

# INFORMATION ENTREPRENEURS AND COMPETITION IN PROCUREMENT AUCTIONS\*

Phillip Leslie

NBER, and

Graduate School of Business

Stanford University

pleslie@stanford.edu

Pablo Zoido

Center for Global Business and the Economy

Graduate School of Business

Stanford University

pzoido@stanford.edu

## Abstract

We study the role of an information entrepreneur that collects and sells announcement details of forthcoming procurement auctions. On the face of it, announcement information should stimulate competition, reducing bidders' profits and lowering winning bids. However, a theoretical analysis reveals that such information may stimulate exit of some potential bidders, leading to possibly higher winning bids. We then empirically assess the affects of such an information entrepreneur, finding that bidders who purchase the announcements then submit many more bids, in auctions with fewer competitors, allowing them to win more often while also bidding less aggressively. Procurers also benefit in this case. We find that the cost of drugs procured by public hospitals in Buenos Aires decreased by 2.9%, thanks to the auction announcements sold to potential bidders by an information entrepreneur.

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# 1 Introduction

A major determinant of the winning bid in any auction is the number of bidders. Indeed, Bulow and Klemperer (1996) show that adding one more bidder to a simple competitive procurement auction reduces the winning bid by more than implementing optimal auction design. This is why it is important for buyers to provide effective announcements of forthcoming procurement auctions in order to attract as many bidders as possible. However, the ability to provide effective announcements may be limited. This could be due to weak incentives for governments, the presence of high fixed costs in the announcement technology, information costs for learning the identities of potential bidders, or corrupt behavior that seeks to limit auction participation to favored bidders.

We study the role of a profit-seeking firm to collect and sell announcement information about forthcoming procurement auctions. We refer to such a firm as an information entrepreneur. Specifically, we examine the incentives for such an information entrepreneur, and the implications of their existence for the welfare of potential bidders and buyers in procurement auctions. This is of particular interest for government procurement auctions, where it has been suggested that this kind of profit-seeking behavior by a private firm may be in the public interest—"promoting public values through private enterprise" (Hoyt and McMillan, 2003).

At first glance, the provision of announcement information should benefit procurers, by virtue of reducing barriers to entry, stimulating competition and lowering winning bids. However, in the first part of our study we show that the effect of such information on winning bids is ambiguous—it is possible that the information harms procurers' welfare. The reason is because the information may induce exit of some bidders, due to the presence of fixed costs. Of course, the information would also stimulate more bidding by the incumbents that choose to buy the announcements from the information entrepreneur, which may be the dominant effect, leading to greater participation and lower winning bids.

It is therefore an empirical question whether an increase in the provision of announcement

information is beneficial to procurers. In the second part of the study, we empirically assess the effects of an information entrepreneur that sells announcement information for drug procurement auctions held by public hospitals in Buenos Aires, Argentina. The company is called *Transparent Markets* (TM). TM may be viewed as a test-case of the tantalizing notion that there exist incentives for private firms to increase market transparency, causing greater competition, and possibly reducing corruption. In the empirical part of the study we examine the impact of TM on bidders and hospitals in Buenos Aires hospitals' drug procurement auctions.

We find that TM causes its clients to participate in substantially more auctions. Moreover, the information appears to help potential bidders identify auctions that tend to have relatively low participation. Hence, TM's clients experience an increase in the probability of winning auctions, while also being able to submit less aggressive bids. Potential bidders that don't purchase the announcement information therefore suffer lower profitability. Importantly, the overall effect for public hospitals in Buenos Aires is lower drug prices. We estimate that TM caused a 2.9% decrease in the total cost of drugs for these hospitals.

This paper highlights the importance of providing effective announcements to attract as many bidders as possible. On the one hand, it may be unsurprising that an increase in the provision of announcement information causes greater participation and lowers winning bids. On the other hand, our empirical findings indicate that, *in practice*, ineffectual announcements are a significant barrier to entry for potential bidders. We also show that there is a market-based solution to this problem. The empirical analysis verifies the incentives for a profit-seeking third party to collect and sell forthcoming auction announcements. Although the theoretical analysis reveals that the consequences of such an information entrepreneur for bidders and procurers welfare is ambiguous.

Baye and Morgan (2001) show a theoretical result that is similar in spirit to the ambiguity in our analysis. They study web sites providing price comparisons of homogeneous goods. On the face of it, such web sites would encourage perfect competition. However, the authors show that it is in the interests of the web site owner to maintain an equilibrium with price dispersion.

In their paper and ours, a profit-seeking firm provides an information service that appears to promote competition. And in both cases it is in the interest of the information entrepreneur that competition remains less than perfect.

Our study also contributes to the empirical literature concerning the effects of information on the behavior of firms.<sup>1</sup> We differ from the prior research in two ways. First, prior studies examine the effect on firm behavior from an increase in the provision of information to consumers. In contrast, we examine the impact on firms from information that is provided to these firms. In this respect the prior studies document a more subtle mechanism than we do here. However, a second difference is that we focus on the incentives for the private market to generate the information in the first place. In other words, we examine the profitability of an information entrepreneur by analyzing of the impact of the information on the entrepreneur’s customers.

Lastly, our paper also concerns the endogeneity of auction participation, which is usually assumed to be exogenous in empirical auction analyses. A notable exception to this is the study by Athey, Levin and Seira (2004). Our findings verify that, in practice, ineffectual announcements about the existence of forthcoming auctions can be a significant barrier to entry for potential bidders.

In Section 2 we present a theoretical model of an information entrepreneur selling auction announcements to potential bidders. Section 3 summarizes the dataset and gives institutional details of the drug procurement auctions we study. This is followed in Section 4 by a description of the information services provided by TM, and an examination of which firms choose to obtain this information. Our analysis of the effects of the information on sellers’ auction participation decisions is contained in Section 5, and in Section 6 we analyze the effects of the information on bids. Section 7 is the conclusion.

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<sup>1</sup>For example, see Jin and Leslie (2003) and Milyo and Waldfogel (1999).

## 2 Model

What are the incentives facing an information entrepreneur that gathers and sells announcement information about forthcoming procurement auctions? To answer this question, we need to assess the consequences of this information for the profitability of potential bidders, since this is the source of demand for the information entrepreneur. Also, an important question of interest is whether procurers benefit from the increased provision of announcement information. We contend that the answers to these questions are not obvious, because it seems the information entrepreneur provides a service that may reduce the profitability of their customers who are potential bidders. In this section we present a model to clarify these issues. The model also serves to guide the empirical analysis that follows.

We model the interaction of three groups of economic agents: (i) organizations (firms or governments) that purchase products via procurement auctions, (ii) firms that are potential bidders to supply these products, and (iii) a profit-seeking firm, called an information entrepreneur, that collects and sells information about the existence of forthcoming procurement auctions. We assume throughout that the organizations which purchase the products have inelastic demand, making them passive agents in our analysis.<sup>2</sup>

There are  $T$  procurement auctions for a range of different products, and there are  $N$  firms that are potential bidders for these products. Potential bidders vary in the set of products they can provide, and hence the set of auctions they could feasibly participate in. Let  $m_i \leq T$  denote the number of feasible auctions for bidder  $i$ . Each bidder knows his  $m_i$  and the distribution for other bidders, but does not know which value is assigned to which bidder. From the point of view of any other bidder, the probability that any single auction is in the feasible set for bidder  $i$  is  $m_i/T$ . Without loss of generality, assume  $m_1 \geq m_2 \geq \dots \geq m_N$ .

The point of the model is to understand the implications of bidders being imperfectly informed

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<sup>2</sup>We think this is especially reasonable for the empirical example we study which concerns hospitals' purchases of drugs.

about the existence of auctions, and the impact of an information entrepreneur that provides superior information. In the absence of the information entrepreneur, we assume potential bidders are aware of the existence of each auction with probability  $\beta$ . Also, we assume that a bidder will submit a bid in an auction if and only if the auction is in the feasible set for this bidder, and if the bidder is aware of the auction. Initially, we examine the equilibrium without an information entrepreneur.

Auctions are private value, first-price, sealed-bid auctions. It is assumed that each bidder obtains a cost draw for each auction that is independent and identically distributed across bidders and auctions. The expected total profit for each bidder is equal to the expected number of bids submitted, times the probability of winning each auction, times the expected profit conditional on winning, less any fixed cost,  $f$ . The presence of a fixed cost implies that some firms may have negative expected profits and would therefore exit. Allowing for endogeneity in the number of potential bidders is an important feature of the model, as it allows for the possibility that the information entrepreneur may influence the total number of potential bidders, and hence the average number of bids per auction.

To facilitate the analysis, we assume that potential bidders decide whether to exit in *decreasing* order of the values of  $m$ .<sup>3</sup> Importantly, we also assume that when each potential bidder makes their exit decision, the bidder does not know their cost for any of the auctions. Thus, the exit decision of bidder  $i$  is based on the exit decisions of earlier agents and the vector of  $m$  values. This observation leads to the following proposition.

*Proposition.* In any subgame perfect equilibrium of the game described above, if agent  $i$  chooses to exit, then for all  $j > i$ , agent  $j$  also decides to exit.

*Proof.* By induction on  $N$ . For  $N = 1$  the result is trivial. Assuming  $N > 1$ , note that conditional on agent 1's decision, the problem for agents  $2, \dots, N$  has the same structure, and we can thus apply induction. This implies that, in equilibrium, if agent  $j \geq 2$  exits, all agents  $k > j$

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<sup>3</sup>This is equivalent to the assumption used in some studies of firm entry, such as Berry (1992), where firms decide whether to enter in the order of decreasing profitability.

exit. Consider the agents' equilibrium strategies. It suffices to show that if agent 1's equilibrium strategy is to exit, agent 2's equilibrium strategy is to exit as well. Assume to the contrary that agent 1 exits in equilibrium and agent 2 stays. This means that agent 2 makes positive expected profits when agent 1 exits and agents 3, ...,  $N$  play their equilibrium strategies. Also, agent 1 makes zero profit, since she exits. We now show that agent 1 would make positive profits if she decided to stay, in contradiction of the above assumption.

If agent 1 decides to stay instead of exiting, agent 2's equilibrium response could be either to exit or to stay. (1) If agent 2's response is to exit, then by the induction hypothesis, all agents 3, ...,  $N$ , would also exit, leaving agent 1 alone. Recall that agent 2 makes positive expected profit when agent 1 exits and agents 3, ...,  $N$  play their equilibrium strategies (ie. some may stay and some may exit). Since  $m_1 \geq m_2$  agent 1 would make positive profits when staying and facing (weakly) less competition. Thus, when agent 2 exits, agent 1 would be better off staying than exiting. (2) If agent 2's response is to stay, this means that agent 2 makes positive profits, but this implies that agent 1 makes positive profits as well—agent 1 faces (weakly) less competition and can participate in (weakly) more auctions, since  $m_1 \geq m_2$ .  $\square$

A corollary of the above proposition is that there exists a unique subgame perfect equilibrium in which the first  $k$  agents stay and the remaining  $N - k$  agents exit. We note that the number of stayers depends on the number of potential bidders,  $N$ , their values,  $m_i$ , the fixed cost,  $f$ , and auction awareness probability,  $\beta$ . In particular, when  $f = 0$ , all agents stay. And for any given values of  $N$ ,  $m_i$  and  $\beta$ , there exists an  $f$  large enough that all will exit. Intermediate values of  $f$  will induce some potential bidders to stay and some to exit, even when  $m_i = m_j$ , for all  $i$  and  $j$ . This is due to the sequential nature of the exit decision, and the fact that expected profits decline in the number of expected competing bidders.

We now consider the possibility of subscribing to the superior announcements from the information entrepreneur for a price,  $p$ . If a potential bidder purchases the information, the probability of knowing the existence of any given auction is  $\alpha$ , which is greater than base-probability  $\beta$ . As above, we assume that potential bidders decide whether to exit and whether to purchase

the information in *decreasing* order of  $m$ , prior to learning costs for any of the auctions. The information entrepreneur sells the information at zero marginal cost, and incurs a fixed cost that is sufficiently high such that it is unprofitable for individual bidders to replicate the services of the information entrepreneur themselves.<sup>4</sup>

Decisionmaking takes place in three stages. In the first stage, the information entrepreneur chooses  $p$  to maximize profit. In the second stage, the  $N$  potential bidders sequentially decide whether to exit and whether to subscribe to the announcements from the information entrepreneur. In the third stage, bidders simultaneously submit bids in each auction they are aware of in each of their feasible sets, as before.

Similar to before, agent  $i$ 's exit decision is based on earlier agents' exit and subscription decisions, and the vector of  $m$  values. The problem has an equivalent structure to the model without an information entrepreneur, and the analysis of the equilibrium follows an almost identical logic. For this reason, it is straightforward to show the following: Any subgame perfect equilibrium of the game with an information entrepreneur satisfies the following: (i) if agent  $i$  chooses to exit, then for all  $j > i$ , agent  $j$  also decides to exit; and (ii) if agent  $j$  ( $j > 1$ ) decides to stay, and agent  $j - 1$  decides not to subscribe, then  $j$  will also not subscribe.

Again, it immediately follows that the equilibrium of the game with an information entrepreneur has the following form: There is a unique subgame perfect equilibrium in which (i) agents  $1, \dots, k$  stay, and agents  $k + 1, \dots, N$  exit; and (ii) agents  $1, \dots, l$ ,  $l \leq k$ , subscribe to the announcement information, and agents  $l + 1, \dots, k$  do not.

Note that the number of stayers and information subscribers depends on the number of agents,  $N$ , their values,  $m_i$ , the fixed cost  $f$ , subscription price,  $p$ , and the awareness parameters  $\alpha$  and  $\beta$ . For example, when  $f = 0$  all agents stay, and  $p = 0$  all stayers subscribe. For any given parameterization, there exists an  $f$  large enough so that all exit, and there exists a  $p$  large enough that all stayers do not subscribe. Intermediate values will induce some agents to stay and some to

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<sup>4</sup>The fixed cost of the information entrepreneur is also sufficiently low that the entrepreneur earns non-negative profits.



exit, and a subset of stayers to subscribe to the announcement information. Moreover, in such cases, the model implies that larger firms are more likely to stay and more likely to subscribe.

What is the effect of the presence of the information entrepreneur on potential bidders' profits? On the one hand, bidders may be better off since, if the information is sold at a low enough price, purchasing it allows bidders to participate in more auctions, thus increasing profits. On the other hand, other potential bidders have the same purchasing opportunity, and so bidders may face increased competition in each auction, which reduces profits. The net effect is ambiguous for any individual bidder, and ambiguous for bidders overall.

Consider the following example. There are two potential bidders with  $m_1 = m_2 = T = 2$ , and the awareness probabilities are  $\beta = 1/2$  and  $\alpha = 1$ . When information purchase is not possible, if both agents choose to stay, each agent expects to participate in one auction. In each auction an agent participates in, she faces zero opponents with probability  $1/2$ , and one opponent with probability  $1/2$ . Assuming bidders' costs are *iid* draws from a uniform distribution on the interval  $[0, 1]$ , the expected profits under this scenario are  $\pi_1 = \frac{1}{2} \frac{1}{2} + \frac{1}{2} \frac{1}{2} \frac{1}{3} - f = \frac{1}{3} - f$ . If  $f = \frac{1}{3} - \epsilon$ , then both agents will stay for an expected profit of  $\epsilon$ .

If there is an information entrepreneur selling auction announcements, and agent 1 subscribes but agent 2 does not, then agent 2 still expects to participate in one auction and faces one opponent with certainty. The expected profit for agent 2 is now  $\frac{1}{2} \frac{1}{3} - f = \frac{1}{6} - f$ . If agent 2 also subscribes, his expected profit is  $\frac{1}{3} - f - p$ .

If  $f = \frac{1}{3} - \epsilon$  and  $p = 2\epsilon$ , and if agent 1 stays and subscribes to the announcements, then agent 2 prefers to exit. In this case, the expected profit for agent 1 is  $1 - \frac{1}{3} - 3\epsilon = \frac{2}{3} - 3\epsilon > \epsilon$  (for small enough  $\epsilon$ ). Recall, if both agents stay, the expected profit is  $\epsilon$ , hence agent 1 will choose to stay and subscribe. Note that  $p$  could be set higher than  $2\epsilon$  and still maintain this equilibrium.

In this example, the existence of the information entrepreneur is beneficial to agent 1 and harmful to agent 2. Note also, the procurer is worse off (assuming zero payoff if the item is not provided).

In both scenarios the expected number of bidders is one, but with the information entrepreneur there is always exactly one bidder, and thus no competition exists and no competitive rents go to the procurer.

However, for different parameterizations of this simple model we can obtain quite different welfare effects from the information entrepreneur. If  $p = 0$ , both agents purchase the information and have expected profits  $2\frac{1}{2}\frac{1}{3} - f = \frac{1}{3} - f = \epsilon$  (assuming  $f = \frac{1}{3} - \epsilon$ ). Hence, if  $p < \epsilon$  then both firms will choose to subscribe to the announcements, and both agents will be worse off, while the procurer will be better off. It is also possible to show that if  $\beta$  is small enough, both agents are better off in an equilibrium where both agents subscribe to the announcements. In this latter case, the procurer is also better off.

The example leads us to the following proposition: Comparing the subgame perfect equilibria of the games with and without the information entrepreneur, the effects from being able to purchase announcement information on bidders and procurers welfare are ambiguous.

In the above example, the average number of bids per auction is the same with and without the information entrepreneur. The procurer is better off without the information entrepreneur because there is a chance that 2 bidders will compete in an auction. More generally, however, the reason why an information entrepreneur may cause an increase in winning bids is because they cause a decrease in the average number of bids per auction.

Consider the following example. Suppose there are 100 potential bidders for some set of auctions. Also, suppose the awareness probability,  $\beta$ , equals .05. Then the average number of bidders per auction is 5. Now suppose there exists an information entrepreneur that provides perfect announcements (ie.  $\alpha = 1$ ). Say that 4 firms subscribe to this information, and therefore these 4 firms participate in every auction. This reduces the profitability for the remaining bidders and may cause many to exit. Say that 90 potential bidders exit. The remaining 5 non-subscribing bidders each participate with probability .05, as before. The average number of bidders per auction is now 4.25, which is less than before the information entrepreneur existed.

The example indicates the kind of situation where an information entrepreneur is more likely to harm procurers' welfare. Namely, if the difference between  $\alpha$  and  $\beta$  is large, and if relatively few firms subscribe to the announcement information.

Let us summarize the implications from the model that are relevant to the empirical analysis that follows. Each prediction makes a comparison of equilibria with and without an information entrepreneur. The model implies that (i) firms which tend to submit many bids relative to other bidders, are more likely to buy the announcements from the information entrepreneur; (ii) firms which do not purchase the announcement information will submit the same number of bids but will win less often, because they tend to face more competition; (iii) firms which purchase the announcement information will bid more often; (iv) the existence of an information entrepreneur may either increase or decrease the average winning bid. We now examine these predictions in the context of the drug procurement auctions by public hospitals in Buenos Aires.

### 3 Market Summary

In this section we summarize the institutional details of the auctions we examine in the empirical analysis. We also present basic evidence suggesting there is a low degree of competition in these auctions, which underlies the motivation for TM's existence.

We study all 62,283 drug procurement auctions held by all 33 public hospitals, plus 8 government departments in the city of Buenos Aires, between November 2002 to June 2004.<sup>5</sup> We use the term *hospital* to include the government departments. The auctions are first-price sealed-bid auctions. There are no reservation prices or participation fees.<sup>6</sup>

A virtue of studying drug procurement auctions is that products can be precisely defined.

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<sup>5</sup>The government department departments include the Office of the Director of Hospitals in the City of Buenos Aires. Note that the financial crisis in Argentina in 2002 had mainly subsided by around the third quarter of 2002.

<sup>6</sup>We are not the first to study procurement practices in Buenos Aires' hospitals. Di Tella and Schargrodsky (2003) examine corruption in Buenos Aires' hospitals during 1996-97, prior to the existence of TM.

Throughout this study we define a *drug* as a unique combination of active ingredient, dosage and presentation. There may actually be quality differences among purportedly identical drugs. Many local drug manufacturers in Argentina produce “copies” of brand-name drugs. While the copies may have identical active ingredients, they do not necessarily satisfy “bioequivalence” standards.<sup>7</sup> The term “generic” is usually applied to copies that have also proven bioequivalence. During the period of our data, the legal status of bioequivalence requirements in Argentina is in a state of flux. In other words, the difference between drugs that are copies and drugs that are generics in Argentina is unclear at this point in time. We abstract from these issues in our study. Also, only a few drugs have patent protection in Argentina, which we also ignore in our analysis.

Table 1 provides summary statistics of the data. There are 3,638 different drugs procured in the 62,283 auctions. The total value of the awarded contracts is 84 million Argentine pesos, or about US\$25 million.<sup>8</sup> We adopt the convention of reporting all price and revenue figures in US dollars.<sup>9</sup> The mean auction value is about \$1,348 and the median is \$109. There is a lot of dispersion in revenue across auctions—25% are for less than \$34, 25% are for more than \$370, and the maximum revenue in a single auction is \$3.6 million. We observe multiple auctions for each drug. The mean number of auctions per drug is 17.1, but the distribution is highly skewed, with a median number of auctions per drug equal to 5. The most frequently procured drug in the data is *Dextrose*, for which we observe 301 auctions. There are 322 drugs for which we observe at least 50 auctions.

There are 340 bidders in the data and we observe each bidder participating in multiple auctions. Bidders are one of three types. First are the 212 drug distributors, known as *droguerías*. They are generally smaller (in terms of revenue, number of drugs, number of bids per month) than the other bidders, and some are specialized in providing drugs to public hospitals alone. Second, there are 86 national drug manufacturers (known as national laboratories). These firms produce

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<sup>7</sup>To establish bioequivalence it must be shown that the drug copy has the same actual effects on a person as the drug it copies.

<sup>8</sup>Di Tella and Savedoff (2001) report that total health spending in Argentina in 1998 was \$795 million (in 1995 dollars), equal to 9.8% of GDP.

<sup>9</sup>We apply the exchange rate of one peso equals 0.30303 US dollars.

copies of existing drugs and do not develop new drugs. They generally sell their products only inside Argentina. Third, there are 42 multinational drug companies. Both national laboratories and multinationals sell drugs to droguerías as well as direct to hospitals via the procurement auctions.

As shown in Table 1, the average number of drugs per bidder, is 135 and the median is 19. A quarter of the firms bid to provide over 87 different drug products. The average number of bids (or auctions) per bidder is 870.4, with a median 32. The maximum number of bids by a single firm in our data is 19,876. A key determinant of any auction outcome is the number of bidders. In Table 1 we report the mean number of bidders per auction is 4.8. While 25% of the auctions have 7 or more bidders, 16% of the auctions have two bidders and 15% have only a single bidder.

In Table 1 we also describe the distribution of *money left on the table*, defined as the difference between the lowest and second-lowest bids, expressed as a percent of the winning bid. This variable may be interpreted as an indicator of underlying cost heterogeneity of the bidders. *Money left on the table* also indicates the degree to which the winner of the auction bid more aggressively than was needed—conditional on winning, a bidder would like to leave as little money on the table as possible. Of course bidding less aggressively reduces the probability of winning the auction. Hence, a high degree of money left on the table, does not necessarily imply sub-optimal bidding. The mean of this variable is 29.2% and the median is 12.8%. As a comparison, in the data on bidding for road construction contracts used in the study by Bajari and Ye (2003), the average amount of money left on the table is about 8%.<sup>10</sup> The comparison is surprising, since we expect there would be greater cost heterogeneity among bidders for road construction contracts, due mainly to heterogeneity in geographic location of the firms, than for suppliers of narrowly defined drugs.

Several features of the data suggest a low degree of competition in these auctions. We define the set of potential bidders for each drug as the set of firms who bid to provide each drug at least once during the period of our sample. In Table 1 we report that the average number of

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<sup>10</sup>See Table 5 in Bajari and Ye (2003).

bidders per drug is 12.6, with a median of 7. There is also sizable dispersion, with 25% of drugs having three or less potential bidders, and 25% of drugs having more than 18 potential bidders. An alternative indicator of the degree of competition is the Herfindahl-Hirschman Index (HHI), defined as the sum of squared market shares for a given drug.<sup>11</sup> For the 3,638 drugs in the data, the mean HHI is 5,849 and the median is 5,108. To put these numbers in perspective, the U.S. Department of Justice, in their horizontal merger guidelines, regard markets with an HHI in excess of 1,800 to be highly concentrated. In this data, 93% of drugs have an HHI in excess of 1,800. While this suggests a generally low degree of competition in these procurement auctions, it should be remembered that we use a very narrow market definition (a drug is defined as a unique combination of active ingredient, dosage and presentation), which is likely to understate the true degree of competition.

Another feature that suggests a low degree of competition is the large degree of variation in the distribution of winning bids (in terms of price per unit) for a given drug. In Table 2 we summarize the variation in winning bids for the twenty most procured drugs. Consider the most procured product in the data, *Dextrose*. As shown in the table, there are 301 auctions for *Dextrose* in the data, and there are 42 different bidders who submit at least one bid to supply it. The mean value of the unconditional winning bid for this drug is 0.26 (denominated in dollars per unit of the drug). The standard deviation of the distribution of winning bids for *Dextrose* is 0.30. However, it is unclear if this is a large or small degree of dispersion. A more meaningful measure may be the coefficient of variation, which is 1.15 in this case. In other words, the standard deviation in the distribution of winning bids equals 1.15 times the mean—that seems quite large. Looking down the list of top twenty drugs, most have an unconditional coefficient of variation below 0.5. The drug with the highest dispersion, by this measure, is *Cephalexin*, for which there is 85 potential bidders, making it all the more surprising.

It is conceivable that the dispersion in the unconditional distribution of winning bids for a given drug may be explained by quantity discounts or temporal cost fluctuations. These would be

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<sup>11</sup>We define market shares based on revenue shares. HHI ranges from (nearly) zero for highly fragmented markets, to 10,000 in the case of monopoly. Hence, drugs that are dominated by a small number of bidders will tend to have higher HHI values.

relatively benign explanations for the observed price variation. To address this, we separately regress the winning bids for each drug on month-year dummies, quantity and quantity-squared. The standard deviation, and coefficient of variation, for the residuals from these regressions are reported in Table 2. It must be the case that measures of price dispersion in the conditional distribution are less than in the unconditional distribution. For many of the drugs, these factors reduce the standard deviation of prices by half or more. Similarly for the coefficient of variation. For example, the coefficient of variation for *Cephalexin* falls from 1.62 to 0.61 after conditioning on these factors. Nevertheless, substantial dispersion remains for many of these drugs, after conditioning out these factors. And remember, these are the most frequently procured drugs in the data, making it all the more striking.

To better gauge the magnitude of this price dispersion, we compute a simple counterfactual. Using quantile regression, we predict the 10th-percentile price for each drug purchase, conditional on the quantity requested and the year-month of the auction. In other words, controlling for quantity-discounts and month-to-month cost fluctuations, we compute the price each hospital would pay if they could all obtain the 10th-percentile of the price distribution. We then compute the percent change in predicted revenue (to the drug suppliers) relative to the observed revenue, on a drug-by-drug basis. This is intended only as an illustration, but it allows us to attach a dollar value to the observed price dispersion.<sup>12</sup> The results from the counterfactuals are reported in the last column of Table 2. For the most procured drug, *Dextrose*, the counterfactual pricing would lower revenues by 8.5%, or about \$51,000. The greatest percent decrease in the table is for the second-most procured drug, *Ciprofloxacin*. In this case, revenue falls by nearly 38% under the counterfactual pricing, which is equivalent to almost \$19,000. The drug for which the absolute change in revenue is greatest is *Vancomycin*, with a decrease in revenue from the pricing counterfactual of about \$220,000. We should re-emphasize, all these figures are highly speculative in nature, but they do suggest the hospitals tend to pay significantly more for drugs than would be expected from a competitive market.

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<sup>12</sup>It's somewhat unreasonable, but one might interpret the counterfactual as suggestive of the amount of money that the government could save, if it were able to intensify competition and eliminate price variation unrelated to quantity discounts and cost fluctuations.

Another indication that there is a low degree of competition is the large fraction of single-bidder auctions that take place. There were 9,542 single-bidder auctions, out of 62,283 total auctions. Some auctions may have a single bidder because there is only one potential bidder (or supplier) of that drug. Indeed, there are 508 auctions in which this is the case. We determine the set of potential bidders for each given drug based on which bidders submit a bid for each drug at any time during our sample. In Figure 1 we show the histogram for the distribution of number of potential bidders in each auction, conditional on a single bid being submitted. Clearly there are a large number of potential bidders for many of these single-bidder auctions. There are 6,082 single bidder auctions, equal to 10% of the total number of auctions, for which there are at least 10 potential bidders. And there are 3,278 single-bidder auctions for which there are at least 20 potential bidders. There may be several explanations for the absence of more bidders in these auctions. One possibility is that hospitals sometimes have an urgent need for a drug and find it inconvenient to provide sufficient notification to attract multiple bidders. Another possibility is that hospitals may collude with a single bidder to avoid other potential bidders becoming aware of the auction. We make no attempt to determine if either of these explanations is supported, although we do show that the information from TM reduces the likelihood of a single-bidder auctions.

Neither the high degree of price dispersion or the high incidence of single-bidder auctions is proof of an artificially low degree of competition. But these facts are suggestive, and underly the motivation of TM to stimulate competition by increasing the provision of information to the market. In the next section, we outline the information services that TM provides, and which firms have subscribed to obtain it.



## 4 Transparent Markets Information Services

TM is a for-profit business that collects and sells information. TM's clients receive a daily email with summary information on new announcements of forthcoming drug procurement auctions at public hospitals in Buenos Aires. For each auction, there is a link in the email to the complete details of the auction: specific drug requested, quantity requested, and time and location for submitting bids. Clients may also go directly to TM's website and search the announcement database. For example, a client can search for all forthcoming auctions for a specific drug, or for auctions held by a specific hospital. The price for these services is about \$30 per month.

TM collects the information on forthcoming auctions from public sources of information. These sources are also available to potential bidders, without having to pay for the information from TM. The problem is that hospitals have a high degree of discretion in how they provide the information on forthcoming auctions, making it difficult for some potential bidders to obtain this information on their own. Sometimes a hospital may call as few as three potential bidders and then place a paper copy of the announcement on a publicly accessible desk in their procurement office. At one hospital we were told they send out an email every day to any firm that signs up for it. But this email includes a lot of information about procurements for all items needed by the hospital, not just drugs.

In addition to their own discretionary effort to provide announcement details, hospitals are required to upload the announcement information to a central web site maintained by the city of Buenos Aires. In principle, this web site should be an effective source of information about forthcoming auctions for potential bidders. However, in practice it is unreliable, especially for many hospitals that lack human or technological resources to upload the information in a timely fashion. While the government website relies on the hospitals to upload the information, TM actively tracks down the information and provides it to their clients in a timely manner. TM sends correspondents to each hospital on a regular basis. These individuals know when and where to look for announcement details at each hospital, and they have established relationships

with hospital administrators, helping them to efficiently obtain information. Importantly, TM also repackages the information into a user-friendly format, in the form of the emails sent to their clients, and their searchable web site.<sup>13</sup> In short, TM incurs the fixed costs associated with obtaining comprehensive, timely and user-friendly information about forthcoming auctions, which is spread among many potential bidders (their clients).

Prior studies into the effects of information on firm behavior tend to rely on unanticipated policy changes as a source of exogenous variation in the provision of information.<sup>14</sup> However, in this case TM sells the information to anyone that chooses to buy it. Clearly, the variation in which firms obtain information from TM, and when, is an endogenous decision of these firms. In Table 3 we compare characteristics of three groups of bidders: (i) firms that did not purchase announcements from TM during the period of our data—labeled as “Never TM Client”; (ii) firms that subscribed to announcements for the entire period of our data—labelled as “Always TM Client”; and (iii) firms that subscribed to the announcements for some but not all of the periods in the data—labelled as “Sometime TM Client”.

There are 340 bidding firms in the data, and 298 of these never subscribe to TM. The non-subscribers tend to be relatively small and are less likely to be a drug manufacturer of any kind. It is also apparent from Table 3 that the “Never TM clients” tend to bid significantly less often, provide fewer drugs, and bid at fewer hospitals. Clearly these firms could not be considered a meaningful control-group for evaluating the impact on the other bidders of obtaining information from TM. There are 20 firms that are clients of TM for the entire period of our data. They tend to be drug manufacturers (both multinational and national) with high monthly revenues, although relatively few bids per month.

Importantly, there are 18 firms for which we observe bidding in periods when they receive information from TM, and in periods when they do not. This time-series variation is an important source of identification in the analysis below. In Table 3 we report summary statistics for

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<sup>13</sup>In some ways TM is similar to firms in the US that obtain census data from the government and then resell it in a more user-friendly format.

<sup>14</sup>For example, see Milyo and Waldfogel (1999) and Jin and Leslie (2003).

these firms for the periods when they are a TM client or when they are not. These are the columns headed “Sometime TM Client”. Comparing the periods with and without TM, we see the following patterns in the data. When these firms subscribe to TM’s forthcoming auction announcements:<sup>15</sup> (i) the median number of bids per month increases by 84%; (ii) the median number of drugs bid on per month increases by 85%; (iii) the median number of hospitals where bids are submitted increases by 56%; and (iv) median monthly revenue increases by 173%.

On the face of it, these changes suggest the announcement information causes a dramatic increase in bidding activity for subscribing firms. However, the timing of when each firm subscribes to TM is not random, and may be correlated with other factors driving an increase in bidding activity. The analysis in the next couple of sections is intended to address some of these concerns. Nevertheless, in the middle of Table 3 we present additional summary statistics which, arguably, are more likely to capture the causal effects of becoming a TM client. Consider the variable *number of competing bidders*. Ideally, bidders would like to participate in auctions that have few other bidders, all else equal, since this increases the chances of winning and allows firms to offer less aggressive prices. For the “Sometime TM clients” the mean and median are both lower during the periods when these firms obtain the announcement information. The biggest change in the *number of competing bidders* is in the mean, and in this case the mean may be more meaningful, because the distribution is left skewed—the distribution of the *number of competing bidders* shifts disproportionately towards zero in the periods with TM.

If firms happen to join TM at a time when they are increasing their bidding activity regardless of the information from TM, there is no reason to expect these firms would also tend to face fewer competitors. On the other hand, the announcement information from TM probably helps bidders to become aware of auctions that they otherwise would not have known ever existed. It is plausible that these auctions would also tend to have fewer competitors, since bidders in general may be less likely to know about these auctions. Hence, the fact that firms tend to face fewer competitors in the periods when they obtain information from TM, is a more compelling

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<sup>15</sup>The distributions of most variables in Table 3 are highly skewed, as evidenced by the large differences between the mean and median values. We therefore emphasize the median as a better measure of central tendency in this discussion.

indication that TM has a causal effect on behavior.

Similar logic applies to the variable *sole bidder*, defined as the percent of bids submitted by each bidder in auctions for which theirs is the only bid. In this case the mean falls and the median rises, when firms become TM clients. As the mean is much greater than the median, the median is a more reasonable measure of central tendency in this case. Thus, the data shows that the median percent of *sole bidder* auctions rises from 2.2 to 3.0 when bidders join TM. Again, there is no obvious reason why the percent of *sole bidder* auctions would change if firms simply increased their bidding activity. This change reflects the fact that firms are better able to identify auctions which are advertized less effectively than most other auctions. Again, this suggests the patterns in the data are due to the causal effect of receiving announcement information from TM.

In the bottom part of Table 3 we report summary statistics for three variables related to bid levels. The first of these is *auction wins*. Most firms tend to win around 25% to 30% of the auctions in which they participate. Obtaining the announcement information from TM is correlated with a small increase in the frequency of winning. Although a higher rate of winning is not necessarily a good outcome for a bidder. It may be a sign that a firm is bidding too aggressively, and winning at the expense of their margin. An indication of this may be obtained from the variable *money left on the table*, which measures the percent difference between the lowest and second lowest bids.<sup>16</sup> Focusing on the set of firms that are sometime TM clients, we see that the median for money left on the table is higher with TM. A possible explanation is related to the fact that these bidders tend to face less competition when they join TM—the expected difference between the top two bids is decreasing in the number of bidders.

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<sup>16</sup>Expressed as a percent of the lowest (ie. winning) bid. The conditional mean and median values for *money left on the table* in Table 3 appear to be higher than was reported in Table 1. This is because the two tables weight observations differently. In Table 1, each auction is weighted equally. In Table 3, we compute the mean and median for each bidder, then weight each bidder equally.

## 5 The Effect of Information on Auction Participation

In this section and the next we analyze the effects on bidding behavior from individual bidders subscribing to TM’s announcement information service. The main goal of this section is to examine whether the information leads bidders to participate in more auctions. We fully expect this to be the case, but it is nonetheless helpful to verify and measure the size of the effect. Also, by looking at changes in the kinds of auctions that TM clients submit bids for, compared to before they became a client of TM, we may learn about the particular informational barriers to participation that are present in this market. In the next section we consider the effects on bid levels, and especially the winning bid which matters for hospitals’ drug costs.

As previously noted, the summary statistics in Table 3 indicate that the announcement information from TM leads to increases in the number of bids per month, the number of drugs bid on, and the number of hospitals where bids are submitted. However, a more convincing estimate would control for time-invariant bidder heterogeneity and time-period fluctuations that are common to all bidders (month dummies). We therefore estimate the following specification:

$$\ln(\text{Number of Bids per month}_{im}) = \alpha_i + \tau_m + \theta \text{Announcements}_{im} + \epsilon_{im} \quad (1)$$

where the dependent variable is the number of bids submitted by bidder  $i$  in month  $m$ , *Announcements* is the fraction of that month for which the bidder receives forthcoming announcements from TM, and  $\alpha_i$  and  $\tau_m$  are bidder and month fixed effects, respectively. Since the specification includes bidder fixed effects, identification of the coefficient on the information variable is based on time-series variation for given bidders. This approach precludes some sources of bias. Identification of causal effects therefore relies on the assumption that there is exogenous variation in the timing of when individual firms sign-up with TM. However, a causal interpretation is misleading if, for example, bidders sign-up for TM’s service as part of a broader set of organizational changes that also lead to increased bidding activity.

The estimate for  $\theta$  is shown in the top row of Table 4 (each row of the table is a different regression). The estimate for the coefficient on forthcoming announcements is large and signif-

icantly different from zero with 99% confidence. On the face of it, this finding suggests that announcement information is highly effective at increasing auction participation by individual bidders. We may also conclude that the shortage of information about forthcoming auctions is a significant barrier to entry in this environment.

We can examine where the informational barriers appear to be greatest — does the lack of information inhibit firms from bidding at some hospitals, for some drugs, or both? To answer these questions we estimate similar specifications to equation (1), in which we change the dependent variable to  $\ln(\text{Number of Drugs per month})$  or  $\ln(\text{Number of Hospitals per month})$ . The results are shown in the rows (ii) and (iii) of Table 4. We find that the announcement information has a positive impact on both the number of drugs and the number of hospitals. The informational barriers with respect to drugs are probably very different to the barriers with respect to hospitals. Bidders will generally have better relationships with some hospitals than others. But conditional on having a good relationship with a hospital, it is unclear why they would be better informed about procurements of some drugs but not others. This reasoning suggests it is surprising that the announcement information has such a big impact on the number of drugs each firm bids to supply. A possible interpretation of these findings is that hospitals do not provide equal amounts of information about forthcoming procurements to all potential bidders.

The estimated increases in the number of drugs and hospitals per month may be because firms start bidding on drugs or at hospitals they have never submitted bids for in the past, or because of an increase in the frequency of bidding for drugs or hospitals they have bid on previously. If the latter, it is misleading to say the information causes firms to bid for more drugs or at more hospitals. To distinguish these alternatives, in rows (iv) and (v) of Table 4 we report the estimates for a specification in which the dependent variable is the  $\ln(\text{Number of New Drugs per month})$ , defined as the number of drugs a firm bids for in a given month that it has never previously bid to provide in any prior month; or  $\ln(\text{Number of New Hospitals per month})$ , defined as the number of hospitals a firm bids at in a given month that it has never previously bid at.<sup>17</sup> These variables will tend to be positive even for firms that don't obtain information

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<sup>17</sup>We leave out the first two months of data in the regression, although this data is used to construct the

from TM, which is why the month dummies are all the more important in this specification. The coefficient on the announcement variable captures the extent to which the number of new drugs or new hospitals is even higher when bidders subscribe to TM's services. Again we find the announcement information has positive, large, and highly statistically significant effects in both cases. Hence, it appears that the announcement information does indeed lead firms to bid for a broader range of drugs and at a broader set of hospitals.

We also estimate the effect of joining TM on the average number of competing bidders faced in each auction. As reported in row (vi) of Table 4, the estimate is negative and significantly different from zero with 99% confidence. This is interesting because it indicates that one of the benefits of the announcement information is that it not only helps bidders to participate in more auctions, but to participate in auctions where they face less competition. The finding also indicates there is heterogeneity in the degree to which information is made available about forthcoming auctions in the absence of TM's service. Some auctions are more difficult to find out about than other auctions. The announcements from TM, however, make it possible to participate in relatively unknown auctions.

Given that the announcement information helps bidders to participate in auctions with fewer bidders, we also expect TM's clients tend to win more often than before joining TM. This is indeed the case. The probability of winning, conditional on submitting a bid, rises from .13 to .15 when firms join TM.<sup>18</sup> Finally, since TM causes firms to bid in more auctions and to win more frequently, we also expect monthly revenues for these firms to also rise. Again, this turns out to be the case. In row (vii) of Table 4 we report that monthly revenues significantly increase when bidders obtain TM's announcement information.

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dependent variable. This is the reason why there are fewer observations in this regression than the previous three.

<sup>18</sup>The difference is statistically different from zero.

## 6 Effect of Announcement Information on Prices

In theory, if the firms that obtain the announcement information from TM then participate in more auctions, and if this does not crowd-out participation by other bidders, then the average number of bidders per auction should increase and the average winning bid should decrease. Indeed, this is the prediction of the model presented in Section 2. We divide the analysis of prices into two subsections. In the first subsection we analyze the effect of subscribing to TM on bid levels of TM’s clients. In the second subsection, we assess whether the winning bids (regardless of whether the winner is a client of TM) have been impacted by TM’s provision of announcement information. This is the most important question from the point of view of hospitals and the Buenos Aires government.

### 6.1 Effect of Announcements on Bid Levels

To examine the effect of TM on bid levels of its clients, we regress  $\ln(\text{Bid Price})$  on a dummy for whether the bidder is a client of TM at the time of the auction. We also experiment with the inclusion of a variety of different fixed effects to better understand where the bid changes take place, as we explain below. Table 5 shows the results from nine different specifications. An observation in each case is a particular bid, and all regressions are based on the complete dataset of 295,943 bids in the data. All reported estimates are significantly different from zero with 99% confidence.

With no controls, we find that TM’s clients tend to submit bids that are 13.0% less than the other bidders (see row (i) of Table 5). Of course this fact may simply reflect selection—the firms that choose to subscribe to the announcements may be more aggressive bidders regardless of obtaining this information. The inclusion of bidder fixed effects helps to control for this possibility, and actually reverses the result. In this case we find that firms appear to raise their bid prices by 9.4% when they join TM relative to when the same bidder is not with TM, as shown in the second specification in Table 5. The change in sign implies there is indeed a high



degree of selection in the data. The firms that subscribe to TM’s announcements are firms that tend to submit more aggressive bids than other firms. The addition of month dummies, to control for the possibility that firms tend to join TM during periods when prices are higher for some reason, makes little difference, as shown in row (iii).

We noted above that the announcement information appears to lead firms to bid in auctions with relatively few bidders. This may explain the apparent increase in bids levels for TM’s clients—they bid less aggressively because they face less competition. One way to verify this interpretation is to include auction fixed effects which control for the number of bidders in an auction (and also controls for month effects, and the specific drug and hospital). We can do so because an observation is a bid and we observe multiple bids per auction. In this case, the estimated effect of joining TM is to decrease bid prices by about 3%, as reported in row (iv) of Table 5. The two facts—(i) without controlling for the number of bidders in an auction, joining TM appears to increase bid levels; and (ii) controlling for the number of bidders, joining TM lowers bid levels—adds support to the claim that the announcement information helps bidders to participate in less competitive auctions.

However, it is puzzling why TM’s clients would lower their submitted prices, conditional on the number of bidders. There is no obvious theoretical explanation why announcement information would cause bidders to behave in this way. Perhaps it reveals that firms choose to join TM as part of other organizational changes aimed toward more aggressive participation in these auctions. Regardless of the reason, this is a further benefit to the hospitals since it contributes to lower drug prices.

In rows (v) and (vi) of Table 5 we experiment with the inclusion of drug or hospital fixed effects. In the presence of hospital fixed effects, identification of the coefficient on the information variable is based on within-hospital variation in bidding. In other words, we estimate the average effect of joining TM on bidding behavior for a given bidder at a given hospital. In this case, as shown in row (v) of the table, the estimated effect is a 9.2% increase in bid levels. This may be because the announcements lead firms to bid on auctions at the same hospital which tend have

less competition, or to bid on other drugs at the same hospital which tend to have higher costs.

The specification used for the estimate in row (vi) of Table 5 includes drug fixed effects instead of hospital fixed effects. Identification in this case is based on bidding behavior by a given individual for a given drug, which is then averaged across bidders and drugs. This yields an estimate of 3% lower prices due to the announcements. Hence, when potential bidders join TM they tend to bid slightly more aggressively for the drugs that they had previously bid on. In theory, this could have been because they also tend to face more competition when bidding on these drugs, but the fact that we obtain the same point estimate in the specification with auction fixed effects, indicates that TM’s clients are more aggressive even with the same degree of competition.

The main conclusion from the results shown in rows (i) to (vi) of Table 5 is that obtaining the announcement information from TM appears to cause firms to submit bids on new drugs that tend to have higher prices (either because of higher costs or less competition), and to bid more aggressively on old drugs.<sup>19</sup> Also, it does not appear that the announcement information leads firms to bid on old drugs at “new hospitals” where there is less competition. The remaining rows 7 to 9 in Table 5 serve as robustness checks. The inclusion of both drug and hospital fixed effects has a minor impact on the results. Removal of bidder fixed effects makes little difference, and inclusion of bidder-drug fixed effects also has negligible impact.

## 6.2 Effect of Announcements on Winning Bids

The question now is whether the existence of TM has affected the prices paid for drugs by the hospitals? The fact that TM seems to cause its clients to participate in substantially more auctions, and somewhat paradoxically to bid more aggressively in all auctions, suggests that hospitals should benefit from TM’s existence. However, relatively few firms choose to purchase the announcements from TM, so the impact on winning bids may be very small. Although,

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<sup>19</sup>We use the term “new drugs” to refer to drugs that a given firm did not bid for prior to joining TM, but did so after joining TM. And the term “old drugs” to refer to drugs that a given firm had previously bid on.

firms that don't join TM may still be forced to bid more aggressively in the face of intensified competition from the firms that join TM, which would compound the extent to which TM's existence may stimulate lower drug prices for hospitals.

There are several ways one could estimate the effect of TM's existence on winning bids. One approach may be to estimate the impact of having at least one bid submitted by a TM client on the winning bid of an auction. But suppose that TM clients tend to participate in auctions with relatively fewer bidders, which tend to have higher winning bids, then it would appear that TM causes an increase in winning bids. A solution to this problem is to control for the number of bidders in the auction. But we believe the main way that TM affects winning bids is by increasing the number of bidders, which this would suppress.

An alternative approach may be to estimate the effect of TM on the average number of bidders in an auction, then estimate the effect of the number of bidders on the winning bid, and compute the implied impact of TM on winning bids. However, we do not observe any auctions where TM does not exist—we have no data on auctions before TM exists, or for auctions in a comparable market without TM. But we do observe individual bidders before and after they join TM. In principle, we could estimate the effect of joining TM on the probability of an individual bidder participating in an auction, then also estimate the effect of number of bidders on the winning bid. An important complication to such an approach would require a distinction between auctions for drugs that a firm is a potential bidder for, and auctions that the firm is unable to participate in regardless of joining TM. We adopt a reduced-form analog of this approach.

We estimate the following specification:

$$\ln(\textit{Winning Bid}_{jktm}) = \alpha_{jk} + \tau_m + \theta TM_{jt}^* + \epsilon_t,$$

where  $j$  indexes drugs,  $k$  indexes hospitals,  $t$  indexes auctions, and  $m$  indexes months. The variable  $TM_{jt}^*$  is defined the fraction of potential bidders for drug  $j$  that are receiving the announcement information from TM at the time of auction  $t$ . Recall, a bidder is determined to be a potential bidder for a given drug if at any time during our data period, that bidder submits

a bid at any hospital to supply that drug. Drug-hospital fixed effects are included to control for time-invariant differences in winning bids across drug-hospital combinations, and year-month dummies are included to control for general price changes over time that apply to all drugs and hospitals.

This approach incorporates the effect of TM’s existence on auction participation and the effect on bid levels (conditional on participation) for its clients. It also takes into account the differences across drugs in the set of potential bidders. For example, there may be two drugs each with 10 potential bidders that have joined TM, but one drug has a total of 15 potential bidders and the other has 100 potential bidders. Then we expect TM has a bigger impact on auctions for the former drug, because a larger fraction of potential bidders for that drug have signed up to receive the announcement information. The coefficient of interest,  $\theta$ , is identified by within-drug variation in the (unweighted) fraction of potential bidders that have joined TM.<sup>20</sup> To identify a causal effect, we rely on the assumption that changes in  $TM^*$  for a given drug are uncorrelated with other changes impacting on winning bids for that drug. This may be a reasonable assumption since individual bidders vary in the set of the drugs they are a potential bidder for, so that each time an individual bidder joins TM the consequent change in  $TM^*$  randomly differs across drugs.

A missing variable in the above winning bid equation is the quantity of drugs requested in the auction, which may explain variation in winning bids due to quantity discounts. While we do observe quantities, it is excluded because the units of quantity are different for each drug, and also because quantity discounts may apply at very different quantities for each drug. This suggests allowing the coefficients on quantity (and quantity-squared) to differ by drug. But there are 3,638 drugs in the dataset. Ultimately, it seems reasonable to us that the quantity requested is uncorrelated with  $TM^*$ , for a given drug, and therefore does not bias our estimate of  $\theta$ .

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<sup>20</sup>The inclusion of drug-hospital fixed effects allows for differences in average prices across hospitals for a given drug without impacting the estimate of  $\theta$ .

The estimate for  $\theta$  is shown in Table 6. We find that TM has caused a significant decrease in winning bid prices. The estimate of -.16 does not convey the magnitude of the effect. However, we can compute predicted prices (winning bids) based on the complete set of estimates for the equation (including all fixed effects), and then re-compute predicted prices with  $TM^*$  set to zero for all observations. With predicted and counterfactual predicted prices in hand, we can multiply by the quantity of drugs requested in each auction, and aggregate over all auctions, to compute the total cost of drugs to hospitals in Buenos Aires, with and without TM. We find that the existence of TM causes the public hospitals of Buenos Aires to save 2.9% of their drug purchase costs. In absolute terms, this is an estimated saving of \$2,857,296.

The number of bidders in each auction does not enter the estimated equation for the winning bid. However, the primary mechanism by which  $TM^*$  affects winning bids is via the number of bidders. To verify this we also estimate a version of the above equation in which we replace the dependent variable with  $\ln(\text{Number of Bidders})$ . The result is also shown in Table 6. As expected, it appears that TM does indeed cause a significant increase in the average number of bidders per auction.

## 7 Conclusion

This study examines the effects of an increase in the provision of information about the existence of forthcoming procurement auctions on the behavior of bidders. The empirical analysis indicates that the information helps potential bidders to participate in more auctions for more drugs at more hospitals, and to participate in auctions which tend to have relatively fewer competing bidders. Hence, the firms that purchase the information obtain the benefit of being able to bid less aggressively while also winning more often. Importantly, we also find that winning bids tend to be lower, which benefits the procurers. In particular, we estimate that TM has caused a 2.9% decrease in the cost of drugs for public hospitals in Buenos Aires. In absolute terms, this is a saving of US\$2.9 million, or 9.4 million Argentine pesos.

On the face of it, it is unsurprising that an increase in the provision of announcement information causes lower winning bids. However, the theoretical model presented in this paper shows how the information could have had the opposite effect, by stimulating exit of potential bidders. This would be a somewhat perverse outcome—improved announcements causing less competition. How plausible is the perverse outcome? It seems likely that the information will cause an increase in concentration among bidders, the only question is by how much. If there are a large number of small-scale bidders in any given market, and a small number of firms (in our case, multinational drug companies) that have the ability to bid in many more auctions, this is when the perverse outcome could arise.

Nevertheless, our empirical findings highlight the importance of effective announcements about forthcoming procurement auctions in order to attract bidders, stimulating competition for lower prices. Also, the results indicate that private firms can play an important role in providing this information, especially for government procurement auctions. We have shown that TM provides value for both their customers and procurers, at the expense of bidders that do not purchase the announcement information.

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Table 1: Summary Statistics

	Observations	Min.	Max.	25th-perc.	50th-perc.	75th-perc.	Mean	Std. Dev.
Auction revenue (US\$)	62,283	0.03	3.6M	33.9	109.1	370.9	1,348.5	29,640.1
Auctions per drug	3,638	1	301	2	5	16	17.1	32.8
Total revenue per drug (US\$)	3,638	0.3	5.6M	186.5	1,298.6	7,433.3	23,086.8	183,484.9
Drugs per bidder	340	1	1,663	4	19	88	134.8	286.3
Bids per bidder	340	1	19,876	7	32	243	870.4	2,507.8
Bids per auction	62,283	1	25	2	4	7	4.8	3.4
Money left on table (%)	52,741	0.0	21,211.0	4.6	12.8	28.6	29.2	127.5
Bidders per drug	3,638	1	94	3	7	18	12.6	13.6
Drug-specific HHI	3,638	731	10,000	2,995	5,108	10,000	5,849.3	3,130.4



Table 2: Dispersion in Winning Bids for Twenty Most Commonly Procured Drugs

	Number of auctions	Potential bidders	Mean unit price (\$)	Unconditional		Conditional*		Total revenue (\$)	Percent decrease in revenue**
				Std dev.	Coef. of variation	Std dev.	Coef. of variation		
Dextrose	301	42	0.26	0.30	1.15	0.29	0.95	599,172	8.52
Ciprofloxacin	277	94	0.06	0.02	0.26	0.01	0.13	49,950	37.62
Midazolam	265	71	0.53	0.21	0.40	0.08	0.08	221,086	6.16
Paracetamol	258	66	0.02	0.00	0.25	0.00	0.12	15,782	12.30
Ranitidine	250	89	0.03	0.01	0.25	0.00	0.10	41,126	18.15
Omeprazole	247	70	0.12	0.19	1.53	0.18	1.02	23,110	25.91
Espironolactone	244	57	0.18	0.07	0.38	0.04	0.16	32,095	16.34
Neostigmine	244	62	0.41	0.14	0.35	0.06	0.09	61,308	13.51
Cephalexin	238	85	0.11	0.17	1.62	0.16	0.61	120,854	1.69
Clonazepam	237	65	0.04	0.02	0.53	0.02	0.29	95,716	35.80
Vancomycin	234	73	2.55	0.68	0.27	0.38	0.11	813,676	26.94
Ibuprofen	231	82	0.02	0.01	0.28	0.00	0.15	22,658	14.66
Ceftazidime	229	67	1.98	0.52	0.27	0.24	0.09	462,288	12.42
Clindamycin	223	61	0.67	0.26	0.39	0.12	0.11	166,273	11.35
Enalapril maleate	221	71	0.02	0.01	0.32	0.00	0.10	45,446	13.88
Loperamide	220	53	0.03	0.02	0.67	0.02	0.49	6,616	23.13
Carbamazepine	218	55	0.04	0.01	0.19	0.01	0.14	219,899	13.39
Propofol	218	71	2.93	0.85	0.29	0.39	0.09	107,352	8.41
Sulfate magnesium	212	49	0.41	0.14	0.35	0.08	0.13	53,359	14.86
Lactulose	210	35	2.55	0.62	0.24	0.44	0.16	54,267	17.49

\* Conditional on month-year dummies, quantity and quantity-squared.

\*\* We use quantile regression to predict the 10th-percentile of the price distribution, conditional on month-year dummies, quantity and quantity-squared. We then compute the change in total revenue based on the assumption that the price for each procurement equals the 10th-percentile price, conditional on the month and quantity requested in each auction.

Table 3: Characteristics of TM and non-TM Clients

		Never TM Client	Always TM Client	Sometime TM Client	
				Without TM	With TM
Number of bidders		298	20	18	18
Multinational Laboratories (%)		11.1	20.0	16.7	16.7
National Laboratories (%)		23.5	35.0	33.3	33.3
Distributors (%)		65.4	45.0	50.0	50.0
Bids/month					
	mean	40.5	57.3	140.0	165.0
	median	5.1	9.6	51.1	94.3
	std dev	114.0	127.0	256.0	228.0
Drugs/month					
	mean	25.4	30.2	80.0	93.9
	median	4.8	7.9	30.6	56.6
	std dev	60.8	76.4	114.0	105.0
Hospitals/month					
	mean	3.5	6.1	7.9	10.1
	median	1.4	1.8	4.8	7.5
	std dev	4.8	7.1	7.2	7.7
Revenue/month ('000 US\$)					
	mean	67.3	51.0	42.1	28.2
	median	0.9	10.5	4.1	11.2
	std dev	470.5	88.2	109.1	50.7
Num. Competing Bidders					
	mean	6.1	6.0	6.6	6.2
	median	6.2	5.6	6.6	6.5
	std dev	2.6	2.0	2.5	2.4
Sole bidder (%)					
	mean	7.3	6.5	9.8	9.1
	median	1.8	3.7	2.2	3.0
	std dev	16.0	9.5	23.1	13.1
Auction wins (%)					
	mean	31.8	32.0	30.2	32.0
	median	25.0	26.8	23.6	25.8
	std dev	27.5	25.0	24.1	19.7
Money left on table (%)					
	mean	38.5	34.8	62.1	26.8
	median	27.3	28.1	21.2	26.0
	std dev	55.8	24.5	148.0	15.0

Table 4: Effects of Announcement Information on  
Various Measures of Participation

	Dependent Variable	Coefficient	Standard Error	$R^2$	No. Obs
i.	ln(Number of Bids per month)	1.6023	0.1117	0.81	6,800
ii.	ln(Number of Drugs per month)	1.0590	0.1069	0.74	6,800
iii.	ln(Number of Hospitals per month)	0.6933	0.0537	0.71	6,800
iv.	ln(Number of New Drugs per month)	0.9798	0.0915	0.66	6,120
v.	ln(Number of New Hospitals per month)	0.7001	0.1110	0.27	6,120
vi.	ln(Number of Competing Bidders)	-.0905	0.0075	0.13	295,943
vii.	ln(Revenue per month)	3.9441	0.3076	0.68	6,800

All coefficients shown in the table are statistically different from zero with 99% confidence. All regressions include bidder fixed effects and year-month dummies. The number of observations is lower in regressions (iv) and (v) because we exclude the first two months. In regression (vi) an observation is an auction, in all other regressions an observation is a bidder-month combination. Standard errors are in brackets. Robust standard errors are in brackets.

Table 5: Effects of Announcement Information on  $\ln(\text{Bid Price})$  with Alternative Fixed Effects

	Coefficient	Standard Error	Bidder	Yr-Mnth	Hospital	Drug	Auction	Bidder-Drug	$R^2$
i.	-0.1304	0.0086							0.01
ii.	0.0941	0.0227	Y						0.15
iii.	0.1028	0.0226	Y	Y					0.15
iv.	-0.0296	0.0041	Y				Y		0.98
v.	0.0929	0.0220	Y	Y	Y				0.19
vi.	-0.0296	0.0045	Y	Y		Y			0.97
vii.	-0.0398	0.0046	Y	Y	Y	Y			0.97
viii.	-0.0263	0.0018		Y	Y	Y			0.96
ix.	-0.0298	0.0045		Y				Y	0.98

The number of observations in all regressions is 295,943. All coefficients shown in the table are statistically different from zero with 99% confidence. Robust standard errors are in reported.

Table 6: Effects of Announcement Information on  
Competition and Winning Bids

Dependent Variable	Fraction of Potential Bidders with TM	$R^2$	Number of Observations
$\ln(\textit{Winning Bid})$	-.1601 (0.0485)	0.98	62,283
$\ln(\textit{Number of Bidders})$	0.2108 (0.0702)	0.69	62,283

Both regression include year-month dummies and drug-hospital fixed effects. Robust standard errors are in brackets. All reported estimates are significantly different from zero with 99% confidence.

Figure 1: Histogram of Potential Bidders for Auctions with a Single Bid

