

DOES e-PROCUREMENT SAVE THE STATE MONEY?

Marcos Singer, Garo Konstantinidis,
Eduardo Roubik and Eduardo Beffermann*

ABSTRACT. Scientific literature reports scarce evidence of whether Internet-based procurement systems improve the efficiency of State purchases. We propose a methodology to estimate savings in: (i) the centralization of administrative tasks, and (ii) price differentials due to a larger number of contractors and suppliers bidding on contracts. We test our methods with ChileCompra, the Chilean e-procurement agency. During 2007, 885 Chilean State agencies used this system to purchase US\$4.5 billion in products and services. Our preliminary results show price reductions of 2.65% and administrative cost savings of 0.28%-0.38% between 2006 and 2007.

INTRODUCTION

Government procurement represents 18.42% of the world GDP (Auriol, 2006). Many countries have created specialized agencies in order to develop and manage business-to-government (B2G) electronic procurement (e-procurement) systems. They have done so to achieve the following objectives:

- 1) Promote the use of Internet across different industries;
- 2) Give signs of transparency, as the transactions between contractors and State agencies become public;
- 3) Reduce administrative cost by improving the procurement process; and

* *Marcos Singer, Ph.D., is a Professor, Business School, Pontificia Universidad Católica de Chile. His teaching and research interests are in operational research, public procurement and public policy. Garo Konstantinidis, Eduardo Roubik, and Eduardo Beffermann are research assistants.*

4. Reduce purchasing prices, due to a more efficient operation and to a larger number of potential contractors.

This paper will evaluate objectives (3) and (4) when the procurement mechanism is through “electronic public bids.” It is “electronic” as the interaction takes place through the Internet. First, we present a method to assess the administrative cost reductions due to centralization. It consists of estimating the unit costs of different procedures, and multiplying those costs by the number of times the State avoids repeating the procedures. Second, we use auction theory to estimate the price differential due to a change in the number of bidders. Third, we present two surveys, one for State executives in charge of procurement and one for contractors, which allow us to learn how e-procurement affects the number of bidders. Fourth, we apply these methodologies to estimate the savings produced by ChileCompra, the Chilean governmental agency in charge of procurement. Finally, we summarize our conclusions, the limitations of our work and future research.

ADMINISTRATIVE COSTS SAVINGS

In theory, e-procurement reduces administrative costs and bureaucracy by helping the State avoid repeating tasks such as registration and certification of contractors, allowing for more efficient control mechanisms and reducing paperwork. Anecdotal evidence seems to confirm this. In an exploratory study, Carter et al. (2004) find that electronic reverse auctions (e-RAs) increase productivity and reduce cycle times for buyers, particularly in the case of repeated auctions.

Many scholars observe these success stories with skepticism, and are reluctant to interpret them as general results (Presutti, 2003; Brun, Corti & Cozzini, 2007). Information and communication technologies do not generate efficiency by themselves. To be successful, several organizational strengths (education and expertise, discipline, process effectiveness, technical infrastructure) must complement them. Technologies that are at a more developed stage, such as ERP, SCM, and CRM systems, still have very dissimilar, and often disappointing, effects (Hendricks, Singhal & Stratman, 2007). The results are even less auspicious in developing countries, as their

institutions often lack many of the above-mentioned complementary strengths (Dewan & Kraemer, 2000).

A potential advantage of an Internet-based system is that it facilitates a Business Process Reengineering (BPR) of the procurement activities. Since Activity-Based Costing (ABC) allocates the organization's resources to activities, it is a natural tool for assessing the expected savings due to BPR (Tatsiopoulos & Panayiotou, 2000), and in particular due to e-commerce (Tatsiopoulos, Panayiotou & Ponis, 2002). For instance, Brun et al. (2007) identify five phases in the procurement process: Order request, Order acceptance, Order emission, Order receipt and Invoices fulfill. For each phase, they define a set of activities and estimate how the activities' performance indicators will change, including cost.

To the best of our knowledge, empirical validations of ABC are scarce (Singer & Donoso, forthcoming, is an exception), so to use it for assessing expected savings is unreliable. If the e-procurement system is supposed to increase the productivity of employees, are they handling more transactions after its implementation? Does the headcount go down? As there are no systematic studies, comparing the ABC predictions with the practical results of BPR, we doubt that ABC allows inferring how much efficiency e-procurement brings.

As an alternative, we propose to use the following equation to estimate the economies of scale gained by the State due to the centralization of procurement activities:

$$A = \sum_{\forall s} C_s \times U_s$$

Where:

- A Administrative savings.
- s Service provided by the e-procurement agency to the State agencies.
- C_s Cost incurred by the e-procurement agency to provide the service s.
- U_s Number of times that service s is used by any State agency.

We assume that if service s is used U_s times, e-procurement is generating savings for C_s × U_s. (At the end, we consider the cost of providing all the services to estimate the net savings). The main

services that may generate savings include contractor certification, repetitive purchases, and one-time purchases.

Contractor Certification (CC)

The government must certify their contractors regarding tax and patent payments, labor legislation abidance and other regulations. We assume that the certification cost (C_{CC}) does not depend on the type and size of the contractor. We estimate such cost assuming that the e-procurement agency has a specific department in charge of the task, so:

$$C_{CC} = \frac{\text{Annual budget of the certification department}}{\text{Number of contractors certified during the year}}$$

To estimate the economies of scale of the certification, we count how many contractor-public agency combinations traded during the year. In other words, U_{CC} corresponds to the number of certifications that would have occurred if the e-procurement agency did not offer centralized certification.

Repetitive Purchases (RP)

Several government agencies purchase a standard item many times a year. To increase efficiency, the e-procurement agency auctions Framework Agreements for one or more years, which are contracts that commit a supplier for the delivery of goods and services within a certain time frame at specified price and conditions. The results are published in an electronic catalog that the State agencies may use.

Items are diverse, from paper and pencils to computers and airline tickets. Nevertheless, we will assume that the administrative cost to incorporate an item is similar. To estimate such cost C_{RP} , we assume that the e-procurement agency has a specific department for placing items in the electronic catalog. If so:

$$C_{RP} = \frac{\text{Annual budget of the online - catalog department}}{\text{Number of items placed on the catalog during the year}}$$

To estimate the economies of scale, we count how many times U_{RP} an item is purchased through the electronic catalog by enough agencies (in section "THE CASE OF CHILECOMPRA" we define what

“enough” means). Below a minimum use, it would not make sense to place the item in the catalog.

One-time Purchases (OP)

The e-procurement agency assists State agencies in purchasing specific goods or services, such as a construction or a consultancy project. Again, we assume that the procurement cost is similar between different items, regardless of their value. We also assume that the purchasing agency would have incurred a similar unit cost as the e-procurement agency in order to auction the item. Since it handles thousands of public bids and is unable to place special attention on each one of them, they are not always successful (in section “THE CASE OF CHILECOMPRA” we define what “successful” means). Therefore:

$$C_{OP} = \frac{X_p \times P_s}{P_n}$$

Where:

- C_{OP} One-time purchase cost.
- X_p Annual budget to assist one-time purchases.
- P_s Number of successful one-time purchases during the year.
- P_n Number of one-time purchases during the year.

Since each item is unique, there are no economies of scale, so $U_{OP} = 1$.

In summary, the net administrative savings is:

$$A = (C_{CC} \times U_{CC}) + (C_{RP} \times U_{RP}) + C_{OP} \times 1 - B$$

Where:

- A Net administrative savings.
- C_{CC} Contractor certification cost.
- U_{CC} Number of certifications that would have occurred without centralized certification.
- C_{RP} Repetitive purchase cost.
- U_{RP} Number of times an item is purchased through the electronic catalog by enough agencies.
- C_{OP} One-time purchase cost.
- B Total budget of the e-procurement agency.

ASSESSING PRICE DIFFERENTIALS

In theory, e-procurement should reduce procurement prices, as it functions as a “market maker” where many public agencies and private contractors can converge. Case studies report a 20% reduction in purchasing prices for the government in Brazil, 20% in Mexico and 22% in Romania (see references in Auriol, 2006). Unfortunately, there is no hard evidence supporting such dramatic reductions. The studies rely on surveys that suffer from a self-selection problem: only the people who are pleased with the system will answer the questionnaire; unhappy people could be avoiding it. The studies also have a self-reporting problem: answers are biased towards the desired result; nobody likes to declare a failure. On the contrary, according to Vaidya, Sajeev and Callender (2006), a significant portion of the initial value proposition of e-procurement has not been ultimately delivered, due to problems related to technology, business process, and/or people/organizational issues.

Bandiera, Prat and Valletti (2008) analyze purchases of standardized goods by Italian public bodies and find that ministries and the central government pay on average 22% more than semi-autonomous bodies such as health centers. Although Consip, the Italian e-procurement agency, is a tool to improve performance, the authors explain that it can always be bypassed due to incompetence or dishonesty. In other words, better purchasing practices depend also on other conditions, such as governance structure, autonomy and supervision. To evaluate whether e-procurement by itself can lead to a 20% price reduction, one can estimate whether business-to-business (B2B) e-procurement could lead to similar savings to a company. Purchases are about 50% of the variable cost of a firm (Poirier, 2004; Metty et al., 2005). After a study of 2,463 firms, Marn and Rosiello (1992) learned that a 1% reduction of the variable cost translates into a profit increase of 7.8%. A similar study of Fortune 500 firms found that profits increase by 5.1% (Phillips, 2005 p.13). If the above relations were linear, a company that implements B2B e-procurement could reduce its purchasing prices by 20%, increasing its profits by $20\% \times 50\% \times 7.8 = 78\%$, according to Marn and Rosiello (1992) or by $20\% \times 50\% \times 5.1 = 51\%$, according to Phillips (2005). There are no reports of such spectacular outcomes in scientific literature. More realistically, Metty et al. (2005) describe the results of e-procurement at Motorola. Between 2002 and 2003, the

company bought over \$16 billion online, saving over \$600 million, or 3.75%.

Regardless of whether the above price reductions are realistic, Millet et al. (2004) claim that price is not a proper measurement of the success of e-RAs. Although most managers favor price-reduction metrics, such approach fails to take into account quality, reliability, supplier relationships and long-term supplier viability. In addition, items are often new or specific, or have no prior price for the same purchase volume. Furthermore, prior purchases may have occurred under different market conditions, such as the cost of raw materials.

In the case of public procurement, bidding processes are subject to legal constraints that may or may not reduce prices. For instance, making information on all transactions public may reduce corruption and its associated costs (Engelbrecht-Wiggans & Katok, 2006). On the other hand, “billboarding” the price over the Internet promotes collusion among suppliers, as it keeps them well informed of whether anyone is reducing prices below a tacit agreement (Miller, Schnaars & Vaccaro, 1993). Comparing purchasing prices paid by the State with market prices may also be misleading. Governments impose conditions that differ from private buyers. Some e-procurement agencies (for instance, ChileCompra) force suppliers to quote the same price for national and local governments, and for public services and public companies. Since those organizations have their own buying culture, the prices bidden are weighted averages of what contractors would charge if they had the opportunity to trade in a separate manner. In summary, to compare prices is deceptive, and therefore cannot assess the performance of B2G e-procurement.

As an alternative, we propose to use a heuristic derived from auction theory, based in the following definitions:

- N Number of bidders that participate in a public bid, when there is no e-procurement agency participating.
- i Bidder that participates in the public bid, with $i \in \{1, 2, \dots, N\}$.
- i^* Bidder that wins the public bid.
- c_i Cost of providing the products and services for bidder i .
- $p_i(c)$ Pricing function that calculates the bid or price p_i posted by bidder i , taking into account his cost c_i .

As most auction models in the literature, we assume that:

- The cost c_i is private (confidential information) and independent (does not depend on other bidders costs) for each bidder i . It is the realization of a random variable C that has the same probability density function $f(c)$ for all the bidders.
- As bidders are symmetric, they use the same function $p_i(c) = p(c)$.
- The number N is certain and of common knowledge. This is plausible if bidders are experienced enough to know the market and their competitors. If N is uncertain, the expected winning bid is the same if bidders are risk neutral (Dyer, Kagel & Levin, 1989), which occurs when their assets are relatively high compared to the stakes of the public bid.

In equilibrium, if each bidder i is rational, he defines $p(c)$ as the expected cost of the second least expensive bidder, considering that i is the least expensive of all (Milgrom & Weber, 1982). In other words, the price offered by i is the second order statistic of the density function $f(c)$, given that c_i is the first order statistic. The winning bidder i^* is the one that has the lowest cost c_i , and charges a price equal to what he thinks is the cost of the second most efficient bidder. The higher N , the lower the winning bid will be, for two reasons. First, a higher N makes more likely that the bidder with the lowest cost is more to the left of the function $f(c)$. Second, the difference between the first and second order statistic is lower when N is large, so the margin $p(c_{i^*}) - c_{i^*}$ of bidder i^* becomes smaller. According to Bulow and Klemperer (1996), "...in a procurement context, competitive bidding by suppliers will yield lower average prices than negotiating [optimally] with a smaller number of suppliers." In other words, increasing the number of serious bidders by one outperforms any other strategy the auctioneer may envision to improve its position. Brannman, Klein & Weiss (1987) empirically prove that prices fall as N grows, although such result lose statistical significance when N is too high. This occurs in timber auctions with $N \geq 5$, in bond auctions with $N \geq 6$, in oil auctions with $N \geq 8$, and so on. Analyzing 25,000 auctions for commodities, MacDonald, Handy and Plato (2002) find that the price reduction due to more bidders is significant up to $N = 6$.

To calculate the effect of N on the winning bid $p(c_{i^*})$ of each specific public bid, we must conjecture its structure from the observed bids. For simplicity, we assume that bids follow a log-normal distribution, as observed by Brannman et al. (1987) for offshore oil

auctions. Laffont, Ossard and Vuong (1995) assume that private values, not offers, have a log-normal density function $f(c)$, which is equivalent to our conjecture if we assumed that the bidding function $p(c)$ applies a similar transformation of private values c . This may or may not occur in equilibrium, but as suggested by Rothkopf and Park (2001), in realistic settings it may be convenient to depart from the rationality paradigm which requires bidders to estimate the game that all the competitors think they are playing, and forces to assume that the competitors will all behave rationally in this game. As a result, $p(c)$ may not necessarily be a similar transformation, but a much more complex function. We will avoid such complexity with the log-normal conjecture, which we will validate in Section “The Case of Chilecompra” using the Kolmogorov-Smirnov test.

Survey to Estimate the Effect on Bidders

Since the number of serious bidders is the main factor in terms of the purchase price, define:

- ΔN Change in N due to the e-procurement system.
- ΔN^+ Positive part of ΔN , which is the number of bidders attracted by the B2G system.
- ΔN^- Negative part of ΔN , which is the number of bidders deterred by the B2G system.
- μ Average of the offers $p(c)$.
- σ Standard deviation of the offers $p(c)$.
- $\Delta p(c_{i^*})$ Expected difference of the winning bid when there are $N + \Delta N$ bidders and when there are N bidders.

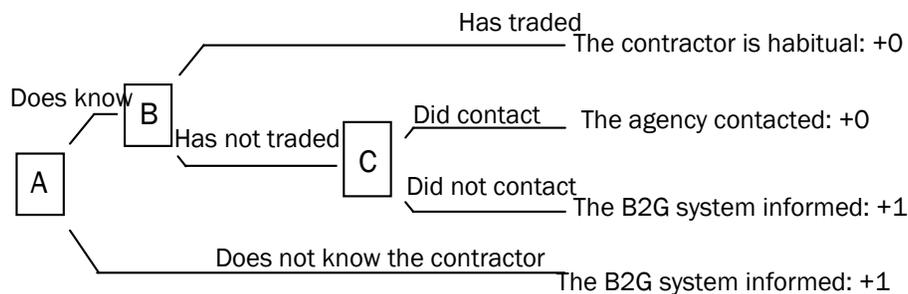
We assess the effect the B2G e-procurement agency has on price in a given year using the following process:

- 1) We randomly select a number of public bids carried out during the year.
- 2) For every selected public bid, we contact the State executive of the corresponding purchasing agency who was in charge of it. The name and contact information is recorded in the system, as bidders interact with him to ask questions and solve problems. He/she is also in charge of publishing the answers or resolutions that affects the public bid.
- 3) We calculate μ and σ . We define a “serious” bidder as one capable of (i) delivering the contracted product or service, and

(ii) having some probability of winning the contract. Assume that a bidder who charges too little is unable to do (i), so discard anyone whose offer is below $\mu - 2\sigma$. Assume also that a bidder who charges too much is unable to do (ii), so discard anyone whose offer is above $\mu + 2\sigma$. Discard any other contractor whose quality or reputation is unacceptable according to the State executive. We define $N + \Delta N$ as the number of bidders who were not discarded.

- 4) We calculate a new average μ' and standard deviation σ' , using the average of the “serious” bids. With μ' and σ' , we obtain the log-normal distribution $LN(\mu', \sigma')$ of $p(c)$. When $N + \Delta N = 1$, μ' is the bid itself and σ' is the standard deviation of other public bids with $N + \Delta N > 1$ and similar traded amounts.
- 5) We estimate the first order statistic, as explained in the Appendix, of $LN(\mu', \sigma')$ with $N + \Delta N$ observations. This is an *a priori* estimation of the winning bid, the one that would have won if the offers follow a log-normal distribution with expected value μ' and a standard deviation σ' .
- 6) For each serious bidder, we ask the State executive the following set of questions, organized as shown by Figure 1:
 - A: Do you know this contractor?
 - B: Have you ever traded with this contractor?
 - C: Did you personally contact this contractor regarding this public bid?

FIGURE 1
Questions Regarding the Bidding Contractors



From the answers, we detect whether the B2G system attracted a particular contractor (+1) to become a bidder, or if it was neutral (+0). We assume that if the State executive has traded before with the contractor, or has not but contacted him, the B2G system was unnecessary. If the State executive has not traded before and did not contact the contractor, the system aggregated an additional bidder.

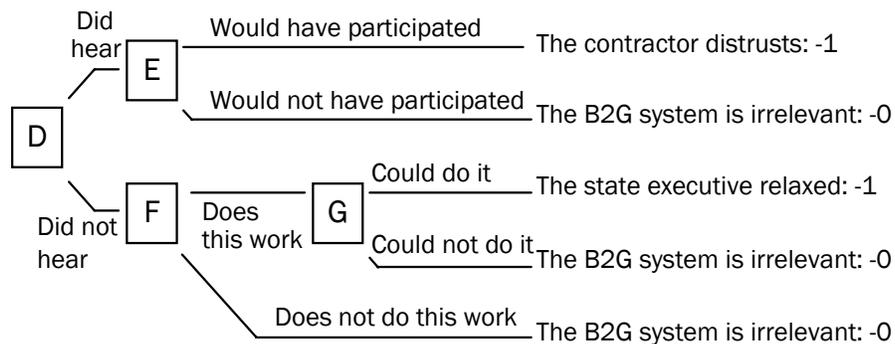
Repeating this procedure for all bidders, and aggregating the results, we obtain ΔN^+ .

- 7) We ask the State executive about all the other serious contractors who did not participate in this public bid.
- 8) We call each contractor mentioned by the State executive and ask them the following set of questions, organized as shown by Figure 2:

- D: Did you hear about this particular public bid?
- E: Would you have participated in this public bid if it had not been posted in the B2G e-procurement system?
- F: Do you perform this type of work?
- G: Could you have done the work required in this public bid?

From these answers, we detect whether the B2G system deterred the contractor (-1), or if it was neutral (-0). If the

FIGURE 2
Questions Regarding the Contractors that Did Not Bid



contractor distrusts the system, or if he was unaware of the public bid and would have been able to participate, then we assume that the system prevented a contractor to become a bidder. The second case is a passive effect; the State executive does not properly scan the market believing that the system will do it for him.

Repeating the procedure with all the contractors and aggregating the results, we obtain ΔN^- .

- 9) We obtain the net effect of the B2G system as $\Delta N = \Delta N^+ + \Delta N^-$.
- 10) If $N = 0$, meaning that all contractors are new and none has been deterred, we assume that the product or service is new to the State agency. In such case, we define $N = 2$, which is a midpoint between two unlikely scenarios: (i) the State executive would have contacted only one contractor, which would be inappropriate, and (ii) he would have contacted three or more contractors, which would be too difficult.
- 11) We obtain the expected difference of the winning bid $\Delta p(c_{i^*})$ as the difference between the first order statistics of $LN(\mu', \sigma')$ with $N + \Delta N$ and with N bidders. We express it as a percentage, by calculating $\Delta p(c_{i^*})/p(c_{i^*})$.
- 12) We define appropriate clusters of public bids with similar features, such as the number of bidders, the amount traded or the type of industry. Then we aggregate the results for all the public bids that belong to the same cluster to obtain the average $\Delta p(c_{i^*})/p(c_{i^*})$.
- 13) For each cluster, we calculate the standard deviation of $\Delta p(c_{i^*})/p(c_{i^*})$. Such deviation provides a confidence interval for the expected change in price.

Although the above process relies on a survey, it does not have a self-selection problem, as long as public bids are selected randomly. In the case of ChileCompra described in the next section, none of the respondents declined to participate, since their duty is to provide all the information requested. However, we discarded some public bids because the answers were not reliable, so some self-selection may occur. The study does have a self-reporting problem, because executives do not know whether they should bias their answers.

THE CASE OF CHILECOMPRA

ChileCompra (“Compra” means “Purchase”) is the e-procurement Chilean agency, created in 2003. During 2007, ChileCompra assisted 885 State agencies to purchase US\$4.5 billion in products and services using electronic public bids.

Administrative Cost Savings

The department in charge of contractor certification (CC) is “ChileProveedores” (“Proveedores” means “Suppliers”). Its budget for 2006 was of US\$506,127. During that year, it certified 8,088 suppliers, so $C_{cc} = 506,127/8,088 = \text{US}\63 . The number U_{cc} of agency-supplier combinations that traded during 2006 was 121,429. Therefore, the savings for 2006 were $63 \times 121,429 = \text{US}\7.6 millions. For year 2007 the savings were $57 \times 226,178 = \text{US}\12.9 millions.

ChileCompra assists repetitive purchases through its department of Framework Agreements. Using an Internet-based system, each contractor or supplier bids a standard price, plus specific delivery conditions. The winning bidders are posted in the electronic catalog. Any time an agency needs to purchase an item offered in the online-catalog, it simply “clicks the button” on the system. To obtain the administrative savings for repetitive purchases (RP), we estimated the cost of placing an item in the online-catalog. The department’s budget for the year 2006 was US\$719,004. Within that year, they placed on the online-catalog 339 new items. Therefore, $C_{RP} = 719,004/339 = \text{US}\$2,124$ per item. In order to calculate the economies of scale, we obtained that 69.2 State agencies purchased at least once an average item in the catalog. Also, we assume that an item would have been included in the online catalog if it is used by “enough” agencies, which is at least 8 (1% of the agencies that traded at least one time), so the effective economy of scale can be calculated as $69.2/8 \times 339 = 2,932$. Summarizing, the savings from repetitive purchases during 2006 is equal to $C_{RP} \times U_{RP} = 2,124 \times 2,932 = \text{US}\6.2 millions. During 2007 the saving was $2,448 \times 4,064 = \text{US}\9.9 millions.

To estimate the savings due to one-time purchases (OP), we followed ChileCompra’s policy of defining a public bid to be “successful” if it attracts three or more bidders. In the next

subsection we will justify this criterion. During 2006-2007, the ratio (Number of successful one-time purchase within the year) ÷ (Number of one-time purchases within the year) was 60%. Given that in 2006 the budget of the one-time purchase department was equal to US\$8.6 millions, $C_{OP} = 8.6 \times 60\%$. Recalling that $U_{OP} = 1$, the savings for 2006 was US\$5.2 millions, and for 2007 was $12.3 \times 60\% \times 1 =$ US\$7.4 millions.

The sum of all savings minus the budget is the total administrative cost saved. For 2006 it was US\$9.7 millions, which represents 0.28% of transactions in ChileCompra. For 2007 it was US\$16.9 millions, which represents 0.38% of transactions in ChileCompra.

Price Differentials

We estimated the price differentials for six industries: engineering services, medical equipment, laboratory supplies, sports equipment, environmental management, and marketing and distribution services. To use the methodology described in section “Assessing Price Differentials”, we required State executives and contractors to have a well-kept recall of the public bids they have managed, so we only considered those performed during 2007. We randomly selected 174 public bids, and contacted the State executives that were in charge of them over the phone. We also called 89 serious contractors mentioned by the State executives who did not participate in the public bids. We discarded 87 public bids because they failed the “reliability” criterion that requires the following three conditions:

1. The State executive contacted was interested in the survey. Recalling that they were in charge of the public bids, most of them understood that to study the mechanism might improve its performance. However, some of them were too busy or uninterested, so we feared that their answers would be useless.
2. The State executive could honestly answer whether the bidders were new or not. Given that for our methodology such information is crucial, any confusion would invalidate our results. The executives sometimes were not confident because they lacked sufficient experience, or because they did not remember the public bid well enough.

3. The survey was completely answered, and by the same person. Each telephone call lasted between 10 and 20 minutes, so sometimes the executive cut short the survey, or asked to call someone else to complement the information. We interpreted this last situation as a lack of self-confidence by the executive regarding his expertise.

Summarizing the overall results of the survey, in each public bid 2.8 serious contractors bid from which 1.5 were habitual; 1.3 contractors were attracted and 0.5 were deterred. Only 6% of the deterred contractors distrusted the system. In the other 94% of the cases, the bidders were lost because the State executive relaxed (believed that the system was going to notify the contractors about the public bid). In order to estimate price differentials, we tested whether the offers followed a log-normal distribution $LN(\mu', \sigma')$. The Kolmogorov-Smirnov test accepted such null hypothesis with a p -value = 0.347. Table 1 shows our results clustered by number of bidders and the range of the winning bid. The "Observations" column counts how many public bids fall into each cluster. The "Difference" column shows $\Delta p(c_i^*)/p(c_i^*)$, which is the average percentage difference of the first order statistic of all the public bids in the

TABLE 1
Price Reduction by Number of Bidders and Winning Bid Range

Number of bidders	Winning bid range	Obs.	Difference	Deviation	Probability
One bidder	Below M\$ 5	12	-9.74%	8.85%	86.45%
	Over M\$ 5	12	-8.27%	5.51%	93.32%
Two bidders	Below M\$ 5	11	4.62%	13.87%	63.04%
	Over M\$ 5	12	-1.71%	4.70%	64.24%
Three bidders	Below M\$ 5	9	6.05%	8.22%	76.90%
	Over M\$ 5	4	1.14%	1.84%	73.21%
Four bidders	Below M\$ 5	7	11.98%	13.19%	81.81%
	Over M\$ 5	7	16.85%	20.09%	79.92%
Five or more	Below M\$ 5	7	6.17%	8.09%	77.71%
	Over M\$ 5	6	6.93%	7.42%	82.51%

cluster. The “Deviation” column shows the standard deviation of the percentage difference, when there is more than one observation. The “Probability” column shows the confidence with which the sign of the calculated average saving is correct.

The price reductions are most prominent when there are three or four serious bidders. With a higher number, the B2G e-procurement agency is less significant, since without it there would be enough bidders. When there is only one bidder, e-procurement is detrimental. According to our survey, in such situations, State executives rely too much on ChileCompra and do not fulfill with their duty of looking for contractors. With two bidders, there is a mixed effect. Therefore, public bids with one or two bidders should trigger a warning about how the State agencies are performing their purchase process.

To make our results extensive to the entire e-procurement system, Table 2 shows the total amount traded in each cluster under the “Amount [MM\$]” column, measured in millions of US\$. The “Saving [MM\$]” column multiplies this amount by the expected difference of the winning bid, shown by in Table 1.

To summarize, we estimated that the savings due to price reduction during 2007 was US\$118.1 millions. We applied the performance of 2007 to estimate the saving for 2006, obtaining

TABLE 2
Amounts Traded In 2007 in Each Cluster and Estimated Savings

Number of bidders	Winning bid range	Amount [MM\$]	Saving [MM\$]
One bidder	Below M\$ 5	176.9	-17.2
	Over M\$ 5	663.0	-54.8
Two bidders	Below M\$ 5	160.2	7.4
	Over M\$ 5	729.8	-12.5
Three bidders	Below M\$ 5	131.7	8.0
	Over M\$ 5	602.5	6.9
Four bidders	Below M\$ 5	105.8	12.7
	Over M\$ 5	389.0	65.5
Five or more	Below M\$ 5	225.8	13.9
	Over M\$ 5	1273.4	88.2
Total		4,458.0	118.1

US\$3.5 billions \times 2.64% = US\$91.8 millions. This last result is less reliable, as we are not sure that in a survey during 2006 the respondents would have followed the trees in Figures 1 and 2 in similar paths as in 2007.

CONCLUSIONS

Table 3 summarizes our estimations of how much money e-procurement saves to the Chilean State. Overall, it is US\$9.7 millions in administrative costs and US\$91.8 millions due to price reductions, which accounts for 2.93% of the amount traded in 2006. For 2007, it is US\$16.9 millions in administrative costs and US\$118.1 millions due to price reductions, which accounts for 3.03% of the amount traded. As expected, our results are far from the spectacular cases reported in non-scientific literature. They are also far from the 22% potential improvement that Bandiera et al. (2008) identify for public procurement in Italy. One may argue that e-procurement, which is still in its infancy (Vaidya et al. 2006), is unlikely to solve by itself the

TABLE 3
Summary of Savings for the Chilean State

		2006		2007	
		MM \$	%	MM \$	%
Administration	Contractor certification	7,6	0,22	12,9	0,29
	Repetitive purchases	6,2	0,18	9,9	0,22
	One-time purchases	5,2	0,15	7,4	0,17
	Operational budget	9,3	0,27	13,3	0,3
	Total administrative savings	9,7	0,28	16,9	0,38
Price differentials	One bidder	-56,0	-1,62	-72	-1,62
	Two bidders	-4,0	-0,11	-5,1	-0,11
	Three bidders	11,6	0,33	14,9	0,33
	Four bidders	60,8	1,75	78,2	1,75
	Five or more bidders	79,4	2,29	102,1	2,29
	Total price savings	91,8	2,65	118,1	2,65
Total savings		101,5	2,93	135	3,03

incompetence and dishonesty problem that explains the waste in public purchasing. In addition, while Transparency International's corruption perception ranks Italy with a score of 5.2/10 in 2007, it ranks Chile with 7/10, so the Chilean potential improvement might be lower. Surprisingly, our estimations are very close to the Motorola case reported by Metty et al. (2005). They break up the savings of (\$600 million ÷ \$16 billion) = 3.75% as follows: around 60% (3.75% × 60% = 2.25%) were related to the capability of engaging more suppliers, while 10% (3.75% × 10% = 0.375%) was due to lower administrative costs. (The remaining 30% were related to the optimization of bids, which is not done by ChileCompra). As in Motorola, most of the savings we estimate come from price differentials gained by the capability of an Internet-based procurement system to attract numerous bidders. Administrative savings (due to the centralization of repetitive purchases, one-time purchases and the certification of contractors) are rather secondary.

A number of considerations restrict the validity of our results. Most likely, we are underestimating administrative savings, since ChileCompra is a specialist and therefore incurs in lower unit costs than any other agency. In addition, while auction theory has been empirically validated, our results are based on assumptions (the log-normal distribution of bids) and simplifications (the results can be clustered by the number of bidders and the range of the winning bid). Furthermore, our estimations depend on a survey answered by State executives and contractors that have an imperfect recollection of what happened with the public bids we investigated.

Future research should address the above limitations by improving the models and devising better ways to collect data. Since reliable assessments allow an effective benchmarking and improvement, to research ways to appraise State procurement has a crucial effect on how public funds are spent.

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APPENDIX First Order Statistic

Suppose a probability function where the bids of an auction are drawn:

$$b_i \sim F(b), \text{ for } i \in \{1, \dots, n\}$$

where n is the number of bids in an specific auction.

The probability function of the first order statistic of n independently drawn bids, from that probability function, must satisfy:

$$P(s_1 > k) = P(b_1 > k, b_2 > k, \dots, b_n > k)$$

Given that the bids are independently drawn,

$$P(s_1 > k) = P(b_1 > k) \cdot P(b_2 > k) \cdots P(b_n > k) = (1 - F(k))^n$$

Then if $s_1 \sim G(s)$,

$$G(k) = P(s_1 < k) = 1 - (1 - F(k))^n$$

$$g(s) = \frac{\partial G(s)}{\partial s} = -n \cdot (1 - F(s))^{n-1} \cdot (-f(s)) = n \cdot (1 - F(s))^{n-1} \cdot f(s)$$

The expected value of the first order statistic of n independently drawn bids is:

$$E[s] = \int_{s=0}^{\infty} s \cdot g(s) ds = \int_{s=0}^{\infty} s \cdot n \cdot (1 - F(s))^{n-1} \cdot f(s) ds$$

If $bi \sim \text{LN}(\mu, \sigma)$:

$$f(x) = \frac{1}{x \cdot \sigma \cdot \sqrt{2 \cdot \pi}} \cdot e^{-(\ln(x) - \mu)^2 / 2 \cdot \sigma^2}$$

$$E[s] = \int_{s=0}^{\infty} s \cdot n \cdot \left(1 - \int_{x=0}^s \frac{1}{x \cdot \sigma \cdot \sqrt{2 \cdot \pi}} \cdot e^{-(\ln(x) - \mu)^2 / 2 \cdot \sigma^2} dx \right)^{n-1} \cdot \left(\frac{1}{s \cdot \sigma \cdot \sqrt{2 \cdot \pi}} \cdot e^{-(\ln(s) - \mu)^2 / 2 \cdot \sigma^2} \right) ds$$