficients are statistically significant: more specifically, the coefficient associated with the number of participants is now larger and still statistically significant; the quadratic term is, instead, estimated to be negative, which corroborates our expectation of a non-linear relationship between the two variables. It can be reasonably

argued, indeed, that increasing participation may increase competition and, hence, improve the final result, that is, the discount obtained; at the same time, for gradually higher levels of participation, the marginal benefit of an additional participant is diminishing.

In column (3), we introduce the dummy variables indicating the type of purchasing public authority, fixing local authorities as our reference dummy. The resulting estimates show that firms competing for contracts with state or federal authorities offer lower discounts. This result contradicts what emerged from the descriptive statistics, although these cannot be taken as fully reliable, due to the very poor representativeness for local and state authorities. The estimated coefficients, indeed, turn out to be not significant. Column (4) adds the two variables *numb_bids* and *numb_bids_others*, which count, respectively, the number of bids of the winner and the average number of bids of other participants. The squares of these two variables are also considered. The number of bids made by the winner proves to affect positively and significantly the discount obtained. The relationship is, however, once again non-linear: the greater the number of bids of the winner, the larger the discount obtained, but this effect gradually decreases. On the other hand, the coefficient estimated for the average number of bids of the other participants, though positive, turns out to be not statistically significant. In Column (5), finally, we estimate the impact of the contract value: unexpectedly, more valuable contracts seem to be significantly associated with lower discounts.

In order to get an even more in-depth picture, we performed a further analysis aimed at identifying a participation threshold beyond which there is a decreasing marginal gain in terms of discount obtained. Graph 2 relates the variable *classes*, indicating the number of participants by class, and the variable *deltamean*, defined as the difference of the (average) discount between each class and the previous one. The red line describes the trend of the moving average at 20% of observations.

Graph 2: Discount moving average by participation class



It is graphically possible to identify a certain dispersion for auctions with over 30 participants. This would suggest the irrelevance of such participation levels. Actually, the econometric model (Table 9) seems to confirm our intuition: coherently with the above graphical analysis, for the sub-sample of auctions with more than 30 participants, no statistically significant coefficient is estimated and the model as a whole proves to be unstable and with a very low significance level (Column (1)). On the contrary, below 30 participants, the variable *numb_part* is positively and significantly correlated with the discount obtained, although the negative sign of the quadratic term shows the concavity of such a relationship (Column (2)).

Furthermore, within the threshold of 30 participants, it is possible to identify an additional cutoff value, above which the coefficient associated with the variable at issue (*numb_part*) is always positive but decreasing for larger classes of participation. Columns (3), (4) and (5) report the results for three sub-samples with a threshold of, respectively, 25, 20 and 15 participants. The coefficient of the quadratic term exhibits the same pattern, indicating, at the margin, a lower and lower additional discount as participation grows. For tenders with less than 15 participants, on the other hand, it is not possible to capture an equally regular trend between the number of participants and the discount obtained.

Table 9: Estimation results (base model with participation thresholds)

	numb_part > 30	Numb_part ≤ 30	Numb_part ≤ 25	Numb_part ≤ 20	Numb_part ≤ 15
	(1)	(2)	(3)	(4)	(5)
numb_part	0.32	2.03***	2.60***	2.98***	4.24***
	(0.55)	(8.54)	(8.71)	(7.30)	(6.64)
numb_part2	-0.00	-0.04***	-0.07***	-0.09***	-0.17***
	(-0.47)	(-5.56)	(-6.11)	(-4.79)	(-4.65)
State	-106	0.18	1.82	1.29	4.01
	(-1.00)	(0.06)	(0.58)	(0.38)	(1.06)
Federal	0.32	-1.84	-1.35	-1.39	-0.52
	(0.04)	(-0.92)	(-0.65)	(-0.64)	(-0.21)
numb_bids	0.81**	0.24***	0.28***	0.29***	0.27**
	(2.72)	(3.78)	(3.92)	(3.81)	(3.17)
numb_bids2	-0.01**	-0.00**	-0.00**	-0.00**	-0.00**
	(-2.48)	(-2.51)	(-2.90)	(-3.08)	(-2.44)
numb_bids_others	-6.21**	0.11	0.13	0.16	0.23
	(-2.66)	(0.74)	(0.87)	(1.01)	(1.35)
numb_bids_others2	0.39**	-0.00	-0.00	-0.00	-0.00
	(2.11)	(-0.31)	(-0.35)	(-0.45)	(-0.83)
contr_value	-0.00	-0.00**	-0.00**	-0.00**	-0.00**
	(-0.03)	(-2.68)	(-3.05)	(-2.90)	(-3.18)
Constant	42.33**	12.99***	10.01***	8.58**	3.77
	(2.53)	(5.27)	(3.81)	(3.01)	(1.13)
R- Squared	0.091	0.091	0.092	0.096	0.097
Adj. R - Squared	0.045	0.088	0.089	0.092	0.093
N	185	2599	2437	2163	1764
Prob>F	0.05	0.00	0.00	0.00	0.00

7. Final Comments and Conclusion

The report provides a novel approach to estimate savings from carrying out electronic rather than non-electronic public procurement procedures. In particular, we have focused on one major feature of the Brazilian public procurement regulation that makes the use of e-auctions *compulsory* for standardized goods, whereas leaving the opportunity of adopting *physical* auctions (that is, reverse auctions whereby bidders have to gather *physically* in the same place to submit their bids) only in exceptional circumstances. It turns, however, that some public buyers seem to rely on physical auctions even in normal circumstances, namely to purchase goods that some other public buyers purchase by using e-auctions. Discussions with Dr. Florencia Ferrer, a well-known specialist of the Brazilian public procurement system, confirmed that in fact the use of physical auctions is not restricted to exceptional circumstances. Thus the results from physical auctions might provide the much-hoped-for counterfactual to evaluate the extra level of competition triggered by e-auctions. We conclude by drawing the reader's attention to two main aspects of our

investigation that should in principle be taken into proper account for future investigation on the same matter.

First, and perhaps foremost, the role of the *reserve price* in the computation of savings. No information was and normally is available as to the rationale used by each single purchasing body in determining the level of the reserve price. Two policy recommendations are in order here:

- Reserve prices should not in principle coincide with the buyer's available budget. While the buyer's budget determines the highest possible amount that can be spent, the reserve price should rather reflect the buyer's most immediately, possibly non-competitive, available option.
- The reserve price for a good to be bought at time *t* should reflect some of the information coming from a competitive process at time *t-1* for the same good. In other words, the outcome of even a single e-auction should modify the buyer's information at least about the most expensive purchasing option. Under normal circumstances, all else being equal, the reserve price for a standardized commodity should be at least weakly decreasing over time. However, we might have quite solid reasons to believe that buyers are reluctant to lower the reserve prices over time as this would positively influence the magnitude of resulting savings, which in turn might be used one of the proxies for the performance evaluation of the procurement process.

Second, it is questionable the extent to which we can aggregate savings resulting from a large number of e-auctions used for purchasing standardized but non-identical objects. While econometric estimations would certainly benefit from using data on very similar goods - say, *portable* PCs rather than the broader class of PCs - *contract heterogeneity* may turn out to be less worrisome than one would expect provided that reserve prices are set in a similar manner across different product categories. In other terms, if the buyer's rationale for setting the reserve price for a photocopier is similar to the one used for the reserve price of a portable PC then averaging out savings across many e-auctions would not raise concrete concerns. This confirms one more time the crucial role played by the reserve price although the econometrician is bound very often to consider it as a "black box."

APPENDIX

Below we list the questions that we addressed to several institutional stakeholders in three Central and Latin American countries in order to obtain data on electronic and physical auctions. The questions contain what we consider the minimal information set on public contracts in order to carry out any sensible empirical analisis on savings.

1. Qué modalidades existen en el país para la adquisición de bienes estandarizados? Por favor describa brevemente cada una de dichas modalidades.
2. Para la adquisición de un mismo bien se podrían aplicar diferentes modalidades de contratación? De qué depende?
3. Existe subasta inversa electrónica para la adquisiciones de bienes estandarizados?
4. Existen adquisiciones de bienes estandarizados por medios NO electrónicos?
5. Que porcentaje (estimado) de subastas inversas se realizan por medios electrónicos? (si aplica)
6. Existe un registro de las adquisiciones realizadas por medios NO electrónicos?

Para este estudio necesitamos comparar los datos de adquisiciones por subasta inversa de los mismos bienes, tanto en modalidad electrónica como presencial. Para este fin, necesitaríamos una base de datos (en un archivo simple de excel) con los datos de un set determinado de bienes estandarizados en los que existan muchos datos, en un período mínimo de 3 años. (si es posible más, mejor.) Al final de este mensaje, consta la tabla de datos con los campos requeridos.

Sería muy valioso contar también con la información de adquisiciones públicas de los mismos bienes que no hayan sido realizadas por medios electrónicos, de ser posible.

La selección de rubros sería de común acuerdo, me permito sugerir los siguientes, a manera de ejemplo:

• Bienes relacionados con informática (computadores y servidores, especialmente)
• Vehículos
• si es posible algún tipo de servicio estandarizado.

Campo Descripción/opciones
* Año de Compra año en que se realizó la compra
* Identificativo entidad De preferencia un número de identificación único o el nombre de la entidad
* tipo de entidad Municipal, provincial o gobierno central
* Tipo Bien o servicio

* Identif Compra un número o clave que identifique a la transacción
* Modalidad Compra Subasta inversa electrónica, presencial, convenio marco etc
* Codigo bien o servicio codificación del objeto adquirido
* Descripción del bien Descripción del objeto de contratación
* tipo de unidad Litro, kilo, días, unidades, etc (si aplica)
* cantidad Cantidad comprada
* Identificativo del ofertante Número de identificación único del ofertante
* Cantidad de ofertas del vendedor En caso de subasta, el número de ofertas que realizó el ofertante
* Precio referencial total (inicial) Precio del que partió la subasta, o precio presupuestado por la entidad
* Precio referencial unitario Precio referencial por unidad
* Valor Última oferta última oferta del ofertante
* Valor unitario final precio unitario final en que se adquirió. Solo aplica al ofertante adjudicado.

References

Andersen, K. V., (2004), *E-government and Public Sector Process Rebuilding (PPR): Dilettantes, Wheelbarrows, and Diamonds*, Boston: Kluwever Academic Publishers.

Bof, F., and P. Previtali, (2007), "Organisational Pre-Conditions for e-Procurement in Governments: The Italian Experience in the Public Health Care Sector," *The Electronic Journal of e-Government* 5(1): 1-10.

Brandon-Jones, A. and S. Carey, (2010), "The Impact of User-Perceived e-Procurement Quality on System and Contract Compliance," *International Journal of Operations & Production Management*, 31 (3): 374-96.

Brown, T. L., Potoski, M. and D. M. Van Slyke, (2006), "Managing Public Service Contracts: Aligning Values, Institutions and Markets," *Public Administration Review,* 66 (3): 53-67.

Brown, T. L., Potoski, M. and D. M. Van Slyke, (2007), "Trust and Contract Completeness in the Public Sector," *Local Government* Studies, 33(4): 607-23.

Brown, T. L., Potoski, M. and D. M. Van Slyke, (2009), "Contracting for Complex Products," *Journal of Public Administration Research and Theory*, 20 (supplement 1): I41-58.

Croom, S., (2000), "The Impact of Web-Based Procurement on the Management of Operating Resources Supply," *The Journal of Supply Chain Management*, 36(1): 4-13.

Croom, S. and R. Johnston, (2003), "E-service: Enhancing Internal Customer Service Through e-Procurement," *International Journal of Service Industry Management*, 14 (5): 539-55.

Enquist, B., Johnson, M., and C. Camén, (2005), "Contractual Governance for Sustainable Service," *Qualitative Research in Accounting & Management*, 2(1): 29-53.

Enquist, B., Camén, C., and M. Johnson, (2011), "Contractual Governance for Public Service Value Networks," *Journal of Service Management*, 22(2): 217-40.

Entwistle, T., (2011), "For Appropriateness or Consequences? Explaining Organizational Change in English Local Government," *Public Administration*, 89 (2): 661-80.

Gichoya, D., (2005), "Factors Affecting the Successful Implementation of ICT Projects in Government," *The Electronic Journal of e-Government*, 3(4): 175-84.

Hardy, C. A., and S. P. Williams, (2008), "E-Government Policy and Practice: A Theoretical and Empirical Exploration of Public e-Procurement," *Government Information Quarterly*, 25: 155-80.

Hawking, P., Stein, A.,Wyld, D. C., and S. Foster, (2004), "E-procurement: Is the ugly Duckling Actually a Swan Down Under?," *Asia Pacific Journal of Marketing and Logistics*, 16 (1): 3-26.

Henriksen, H. Z., and V. Mahnke, (2005), "E-Procurement Adoption in the Danish Public Sector: The Influence of Economic and Political Rationality," *Scandinavian Journal of Information Systems*, 17 (2): 85-106.

Hoque, K., Kirkpatrick, I., Londsdale, C. and A. De Ruyter, (2011), "Outsourcing the Procurement of Agency Workers: The impact of Vendor Managed Services in English Social Care," *Work, Employment and Society*, 25 (3): 522-39.

Hui, W. S., Radiah, O., Normah, H. O., Rashidah, A. R., and N. H. Haron, (2011), "Procurement Issues in Malaysia," *International Journal of Public Sector Management,* 24 (6): 567-93.

Karjalainen, K. and E.M. Raaij, (2011), "An Empirical Test of Contributing Factors to Different Forms of Maverick Buying," *Journal of Purchasing & Supply Management,* 17 (3): 185-97.

Krishna, V. 2009. Auction Theory. Academic Press.

Mota, F. P. B., and J. R. Filho, (2011), "Public e-Procurement and the Duality of Technology: A Comparative Study in the Context of Brazil and of the State of Paraiba," *Journal of Information Systems and Technology Management,* 8 (2): 315-30.

Peck, F., and I. Cabras, (2011), "The Impact of Local Authority Procurement on Local Economies: The Case of Cumbria, North West London," *Public Policy and Administration,* 26(3): 307-31.

Preuss, L., (2007), "Buying Into the Future: Sustainability Initiatives in Local Government Procurement," *Business Strategy and the Environment,* 16 (5): 354-65.

Roman, A. V. 2012. Challenges in Maximizing Transformative Impacts: Public Policy and Financial Management through e-Procurement. Proceedings of the IPPC 5, Seattle, downloadable from http://www.ippa.org/IPPC5/Proceedings/Part2/PAPER2-9.pdf

Singer, M., Konstantinidis, G., Roubik, E., and Eduardo Beffermann, (2009), "Does e-Procurement Save the State Money?," *Journal of Public Procurement,* Volume 9, Issue 1, 58-78.

Varney, M., (2011), "E-Procurement—Current Law and Future Challenges," *ERA-Forum* 12 (2): 185-204.