INFORMATION ENTREPRENEURS AND COMPETITION IN PROCUREMENT AUCTIONS*

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Abstract

One of the most important goals of auction design is to attract as many bidders as possible. In this paper we study the role of a third party, called an information entrepreneur, that collects and sells announcements about forthcoming auctions, with the ostensible goal of encouraging participation. A model is presented in which the entry of an information entrepreneur leads to more participation by bidders if it competes against the previously available information technology. If the information entrepreneur is the sole source of information about the existence of forthcoming auctions, participation may decrease leading to higher costs for procurers. We then empirically examine the effects from an information entrepreneur that provides announcement details for drug procurement auctions at public hospitals in Buenos Aires. By stimulating participation, we find that the information entrepreneur causes a 2.9% decrease in the cost of drugs over a period of almost two years. The empirical example illustrates how markets can provide private incentives to increase the provision of information.

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1 Introduction

One of the most important goals of auction design is to attract as many bidders as possible.[1] But an even more basic determinant of the number of bidders is the degree to which potential bidders are informed about the existence of the auction. For a variety of reasons there may be inadequate auction announcements: there could be weak incentives for governments, high costs in the announcement technology (such as information costs for learning the identities of potential bidders), or corrupt behavior that seeks to limit auction participation to favored bidders. To help overcome these challenges, procurers often rely on third parties that assist in identifying and attracting potential bidders, as well as facilitating the auction in other ways.[2] In this paper we study the role of a third party that specializes in collecting and selling 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 their impact on competition in the auctions.

The information entrepreneur in this case is interesting because it would appear to be a market-based solution to an important practical problem in auctions—the need to attract as many bidders as possible. However, it is possible the information entrepreneur may actually reduce participation. Consider a setting with multiple auctions and multiple potential bidders who are imperfectly informed about the existence of each auction. An information entrepreneur sells enhanced announcement information. For the potential bidders that obtain this information, there is an increased probability that they will participate in any given auction. On the one hand, the information entrepreneur promotes competition by stimulating auction participation. On the other hand, if the information entrepreneur sells the information for a fixed fee then some potential bidders may exit the market altogether, lowering the degree of competition. In the extreme, the information entrepreneur would like to maximize profit by setting a high enough

[1] Klemperer (2004) emphasizes the point: "What really matters in practical auction design is robustness against collusion and attractiveness to entry" (p. 131).

[2] For example, investment banks' certification of firms for initial public offerings, selling agents for housing transactions, and any number of consulting companies that help firms or governments outsource services or procure inputs more generally.

price for the information such that there is a monopoly bidder in each auction, allowing the entrepreneur to extract the monopoly surplus from the auctions. It is an interesting example of how a firm that provides an information service which ostensibly stimulates competition, may in fact reduce the degree of competition.[3]

In Section 2 we present a stylized model to address the question: under what circumstances does the existence of an information entrepreneur increase or decrease the expected costs to procurers? The analysis shows that the existence of an information entrepreneur may either increase or decrease the number of active bidders in the market. However, assuming the original (inferior) announcement technology is still available to bidders for free, we find that the effect of the information entrepreneur on the expected number of bids per auction is always non-negative. Hence, even if the information entrepreneur stimulates exit of potential bidders, the degree of competition is never lowered, because the remaining bidders disproportionately bid more often. This is because the information entrepreneur must compete with the inferior information technology. If the old technology is no longer available, then we show that it is possible the information entrepreneur will cause a decrease in the number of expected bidders per auction, despite providing a service that ostensibly encourages competition. These findings indicate that procurers should be cautious about outsourcing the announcement-process without maintaining the existing technology or promoting competition.

We then analyze the empirical 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). It is well known that imperfect information tends to mitigate competition. TM provides an example of the tantalizing notion that information may be collected and sold in response to market-based incentives, which also promotes competition. We find that TM causes its clients to participate in substantially more auctions. The information also helps bidders to 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

[3]See also Baye and Morgan (2001).

announcement information therefore suffer lower profitability.

Importantly, the overall effect of TM for public hospitals in Buenos Aires is lower cost drugs. We estimate that TM caused a 2.9% decrease in the total cost of drugs for these hospitals, a saving of about $740,000. The cost to TM of acquiring the information is almost certainly less than $100,000, and may be as low as their revenue during the same period of around $22,000. Hence, these findings also highlight the dramatic efficiency gains that can be achieved from relatively low cost information provision. To what extent can we extrapolate these findings? The potential for significant efficiency gains from increased information may not apply to high-profile settings such as spectrum auctions, for which a lot of information is already available. However, in settings where firms or branches of government hold large numbers of auctions for relatively low value items, it is plausible that potential bidders are often uninformed about the existence of any specific auction and would be responsive to enhanced announcements.

A number of studies have examined the effects of the internet on consumer markets. For example, Brown and Goolsbee (2002) show that internet price comparison sites cause 8–15% lower prices for life insurance; and Scott Morton, Zettelmeyer and Silva-Risso (2001) find that internet car referral services cause 2% lower car prices. Our study extends this literature to a business-to-business setting, and to a different mechanism—using the internet to inform potential bidders and stimulate auction participation.

Auction participation is often, but not always, assumed to be exogenous in empirical auction research. Two notable exceptions are the studies by Athey, Levin and Seira (2004), and Li and Zheng (2006). The existing research about participation focuses on how the design of the tendering process may affect participation.[4] We are unaware of prior research into the role of third parties that promote bidder participation, or the impact of basic improvements in the provision of announcement information. Our findings verify that, in practice, ineffectual announcements about the existence of forthcoming auctions can be a significant barrier to entry for potential bidders. It should be noted that we refer to procurement auctions throughout the

[4]See also Albano, *et al*, (2006).

paper because of the empirical example we study. However, our analysis and conclusions apply equally to auctions in which bidders are buyers.

In Section 2 we present a theoretical model of an information entrepreneur selling auction announcements to potential bidders. Section 3 summarizes the dataset and institutional details of the drug procurement auctions we study, and describesthe information services provided by TM. Our analysis of the effects of the information on sellers' auction participation decisions is contained in Section 4, and in Section 5 we analyze the effects of the information on bids. Section 6 is the conclusion.

2 Model

In this section we present a stylized model of procurement auctions in which the expected number of bids per auction depends on the presence of an information entrepreneur that gathers and sells auction announcement information. 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.[5] We assume throughout that the organizations which purchase the products have inelastic demand, making them passive agents in our analysis.[6]

The purpose of the model is to shed light on two potentially opposing effects from an information entrepreneur. On the one hand, by increasing the provision of announcement information an information entrepreneur lowers the cost of auction participation which stimulates competition among bidders. On the other hand, it may be in the interest of the information entrepreneur to sell the information for a high price, increasing fixed costs for potential bidders, which induces

[5] We assume a monopoly information entrepreneur. Related competitive issues are discussed in Caillaud and Jullien (2003) and Rochet and Stole (2003).

[6] We think this is especially reasonable for the empirical example we study which concerns hospitals' purchases of drugs.

exit and leads to less competition among bidders. Hence, in this section we ask the question: under what circumstances does the existence of an information entrepreneur increase or decrease the expected costs to procurers?

Without loss of generality we assume there are two potential bidders for T procurement auctions. The point of the model is to understand the implications of bidders being imperfectly informed about the existence of auctions, and the impact of an information entrepreneur that provides superior information. In the absence of the information entrepreneur, each potential bidder is aware of the existence of each auction with probability β. Each bidder submits a bid in a given auction if and only if they are aware of the auction. If there exists an information entrepreneur, she sells all announcements for a fixed price w, and the buyers of this information are aware of the existence of each auction with probability $\alpha > \beta$.

Auctions are private value, first-price, sealed-bid auctions. It is assumed that each bidder obtains a cost draw (c_{it}) for each auction that is independent and identically distributed across bidders (i) and auctions (t). To simplify the analysis we assume a uniform distribution: $c_{it} \sim \mathrm{U}[0,1]$. In this case, conditional on submitting a bid in an auction with n bidders, the expected profit of the winning bidder equals $(n+1)^{-1}$. The expected profit for any bidder, conditional on submitting a bid, equals $[n(n+1)]^{-1}$.[7]

The timing of the game is as follows. If there exists an information entrepreneur, she chooses a price for her information, w. Both bidders then simultaneously decide their probability of entry into the pool of potential bidders, θ_1 and θ_2 respectively. If there exists an information entrepreneur, after observing entry realizations the bidders then simultaneously decide whether to purchase the proprietory announcement information (α-technology), or to rely on the free public announcements (β-technology). Each bidder then receives their T cost draws and realizations of whether they are informed about the existence of each auction. Bids are then submitted

[7] We assume the number of bidders in any given auction is common knowledge. Krishna (2002) notes that allowing for uncertainty in the number of bidders does not affect key qualities of an auction equilibrium. For example, on p. 32 Krishna shows that the revenue equivalence principle is robust to uncertainty in the number of bidders.

and profits determined. We first characterize the symmetric mixed strategy equilibrium when there is no information entrepreneur, and then determine the equilibrium with an information entrepreneur.

Absent an information entrepreneur, the expected profit of bidder i, conditional on entering the market, is given by:

$$\pi_i(\theta_j) = T\left[\frac{\theta_j\beta^2}{6} + \frac{\beta(1-\theta_j\beta)}{2}\right] - F,$$

where F is a fixed cost (independent of the number of bids submitted). The first term in the square-brackets is the probability that i and j both submit bids in any given auction times the expected profit from an auction with two bids. The second term is the probability that i is the sole-bidder in any given auction times the expected profit in that case. Bidder i will implement a mixed strategy only if they are indifferent to entering; i.e. $\pi_i(\theta_j) = 0$. This implies the following symmetric Nash equilibrium (without an information entrepreneur):[8]

$$\theta_1^* = \theta_2^* = \theta_\beta^* = \frac{3}{2\beta} - \frac{3F}{T\beta^2}.$$

Hence, the expected number of potential bidders is decreasing in the fixed cost of entry (F) and increasing in the number of auctions (T). The awareness probability, β, has a nonlinear effect on the expected number of potential bidders. This reflects two conflicting forces: higher values of β mean it is more likely a bidder will compete in more auctions which is good for profitability; but higher values of β mean it is more likely there will be a competing bidder in any given auction which is bad for profitability.

Now suppose there exists an information entrepreneur selling superior announcements for a fixed fee w. Temporarily assume that both bidders purchase this information if they enter the market. In this case, we replace β with α, and we replace to F with $F + w$, to obtain the symmetric equilibrium:

$$\theta_\alpha^*(w) = \frac{3}{2\alpha} - \frac{3(F+w)}{T\alpha^2}.$$

The information entrepreneur chooses w to maximize their expected profit. We assume the

[8] Strictly speaking θ_i^* is the maximum of zero and this expression, and the minimum of one and this expression.

marginal cost of selling the information is zero. The demand for the information from the two potential entrants is equal to $2\theta^*_\alpha(w)$.[9] Ignoring the entrepreneur's fixed costs, their profit is given by $2w\theta^*_\alpha(w)$. Substituting in the expression for $\theta^*_\alpha(w)$ and solving the FOC yields:

$$w^* = \frac{1}{4}\alpha T - \frac{1}{2}F,$$

which we substitute into $\theta^*(w)$ to obtain the reduced-form symmetric equilibrium entry probability:

$$\theta^*(w) = \frac{3}{4\alpha} - \frac{3F}{2T\alpha^2}.$$

But either bidder may prefer to not purchase the announcements for w, instead using the old β-technology for free. To examine this possibility, assume that each entrant simultaneously decides whether to purchase the α-technology for w or to use the β-technology for free, **after** observing the realizations of the market-entry decisions by both firms. We therefore need to consider two cases: only one firm has entered, or both firms have entered. In the first case, the entrant will purchase the α-technology if and only if

$$\frac{1}{2}\alpha T - F - w \geq \frac{1}{2}\beta T - F. \tag{1}$$

In the second case, assuming firm j purchases the α-technology, firm i will also purchase the α-technology if and only if

$$T\left[\frac{\alpha^2}{6} + \frac{\alpha(1-\alpha)}{2}\right] - F - w \geq T\left[\frac{\alpha\beta}{6} + \frac{\beta(1-\alpha)}{2}\right] - F. \tag{2}$$

Each condition is simply that the profit from buying the α-technology is at least as great as using the β-technology for free, assuming the firm is either a monopolist or is competing against a firm that has the α-technology.

Depending on the model's parameters (α, β, T, and F) it is possible to compute equilibria which satisfy equations (1) and (2). However, our interest is whether the existence of the information entrepreneur may be detrimental to procurers. Note that the expected winning bid is decreasing in the number of bidders. The expected number of bidders without an information

[9] We continue to assume for the time being that both bidders purchase the information if they enter.

entrepreneur equals $2\theta_\beta^*\beta$. The expected number of bidders with an information entrepreneur equals $2\theta_\alpha^*\alpha$, assuming conditions (1) and (2) are satisfied. Also note there is a distinction between entrants and bidders in our model. Entrants incur the fixed cost to join the pool of potential bidders, and potential bidders compete in each auction only with some probability. The expected number of entrants equals $2\theta_\beta^*$ and $2\theta_\alpha^*$, without and with an information entrepreneur, respectively.

Consider the following example: $T = 10$, $F = 1.25$, $\beta = 0.3$ and $\alpha = 0.6$. In this case, $\theta_\beta^* = 0.83$ and $\theta_\alpha^* = 0.73$.[10] Hence, in the presence of an information entrepreneur the expected number of potential bidders falls from 1.67 to 1.46. But even though fewer firms are likely to enter the market, those that do submit more bids because they use the α-technology. In this example the expected number of bids per auction increases from 0.50 to 0.87. The profit maximizing price of the announcements from the information entrepreneur is $w^* = 0.88$.

It is possible to construct examples in which the expected number entrants and the expected number of bidders are both higher in the presence of an information entrepreneur. However, it is never possible in this model that the information entrepreneur will cause a decrease in the expected number of bidders—see the Appendix for proof of this claim. The reason is because the β-technology is still available to firms, which limits the ability of the information entrepreneur to raise w.

Interestingly, if the old technology is no longer available—suppose the government stops providing inferior announcements once the market provides its own announcements—then it is possible that the information entrepreneur will cause a reduction in the expected number of bidders. In the context of our model, in this case we ignore the constraints given by equations (1) and (2). Consider the following example: $T = 10$, $F = 2.4$, $\beta = 0.85$ and $\alpha = 0.95$. In this case, $\theta_\beta^* = 0.77$ and $\theta_\alpha^* = 0.39$. Because of the information entrepreneur, the expected number of bidders and the expected number of bids per auction decreases from 1.31 to 0.74.

[10] Conditions (1) and (2) are both satisfied in this example.

The scenario in which the old information technology is no longer available may be likely in a situation where a branch of government decides to outsource the provision of announcements. In other words, the government decides to no longer devote resources to this task, instead relying on a private firm to perform the service and obtain its own revenues from doing so. The above analysis cautions against such an approach. An alternative may be to outsource the provision of announcements with the condition that the announcements are freely provided, and the government pays a fixed fee to the information entrepreneur. But this reduces the incentive for the information entrepreneur to provide a high quality service, possibly reducing the number of bids per auction. A better approach may be to reward the information entrepreneur on the basis of the number of bids submitted. Although this may encourage disingenuous bids.[11]

Baye and Morgan (2001) show a theoretical result that is similar in spirit to the above analysis.[12] 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. Although we find that the continued presence of the old inferior information technology is sufficient to ensure that the impact of the information entrepreneur is never harmful to procurers, and is often to their benefit.

In the remainder of the paper we consider an empirical example of an information entrepreneur in a setting where the old information technology remains available. Hence, our model suggests the existence of the information entrepreneur should benefit the procurers. We seek to verify this claim. But more importantly, the empirical analysis allows us to quantify the magnitude of these effects—how much benefit does an information entrepreneur have on procurers, and how does this compare to the costs of collecting and providing superior announcements?

[11]Note that the gains from attracting bidders may be limited in circumstances where there is some cost of bidding.

[12]See also Chen, Iyer and Padmanabhan (2002).

3 Market Summary and TM's Information Service

Public hospitals in Buenos Aires, Argentina, purchase drugs and other products via procurement auctions. Each hospital conducts their own auctions. Procurement auctions are not just held for high value purchases, but even relatively small value purchases such as $50 worth of a certain product. The data used in this study come from TM. 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.[13] 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.[14]

A virtue of studying drug procurement auctions is that products can be precisely defined. Throughout this study we define a *drug* as a unique combination of active ingredient, dosage and presentation.[15] 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. We adopt the convention of reporting all price and revenue figures in US dollars.[16] 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

[13]The government 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.

[14]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.

[15]Only a few drugs have patent protection in Argentina which we ignore in our analysis.

[16]We apply the exchange rate of one peso equals 0.30303 US dollars for all the analysis, below. Since we apply a constant exchange rate, this is equivalent to leaving all figures in Argentine pesos and simply re-scaling. Hence, exchange rate fluctuations are inconsequential to our analysis.

auctions.[17] 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.

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 the 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.[18]

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

[17] Bidders are mainly drug distributors (known as droguerias), but there are a significant number of domestic drug manufacturers and multinational drug companies that also submit bids.

[18] As an indication of the low degree of sophistication in this market, during a visit we noted that the procurement office of the largest public hospital in Buenos Aires had one (quite old) computer that was shared by the staff of roughly six people.

of Buenos Aires.[19] 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. 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).[20]

Prior studies of 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.[21] However, in this case TM sells the information to anyone that chooses to buy it. Why do some firms choose to purchase the information and others do not? In principle, the firms which stand to gain the most choose to subscribe. However, our conversations with TM indicate that, in practice, their customers tended to be firms that supported their mission of increasing market transparency. The principle and the practice are not necessarily at odds: firms that find it difficult to obtain information in this market (and feel disadvantaged compared to other firms that can exploit relationships they may have with particular hospitals), are likely to agree with TM's mission, and would also gain from accessing better information. Hence, we need to address the issue that obtaining information from TM is an endogenous decision of these firms.

In Table 2 we compare characteristics of three groups of bidders: (i) firms that did not

[19] Interestingly, the city of Buenos Aires started working on their website only after TM started offering their service. Viewed as a response to TM, this is consistent with the model in the prior section, which emphasizes the importance of providing a competing source of announcement information to the information entrepreneur.

[20] Presumably the hospitals failure to provide high quality announcements is due to the high costs of coordination. A notable example of government intervention to overcome these kind of issues is CONSIP, a branch of the Italian government that uses information technology to promote efficient government procurement.

[21] For example, see Jin and Leslie (2003).

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 distributors. It is also apparent that the "Never TM clients" tend to bid significantly less often, provide fewer drugs, and bid at fewer hospitals.

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 allows us to rely on firm fixed effects to control for (time-invariant) unobserved heterogeneity. In Table 2 we report summary statistics for 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:[22] (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 may be correlated with other factors driving an increase in bidding activity. The analysis in the next couple of sections is intended to address these concerns. Nevertheless, in the middle of Table 2 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*

[22] The distributions of most variables in Table 2 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.

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.[23] 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 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 2 we summarize winning percentages. 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

[23] We were told by TM that the identities of the firms subscribing to their announcement service was not public information. It is reasonable to assume that bidders do not know whether rival's obtain the information from TM.

a firm is bidding too aggressively, and winning at the expense of their margin.

4 Effect of the Information Entrepreneur 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 in fact 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 2 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:

$$ln(Number\ of\ Bids\ per\ month_{im}) = \alpha_i + \tau_m + \theta Announcements_{im} + \epsilon_{im} \tag{3}$$

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 α_i and τ_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 θ is shown in the top row of Table 3 (each row of the table is a different regression). The estimate for the coefficient on forthcoming announcements is large and significantly 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 (3), in which we change the dependent variable to *ln(Number of Drugs per month)* or *ln(Number of Hospitals per month)*. The results are shown in the rows (ii) and (iii) of Table 3. 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. To examine this possibility we also estimated the effect of TM on the incidence of bidding for each separate hospital. However, the estimates were insignificantly different across hospitals.

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 3 we report the estimates for a specification in which the dependent variable is the *ln(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(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.[24] These variables will tend to be positive even for firms that don't obtain information 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.[25]

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 3, 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

[24] We leave out the first two months of data in the regression, although this data is used to construct the dependent variable. This is the reason why there are fewer observations in this regression than the previous three.

[25] Our data allows us to examine the effects of the information separately for each hospital. It is conceivable that barriers to entry for auction participation are higher at some hospitals than others. However, in unreported regressions, we found no significant differences across hospitals.

.15 when firms join TM.[26] 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 3 we report that monthly revenues significantly increase when bidders obtain TM's announcement information.

In short, we find that the information entrepreneur causes an increase in auction participation, as predicted by the model in Section 2. Next we examine whether the information entrepreneur leads to lower drug prices for hospitals, as also predicted by the model.

5 Effect of the Information Entrepreneur on Drug Prices

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.

5.1 Effect of Announcements on Bid Levels

To examine the effect of TM on bid levels of its clients, we regress *ln(Bid Price)* on a dummy for whether the bidder is a client of TM at the time of the auction.[27]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 4 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

[26]The difference is statistically different from zero.
[27]*Bid Price* is defined as the per unit price.

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 4). 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 4. 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 4. 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 4 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 4 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 4 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.[28] 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 4 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,

[28]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.

and inclusion of bidder-drug fixed effects also has negligible impact.

5.2 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, 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:

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

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, θ, is identified by within-drug variation in the (unweighted) fraction of potential bidders that have joined TM.[29] 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.

[29] The inclusion of drug-hospital fixed effects allows for differences in average prices across hospitals for a given drug without impacting the estimate of θ.

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 θ.

The estimate for θ is shown in Table 5. We find that TM has caused a significant decrease in winning bid prices. The estimate of -.16 implies the cost of drugs would be 16% lower if all firms subscribed to the information from TM, compared to the cost when no firms obtain this information. However, in fact not all firms subscribe to TM, and the effective number of subscribing firms vary by drug. Hence, to compute the realized impact of TM (based on the estimate of θ), we 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 the their drug purchase costs. In absolute terms, this is an estimated saving of about $740,000.

As discussed above, 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(Number of Bidders).* The result is also shown in Table 5. As expected, it appears that TM does indeed cause a significant increase in the average number of bidders per auction.

6 Conclusion

This study examines the role of a profit-seeking firm to collect and sell information about forthcoming procurement auctions. We present a model clarifying how such an information entrepreneur may be profitable while at the same time stimulating competition in the auctions, to the benefit of procurers. However, our theoretical analysis suggests it is important that potential bidders may choose to rely on the freely available inferior announcements, which provides a source of competition to the information entrepreneur. Otherwise, if the information entrepreneur is the sole source of announcement details then she has an incentive to reduce competition in the auctions by selling the information for a high price.

The empirical analysis verifies the prediction of the model—if the original inferior announcements are available then the presence of an information entrepreneur stimulates competition. More importantly, we find that the magnitude of this effect is economically significant. The information entrepreneur we analyze caused a 2.9% decrease in the cost of drugs for public hospitals in Buenos Aires over nearly two years. In absolute terms, this is a saving of US$740,000, or 2.4 million Argentine pesos.

The cost of obtaining and disseminating the information is surely less than US$100,000, and may be as low as the revenue of the firm during this period which is about US$22,000. It is therefore striking that there exists such a large benefit of information compared to the cost. The question arises as to why the public hospitals did not provide better announcement information themselves? The answer must be that the costs to coordination across hospitals is high, and/or the incentives for individuals to implement change are low. It seems plausible to us that similar benefits from low-cost increases in the provision information would exist in many other procurement settings, especially government procurement auctions.

This research provides empirical support for the importance of providing effective announcements about forthcoming procurement auctions in order to stimulate entry. As Bulow and Klemperer (1996) show, this may be more important in determining the winning bid than auction design. We have also documented an example of private market incentives driving the generation of information that promotes competition.

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Appendix

We noted in Section (2) that according to our model, as long as the old information service (i.e. β-technology) continues to be available, it is never possible that the information entrepreneur will cause a decrease in the expected number of bidders. We now prove this claim.

Define

$$\begin{aligned} w_1 &= T(\alpha - \beta)\left(\frac{\alpha}{6} + \frac{(1-\alpha)}{2}\right), \\ w_2 &= T(\alpha - \beta)\left(\frac{\beta}{6} + \frac{(1-\beta)}{2}\right), \quad \text{and} \\ w_3 &= \frac{1}{2}T(\alpha - \beta). \end{aligned}$$

Lemma: Under the assumptions of the model in Section (2):

(i) if $w \leq w_1$ then both bidders always buy the information entrepreneur's announcements (if they enter);

(ii) if $w_1 < w \leq w_2$ then bidders will buy the announcements (with certainty) from the information entrepreneur if the other bidder does not enter, and they will mix over buying and not buying if both bidders enter;

(iii) if $w_2 < w \leq w_3$ then bidders will only buy the information if the other bidder did not enter; and

(iv) if $w_3 < w$ then no bidder buys the information entrepreneur's announcements.

Furthermore, $w_1 \leq w_2 \leq w_3$.

Proof: If bidder 1 is present and bidder 2 did not enter, then bidder 1 should buy the information if

$$\frac{1}{2}T\alpha - w \geq \frac{1}{2}T\beta \tag{4}$$

If both bidders are present but bidder 2 does not buy the information, then bidder 1 should buy the information if

$$T\alpha\left(\frac{\beta}{6} + \frac{(1-\beta)}{2}\right) - w \geq T\beta\left(\frac{\beta}{6} + \frac{(1-\beta)}{2}\right) \tag{5}$$

If both bidders are present and bidder 2 buys the information, then bidder 1 should buy the information if

$$T\alpha\left(\frac{\alpha}{6}+\frac{(1-\alpha)}{2}\right)-w\geq T\beta\left(\frac{\alpha}{6}+\frac{(1-\alpha)}{2}\right) \tag{6}$$

We now show that (6) $\Rightarrow$ (5) $\Rightarrow$ (4).

Note that (6) $\Rightarrow T(\alpha-\beta)\left[\frac{\alpha}{6}+\frac{(1-\alpha)}{2}\right]\geq w$. Since $0<\beta<\alpha<1$, then $\left[\frac{\beta}{6}+\frac{(1-\beta)}{2}\right]>\left[\frac{\alpha}{6}+\frac{(1-\alpha)}{2}\right]$. Thus, $T(\alpha-\beta)\left[\frac{\beta}{6}+\frac{(1-\beta)}{2}\right]\geq w$, which is what is required for (5).

To see that (5) $\Rightarrow$ (4), note that $T(\alpha-\beta)\left[\frac{\beta}{6}+\frac{(1-\beta)}{2}\right]\geq w$, and $\left[\frac{\beta}{6}+\frac{(1-\beta)}{2}\right]<\frac{1}{2}$. Hence, $\frac{1}{2}T(\alpha-\beta)>w$. ■

Proposition: For any w charged by the information entrepreneur (optimal or not), the expected number of bidders in the equilibrium of the resulting subgame is (weakly) greater than in the equilibrium without the information entrepreneur.

Proof: Recall from the text, the symmetric Nash equilibrium (without an information entrepreneur) is given by:

$$\theta_\beta^*=\frac{3}{2\beta}-\frac{3F}{T\beta^2}.$$

Since the equilibrium mixing probabilities must lie between zero and one, define $\sigma_\beta^*\equiv\max\left\{\min\left\{\theta_\beta^*,1\right\},0\right\}$. Similarly for $\theta_\alpha^*(w)$, and $\sigma_\alpha^*(w)$.

We divide the proof into four cases over the possible ranges of w:

Case 1: $w\leq w_1$

In this case, both bidders always buy the information entrepreneur's announcements (if they enter).

Note that $\theta_\alpha(w)$ is decreasing in w. Hence, it suffices to show the claim is true at $w=w_1$. Suppose first that $\sigma_\beta^*=1$, and therefore $\theta_\beta^*\geq 1$. This implies that the payoff to bidder i from entering (without an information entrepreneur) is greater than zero, even when $\theta_j=1$. Hence

$$\beta T\left(\frac{\beta}{6}+\frac{1-\beta}{2}\right)\geq F. \tag{7}$$

Now consider the payoffs in the presence of an information entrepreneur (again, with $w=$

w_1):

$$\begin{aligned}\pi_\alpha(\theta_\alpha) &= \theta_\alpha\left[\alpha T\left(\frac{\alpha}{6}+\frac{1-\alpha}{2}\right)-w_1\right]+(1-\theta_\alpha)\left(T\frac{\alpha}{2}-w_1\right)-F \\ &= \theta_\alpha\left[\underbrace{\beta T\left(\frac{\alpha}{6}+\frac{1-\alpha}{2}\right)}_{\pi_1}\right]+(1-\theta_\alpha)\left[\underbrace{T\frac{\beta}{2}+T(\alpha-\beta)\frac{\alpha}{3}}_{\pi_0}\right]-F \qquad (8)\end{aligned}$$

The payoff is clearly higher when the other bidder doesn't enter ($\pi_0 > \pi_1$), and so $\pi(\theta_\alpha)$ is decreasing in θ_α.

Next we show that $\pi\left(\frac{\beta}{\alpha}\right) > 0$, meaning that (in equilibrium) $\theta^*_\alpha > \frac{\beta}{\alpha}$, and so $min\{\theta^*_\alpha, 1\}\alpha > \beta$. From (7) we have $\pi_1 \geq F - T(\alpha-\beta)\frac{\beta}{3}$, and $\pi_0 \geq F + T\left[\frac{\beta^2}{3}+(\alpha-\beta)\frac{\alpha}{3}\right] > F + T\alpha\frac{\beta}{3}$. Thus:

$$\pi(\theta_\alpha) > \theta_\alpha\left[F - T(\alpha-\beta)\frac{\beta}{3}\right]+(1-\theta_\alpha)\left(F+T\alpha\frac{\beta}{3}\right)-F.$$

Plugging in $\theta_\alpha = \frac{\alpha}{\beta}$, we obtain $\pi\left(\frac{\alpha}{\beta}\right) > \frac{1}{3}T\beta\frac{(\alpha-\beta)^2}{\alpha} > 0$, as desired.

If $\theta^*_\beta < 1$, then the payoff to i from entering (absent an information entrepreneur) is less than zero when $\theta_j = 1$. That is, $\beta T\left(\frac{\beta}{6}+\frac{1-\beta}{2}\right) < F$. Since $\pi_1 < \beta T\left(\frac{\beta}{6}+\frac{1-\beta}{2}\right)$, there is also strict mixing in the equilibrium when the information entrepreneur charges w_1 (i.e. $\theta_\alpha(w_1) < 1$). So it suffices to show that $\theta^*_\alpha(w_1)\alpha \geq \theta^*_\beta\beta$. Setting (8) equal to zero and solving for $\theta^*_\alpha(w_1)$ yields

$$\theta^*_\alpha(w_1) = \frac{3\beta}{2\alpha^2} - \frac{3F}{T\alpha^2} + \frac{\alpha-\beta}{\alpha}.$$

Hence

$$\begin{aligned}\theta^*_\alpha(w_1)\alpha &= \frac{3\beta}{2\alpha} - \frac{3F}{T\alpha} + \alpha - \beta \\ &> \frac{3\beta}{2\alpha} - \frac{3F}{T\alpha} + \theta^*_\beta(\alpha-\beta) \\ &= \frac{3\beta}{2\alpha} - \frac{3F}{T\alpha} + \left(\frac{3}{2\beta} - \frac{3F}{T\beta^2}\right)(\alpha-\beta) \\ &= (\alpha^2+\beta^2-\alpha\beta)\left(\frac{3}{2T\beta\alpha} - \frac{3F}{2T\beta^2\alpha}\right) \\ &= \frac{(\alpha^2+\beta^2-\alpha\beta)}{\alpha}\theta^*_\beta \\ &> \frac{\alpha\beta}{\alpha}\theta^*_\beta = \beta\theta^*_\beta\end{aligned}$$

where we used the fact that $\theta^*_\beta < 1$ for the second inequality, rearranged terms, and then used the fact that $\beta^2 + \alpha^2 > 2\alpha\beta$ to obtain the last inequality.

Case 2: $w_1 < w \leq w_2$

In this case, bidders will buy the announcements (with certainty) from the information entrepreneur if the other bidder does not enter, and they will mix over buying and not buying if both bidders enter.

The expected number of bidders is a convex combination of the expected number of bidders when $w = w_1$ and $w = w_2$. We have already shown the expected number of bidders is higher than in the absence of the information entrepreneur at $w = w_1$. Next we show that this is also weakly true at $w = w_2$, yielding the result for $w \in (w_1, w_2)$.

Case 3: $w_2 < w \leq w_3$

In this case, a bidder will only buy the information if the other bidder did not enter.

Thus,

$$\begin{aligned}
\pi_\alpha(\theta_\alpha) &= \theta_\alpha \beta T\left(\frac{\beta}{6} + \frac{1-\beta}{2}\right) + (1-\theta_\alpha)\underbrace{\left(T\frac{\alpha}{2} - w\right)}_{\hat{\pi}_\alpha} - F \\
\pi_\beta(\theta_\beta) &= \theta_\beta \beta T\left(\frac{\beta}{6} + \frac{1-\beta}{2}\right) + (1-\theta_\beta)\underbrace{T\frac{\beta}{2}}_{\hat{\pi}_\beta} - F
\end{aligned}$$

Notice that the payoffs with and without the information entrepreneur are the same when both bidders enter, because w is large enough that it is not worthwhile for bidders to buy the information if the other bidder has entered. If $\theta^*_\beta \geq 1$, then $\beta T\left(\frac{\beta}{6} + \frac{1-\beta}{2}\right) \geq F$, and thus $\theta^*_\alpha(w) \geq 1$. Bidders enter with probability one with or without the information entrepreneur, and therefore the $\alpha-$technology is never used, and the expected number of bidders is the same with or without the information entrepreneur. If $\theta^*_\beta < 1$, then based on the fact that $\hat{\pi}_\alpha > \hat{\pi}_\beta$, it must be that $\theta^*_\alpha(w) > \theta^*_\beta$, which immediately gives the desired result. Note that this result applies for all $w \in [w_2, w_3]$, and so the claim made in Case 2 is also verified.

Case 4: $w_3 < w$

In this case, no bidder buys the information entrepreneur's announcements.

If $w > w_3$ bidders never buy the information, and the equilibrum (and expected number of bidders) is the same as if there is no information entrepreneur. ■

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
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: Characteristics of TM and non-TM Clients

		Never TM Client	Always TM Client	Sometime TM Client Without TM	Sometime TM Client With TM
	Number of bidders	298	20	18	18
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

Table 3: 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 4: Effects of Announcement Information on *ln(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 5: Effects of Announcement Information on Competition and Winning Bids

Dependent Variable	Fraction of Potential Bidders with TM	R^2	Number of Observations
ln(Winning Bid)	-.1601 (0.0485)	0.98	62,283
ln(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.