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Costly Bidding in Online Markets for IT Services

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Abstract

Internet-enabled markets are becoming viable venues for procurement of professional services. We investigate bidding behavior within the most active area of these early knowledge markets—the market for software development. These markets are important both because they provide an early view of the effectiveness of online service markets and because they have a potentially large impact on how software development services are procured and provided. Using auction theory, we develop a theoretical model that relates market characteristics to bidding and transaction behavior, taking into account costly bidding. We then test our model using data from an active online market for software development services, which yields contracts for 30%–40% of posted projects. In its current format, however, the studied market may induce excessive bidding by vendors. Consistent with our theoretical predictions and those of Carr (2003), higher-value projects attract significantly more bids, with lower average quality. Greater numbers of bids raise the cost to all participants, due to costly bidding and bid evaluation. Perhaps as a consequence, higher-value projects are also much less likely to be awarded.

Keywords

Internet, electronic markets, software contracts, reverse auctions, bidding

Disciplines

E-Commerce | Marketing

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Costly Bidding In Online Markets For IT Services

Eli M. Snir and Lorin M. Hitt

Abstract

Internet-enabled markets are becoming viable venues for procurement of professional services. We investigate bidding behavior within the most active area of these early knowledge markets: the market for software development. These markets are important both because they provide an early view of the effectiveness of online service markets and because they have a potentially large impact on how software development services are procured and provided. Using auction theory, we develop a theoretical model that relates market characteristics to bidding and transaction behavior, taking into account costly bidding and bid evaluation (two factors that distinguish these markets from other types of auctions). We then test our model using data from one active online market for software development services. Our data show that the market we examine is quite active, yielding contracts for 30%-40% of posted projects. In their current format, however, the studied market may induce excessive bidding by vendors. Consistent with our theoretical predictions, larger projects attract significantly more bids, with lower average quality. Greater numbers of bids raise the cost to all participants, due to costly bidding and bid evaluation. Perhaps as a consequence, larger projects are also much less likely to be awarded.

Keywords: Internet, Electronic Markets, Software Contracts, Reverse Auctions, Bidding

I. Introduction

The Internet is becoming a universal platform for the development of new electronically-mediated markets. While many of the initial online markets focused on the exchange of physical commodities (books, CDs, collectibles), there has been a recent emergence of marketplaces directed at the trade of services. Given that services are estimated to account for 70% of gross domestic product in the U.S. (Quinn, 1992), this greatly expands the scope of economic efficiencies and new business opportunities enabled by the Internet. Moreover, the emergence of these markets represents the continuation of an ongoing trend toward less hierarchical forms of organization and a more market-based economy (Malone, Yates and Benjamin, 1987; Gurbaxani and Whang, 1991; Malone and Laubacher, 1999).

One of the largest and most active areas of these service markets is the trade of Information Technology (IT) expertise such as software development and web design. Most existing knowledge- or expertise-trading sites[1] provide the ability to trade IT services, and they tend to be very active compared with other types of services transacted in these markets, such as accounting, technical writing, legal services, advertising, consulting, and administrative support. Thus, by examining the behavior of IT service markets, we can gain early insight into how Internet-based service markets will evolve more broadly. Moreover, these types of markets may have a significant impact on the way IT services are procured, enabling the ability to efficiently outsource small[2] projects. Currently this niche is either filled through internal staffing due to the high fixed transactions costs of utilizing external vendors, or through regular relationships with independent contractors or temporary employment firms in situations where internal staff is not available or lack the requisite skills. Online service markets can potentially provide the specialization benefits of using external contractors while substantially reducing procurement

[1] Examples include freeagent.com, eLance.com, and eWork.com that utilize a request for proposals and reverse auction model (bidding on projects). There are also other markets such as Keen.com and liveadvice.com that deliver services over the telephone; experts-exchange.com and hotdispatch.com support the exchange of services in a question and answer format. Transaction sizes in the telephone-based and question and answer markets tend to be small, on the order of $10 or less, while the RFP markets tend to handle much larger transactions. Little is known about the overall profitability of these markets since most are privately held and in startup phase.

[2] Most of the projects traded in these markets would be considered “small”, involving less than six person-months of effort (McConnell, 1996). As a reference point, these projects would fall in the lowest decile of project size considered in software cost estimation studies (see, e.g., Kemerer, 1987, pages 53, 79 and 114).

costs enabling direct cost savings and improved quality, leading to a potential increase in demand for small-scale, specialized IT projects.

A typical transaction in these markets is conducted as a procurement auction (or “reverse auction”) where vendors tender bids. The process of such an online market includes the following activities. A client creates a Request for Proposal (RFP) that describes the desired services (i.e., project description, scope, deliverables, submission deadline, project deadline, etc.) and posts the RFP to the online marketplace. Meanwhile, IT vendors continually search the site for RFPs that match their areas of expertise. When the vendors find a suitable RFP, they prepare a bid package that includes an asking price as well as supplementary information such as a description of their capabilities, and a proposed method of completing the project. The vendor submits the bid, which is routed to the client. The client then reviews all of the bids and chooses the best bid, presumably the best tradeoff between price, vendor quality, and fit. The process of bid evaluation is idiosyncratic to each buyer. There are no guidelines to evaluating bids and the market provides minimal assistance in this process, leading to high evaluation costs.

The primary role of the site is in helping buyers find vendors (and vendors find buyers) by reducing frictional transactions costs. In addition, online marketplaces serve the secondary role of reducing opportunistic behavior by maintaining and disseminating public reputations for market participants. For these services, they typically charge a transaction fee (levied on final project value) and in some cases, membership fees for buyers, vendors or both.

The online auction is unique in that it dramatically reduces transaction costs, enabling a multitude of international vendors to participate in every auction. Increased participation reduces expected costs for clients from intensified competition, while concurrently offering better quality. The online setting also facilitates research of auction behavior through the large number of transactions facilitated on the exchange. Although these markets are essentially procurement auctions, they also have a number of characteristics that distinguish them from auctions for physical goods (especially auctions for commodity goods). The RFP and bidding process must result in the exchange of much more information because projects and qualifications are not standardized. Unlike the trade of physical commodities where a part number, industry standard (e.g., MIS-SPEC, ANSI, ISO, etc.) or short description can be sufficient to fully describe a good required, IT services are highly customized, and idiosyncratic. Moreover, unlike many physical commodities that have objective tests of quality (e.g., composition, strength, reliability, etc.), IT services face subjective evaluation of the work product. As such, the range of possible characteristics and quality levels of services is virtually unlimited. In procuring these services, both buyers and vendors bear substantial costs of bidding and evaluating bids. As shown by Samuelson (1985), costly bidding alters many of the qualitative predictions of the theoretical auctions literature. In these markets costly bidding effects are likely to be large. The success of these markets will be significantly affected by their ability to manage problems of costly bidding and quality uncertainty.

The contribution of this paper is in our evaluation of buyer and vendor behavior in online service markets derived from actual bidding and transaction process in one IT service market. We begin by using auction theory to construct a theoretical model of reverse auctions, which accounts for both costly bidding and variation in vendors' cost and quality. This model generates specific predictions about the number and quality of bidders for each RFP as a function of market characteristics, information revealed by buyers, and bidding costs. Specifically, we predict that when bidding is costly, buyers with a higher willingness to pay for project quality receive more bids, and those bids are of lower average quality. While this may seem surprising, the intuition behind this result is that higher value projects create greater rents for low-quality bidders, encouraging them to participate, even when their likelihood of success is small. When bid evaluation is costly, this "excess bidding" may discourage contracting by buyers. We find empirical support for these predictions using data drawn from one prominent online IT service market. These results are interesting because excess bidding on high value projects may decrease participation or limit the maximum value of projects that can be effectively transacted using online marketplaces.

II. Background and Literature Review

Online spot markets are one way that the Internet is profoundly changing the way business is organized and transacted (Malone and Laubacher, 1998; Lee and Clark, 1996; Malone, Yates and Benjamin, 1987; Malone and Rockart, 1991). The fundamental argument, originally attributed to Coase (1937), is that the choice between external market procurement and internal hierarchical control (firms) is determined by the relative costs of performing transactions in these two organizational structures. Historically, entrepreneurs formed firms because of the high cost of external transactions, including the costs of: searching for vendors; entering into short-term contracts for services; and monitoring supplier behavior (Coase, 1937; Williamson, 1975; Gurbaxani and Whang, 1991). Internalizing transactions into a firm reduced transaction costs at the expense of foregoing economics of scale, scope or specialization available by contracting with the best available supplier in the market.

However, numerous technological and business innovations are shifting the balance between the benefits of firms and the benefits of markets (Bakos and Brynjolfsson, 1993; Clemons, Reddi and Row, 1993). These include the reduction in communications costs, the near universal access of the Internet, innovations that support trust and quality assessment in otherwise anonymous markets (Dellarocas, forthcoming; Maes, 1994; Resnick and Varian, 1993), and standardization of complex transactions. The emergence of online service markets may suggest that transactions costs are now sufficiently reduced to favor market procurement, at least for some types of services (Malone and Laubacher, 1998). IT services have proven particularly attractive for early online service markets because they can be delivered digitally and the transaction participants are typically comfortable with online business interaction.

II.A. Markets for IT Services

While contracting for IT services is similar to other types of business procurement, it has additional complexity due to the degree of customization, the lack of standardization, and difficulty in assessing quality of a largely intangible work product. Moreover, this complexity is further compounded by challenges in the management of software projects, which often have substantial deviations from original specifications of time, cost or functionality (Standish Group, 1995). As a consequence, both the frictional transactions costs (search, vendor selection, negotiations)[3] and potential for vendor or client opportunism in IT outsourcing can be quite high.

Online markets for IT services principally reduce the frictional transactions costs by aggregating supply and demand, facilitating competitive price discovery, broadening reach, and lowering direct procurement costs – thus, they principally reduce frictional transactions costs. Online markets may also be superior to other procurement approaches for small-scale projects as they reduce the role of a high-cost high-service intermediary (e.g., temporary placement firms) and are much faster and more flexible than hiring specialized internal staff. However, the rapid and anonymous nature of the transaction may increase the potential for opportunism or limit the use of outsourcing practices that improve contractual performance such as the promotion of relationship specific investment (see Saarinen and Vepsalainen, 1994; DiRomualdo and Gurbaxani, 1998). As a result, we would generally expect online IT service markets to be prevalent in small-scale projects where transaction risks (opportunism) and needed mitigation measures are limited, and where search and other frictional costs are likely to be large in proportion to the transaction size.

II.B. Bidding in Auctions

The use of auction-like mechanisms for product and service procurement has been well studied in the economics and management literature. Because auctions enable price discovery, they are a desirable way to facilitate trade, especially for those goods and services without a standard market price (McAfee and McMillan, 1987; Milgrom, 1989). Under a standard set of assumptions, many common types of private value auctions are equivalent to an open, ascending bid (English) auction (Vickrey, 1961; Riley and Samuelson, 1981), which has a number of desirable properties such as allocative efficiency and truthful revelation of private value.

However, when the assumptions of the classical auction literature are relaxed, auction design influences outcome in a variety of ways. Most importantly for the purposes of this paper, we reject the common assumption that bidding and bid evaluation have negligible costs. In service auctions, both bidding and bid evaluation for services can entail significant costs in evaluating RFPs, estimating project costs, reviewing bid packages, evaluating prospective vendors, and ranking the bids against complex, subjective criteria. In investigating bidding behavior in forward auctions, where a seller intends to sell an item to the highest bidder, Samuelson (1985) shows that when bidding is costly, only bidders with values above a certain threshold participate. Somewhat counter-intuitively, Samuelson shows that this threshold ***decreases*** as the value of the good increases – lower quality bidders trade off greater bidding costs against the greater surplus to be gained from success and opt to participate. In the procurement context, this implies that a buyer that sends a larger project to the market or has a high demand for quality (thus a greater

[3] For instance, Barthelemy (2001) surveyed outsourcing clients and found that contracting costs amounted to 6% of contract value for contracts less than $10 million.

willingness pay) will attract a larger pool of bidders with lower average quality. By itself, this would not be problematic if bid evaluation is free; but increasing the number of bids increases bid evaluation costs. If these excess bids are also from low quality vendors, then the added breadth of bids brings no added benefit to the buyer. These costs arise either due to the real or opportunity costs of the actual evaluation process, or the losses due to selecting a less than optimal vendor when evaluation costs lead to limited search. In modeling procurement auctions we reframe Samuelson's model of costly bidding to incorporate additional facets relevant in the context of purchasing including the price-quality tradeoff faced by the buyer and bid evaluation costs.

Costly bidding can also affect the optimal length of an auction under the assumption of random arrival of bidders. When bidders arrive randomly at the auction, the optimal length of an auction is determined by the tradeoff between inventory holding costs of the vendor and maximizing transaction price by waiting for additional buyers to arrive (Amihud and Mendelson, 1980; Vakrat and Seidman, 1999). When bid evaluation is costly, however, it may actually be desirable to shorten the auction, because greater arrival of bidders now results in additional evaluation costs.

II.C. Online Auctions

Online auctions have become prevalent for physical goods because they combine broad reach, reduced need for physical infrastructure, and customer convenience of online selling, with the auction benefits of dynamic price discovery, aggregation of demand, and the creation of a better match between supply and demand (Beam and Segev, 1998; Lucking-Reiley, 2000; Klein, 1999). A variety of online auction formats have been utilized, the most common being the ascending price (English) auction format. However, Internet auctions are amenable to more complex auction formats indicated by the increased use of multi-unit and combinatorial auctions (Beam and Segev, 1996; Vakrat and Seidmann, 1999; List and Lucking-Reiley, 2000). In the Business-to-Business (B2B) area, firms such as FreeMarkets.com (founded in 1993) have pioneered the use of RFP-based reverse auctions, principally for the procurement of commodity or near-commodity manufactured inputs (Sculley and Woods, 2000; Rangan, 1999), and the conduct of services marketplaces is gaining attention (Arora *et. al.*, forthcoming). Little is known about the use of online auctions for intangible services.

III. Model: Reverse Auctions for Services

We model a general procurement auction market for services. Consider a single buyer (or "client") interested in finding a vendor to provide her[4] with a well-defined service (a "project") using a 3-stage process facilitated by a marketplace (Figure 1). The process begins with a buyer submitting a project to the market in the form of an RFP. In the RFP, she details the nature of the service required and the criteria that will be used to evaluate replies. This information enables vendors to evaluate their suitability for the project and to discern the value of the project to the client. There are ***n*** vendors in the market. This number is less than the total number of vendors in a domain because some vendors have capacity constraints or do not follow the postings at a certain time. Vendors of heterogeneous quality examine the RFP and decide to bid trading off the cost of bidding against the expected profit from bidding (Stage 1). This expected profit incorporates both the profit from winning at their optimal bid and the probability of winning, given that the buyer ***ex-post*** can determine the optimal price-quality tradeoff among bidders. Bidding vendors prepare a bid description and set a fixed price for project completion. At the end of the auction (Stage 2), after observing the number of bids, the buyer decides whether to incur the cost of evaluating bids or withdraw from the market. If the buyer decides to evaluate bids, she selects (in Stage 3) the bid that maximizes her surplus (trading off price and quality) given the information in the bid and from the marketplace (ratings, descriptions, etc.).[5]

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[4] We use the convention of female for the client and male for vendors.

[5] Given that we assume RFP submission is free and there are no delay costs, we can limit our analysis to the buyer's participation constraint after bidding is completed. If there were opportunity costs in delaying a project until optimal completion or RFP submission was costly, there would be an additional participation decision for the buyer at Stage 0.

Figure 1: <u>Time Line</u>

Stage 0	**Stage 1**	**Stage 2**	**Stage 3**
Participating Buyer posts RFP.	Vendors learn about RFP and decide whether to bid. Bidding Vendors submit price and incur bidding cost.	Project bidding period ends. Buyer decides whether to evaluate bids.	Buyer incurs bid evaluation cost and selects winning bidder

III.A. Model Assumptions and Structure

Figure 1 describes an extensive-form game with n+1 participants (n vendors and a single buyer) and three decision nodes of vendor participation and price setting, buyer participation, and vendor selection.

Buyers are assumed to have a multi-attribute utility function $V(q,p,C_B(R,n_b))$ where q is quality of the vendor selected, p is price paid and $C_B(\cdot)$ is the cost of bidding. $C_B(\cdot)$ is a continuous, increasing, differentiable and quasi-convex function[6] of $(-R,n_b)$ where R is a parameter describing the efficiency of bid evaluation which can vary across buyers and across time within a market, and the number of bids is n_b. For tractability we will assume a specific functional form for utility: $V(q,p,C_B(R,n_b)) = vq - p - C_B(R,n_b)$. The buyer's type is defined by the private information about v, the valuation of quality, which varies across buyers. It is assumed that the buyer communicates v through the RFP. The buyer has a strategic decision whether to evaluate bids in Stage 2. If the buyer chooses not to submit an RFP or to not evaluate bids V=0. A table of notation is provided in Appendix 1.

Vendors (s) are risk neutral and have a cost of performing the required project which depends only on their quality (type), which for tractability we assume is linear in quality ($C(q_s)= cq_s$, $c<v$ where c is a constant cost per unit of quality).[7] All vendors also have a fixed cost of bidding c_T. Thus, it is more costly for a higher quality vendor to complete the project. This can arise either due to higher direct costs or greater opportunities for contracting outside the market. A vendor that bids a project at price (p_s) and is awarded the project has a total profit of $p_s= p_s-cq_s -c_T$, a vendor who bids but is not awarded a project has profit $p_s= -c_T$, and profit is zero if a vendor

[6] The rationale behind the quasi-convexity in n_b is that each bid must be evaluated and ranked against some number of other bids.

chooses not to bid. All parameters and choice variables are common information except vendor quality (type) which is drawn independently[8] (IID) from a market-wide vendor quality distribution over $[q_L, q_U]$ with a commonly-known, continuous, cumulative distribution function $F(q)$. Vendors know their own quality, other vendors know only the distribution of quality, and the client only knows the distribution of quality until Stage 3, after incurring bid evaluation costs. These costs depend on the method chosen to evaluate bids. After incurring bid evaluation costs, the client knows the quality of all bidding vendors with certainty. We also assume that the transaction cost of bidding is low enough so that at least the best vendor could create positive surplus (i.e, $v q_U - c q_U - C_B(R,1) > c_T$). Vendors make a strategic decision in Stage 1, when they decide whether to bid on the project and their bid.

III.B. Equilibrium Behavior

The sub-game perfect, Nash, equilibrium strategies are determined by backward induction. In Stage 3, the client is faced with the trivial decision problem to choose the best tradeoff between price and quality, with full information on vendor quality (having already incurred evaluation cost):

$$\max_{\{s\}} \quad vq_s - p_s \tag{1}$$

$$\text{S.T.} \quad vq_s - p_s \geq 0 \qquad \text{(participation constraint)}$$

Similarly, in Stage 2, the decision problem on whether to incur evaluation cost to select a vendor depends on whether the result in Stage 3 will yield positive surplus in expectation over vendor quality, given bid evaluation costs. The buyer is thus trying to determine whether $E[\max\{vq_s - p_s \mid s\} - C_B(R,n_b)] \geq 0$ at the optimal vendor choice; if this constraint is violated, the buyer opts out of evaluating bids.

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7 This assumption is consistent with higher quality service being more expensive because of higher labor costs and higher opportunity costs; higher quality vendors can command greater prices in the open market.

8 In general in a service market the IID assumption is restrictive because vendor quality may be correlated across projects (see Arora *et. al.*, forthcoming), with high-quality vendors providing exceptional service to many similar customers. It is, however, justified in this context from the heterogeneity in projects and the diversity of vendor qualifications.

In Stage 1, vendors evaluate the client's RFP and decides on their optimal bid given the number of other vendors (n) and the distribution of quality, which, in turn, determines their probability of winning $P_s(p_s,n)$ at any given price. Thus, each vendor solves:

$$\max_{(p_s)} E[p_s(q|q=q_s)] \equiv p_s(q_s) = (p_s - cq_s)P_s(p_s,n) - c_T \qquad (2)$$

s.t. $p_s(q_s) \geq 0$ (participation constraint)

A vendor's optimal action in this formulation depends on the optimal actions of other vendors (through the $P_s(p_s,n)$ term). Following the auction literature (Riley and Samuelson, 1981), we restrict our analysis to behavior under a continuous, pure strategy, symmetric, Nash, sub-game perfect equilibrium, with each vendor's bid strictly increasing in quality: $p_s \equiv p(q_s)$.[9] Intuition for a symmetric equilibrium is based on the assumption that social welfare is increasing in quality (v_i>c). Generating higher surplus enables a high quality vendor to charge a higher price for his service, while assuring that the offer is more attractive than one from a lower quality vendor. In equilibrium, higher quality vendors tender higher bids, earn greater profits and provide the client with more surplus.[10] With this bidding strategy, the buyer's optimal choice is to select the highest quality vendor that bids on the project.

III.C. Hypotheses

Given the structure of the game as described in the previous section, we now derive the equilibrium relationships between our exogenous variables (n, c_T and $F(q)$), and the number of bids.

From the vendors' perspective, this is a first-price, sealed-bid auction over buyer surplus, as given by her multi-attribute utility function. Buyer utility is a function of willingness to pay (v) revealed through the RFP. Assuming a symmetric equilibrium, with price increasing in quality, assures that the probability of a vendor winning the auction is determined by the probability that

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9 Proving the uniqueness of the pure-strategy, symmetric equilibrium is beyond the scope of this paper, and it is possible that asymmetric or mixed-strategy equilibria could exist. The symmetric setting, where vendors draw their quality from a common distribution, suggests a symmetric equilibrium, with bids being monotonic in quality. For a proof of existence and uniqueness of the symmetric equilibrium for a first-price, sealed-bid, forward auction see Maskin and Riley (1996).

10 Deriving vendors' optimal bidding strategy is beyond the scope of this paper. See Snir (2000) for a formal derivation of equilibrium in this game.

all other vendors are of lower quality: $P_s(p_s,n) = [F(q_s)]^{n-1}$ and therefore $p_s(q_s) = (p_s - cq_s) [F(q_s)]^{n-1} - c_T$.

Given the fixed cost of submitting a bid, some low quality vendors generate negative profits, in expectation. These vendors do not participate in the auction, which characterizes participation by a threshold quality level (q_m) – all vendors with quality above this level bid and all below opt out. The vendor that generates zero expected profit by bidding a price that equals the buyer's surplus from the project identifies this break-even quality level. This vendor wins the auction only if all other vendors have lower quality and opt not to bid. Thus, the break-even minimal quality for vendors (q_m) is implicitly defined by:

$$p_s(q_m) = (vq_m - cq_m) [F(q_m)]^{n-1} - c_T = 0 \quad (3)$$

Vendors of higher quality also bid on the project, offering the buyer a more attractive price and generating positive profits, in expectation.

Of interest in our analysis is the characterization of break-even quality level. The next Proposition evaluates the comparative statistics of q_m.

Proposition 1: If $c_T>0$ then q_m exists, $q_m \in (q_L, q_U]$ and q_m is increasing in n, c, and c_T while decreasing in v. (Proof: See Appendix 2)

From the Proposition the minimal threshold quality of a vendor that bids on a posting is a function of the parameters of the market. As the cost of providing service increases, either through increased cost of bidding or due to increased cost of servicing a contract, the minimum threshold quality increases, favoring participation by higher quality bidders. Increasing competition (n) has a similar effect, because more bidders reduce the probability for any one to win the contract, lowering expected profit. This solution also implies that if bidding costs are negligible, all vendors bid on every contract. With very low participation costs for vendors, the market would attract many low-quality vendors. Such a market would collapse under the onslaught of mediocrity (Akerlof, 1970). Only by sustaining reasonable bidding costs on bidders can the market assure that only high-quality vendors tender offers.

Interestingly, however, the buyer quality preference (v) has the opposite result. Buyers who are interested in attracting high quality vendors induce participation by <u>lower</u> quality vendors. The intuition for this result is that lower quality vendors realize that the probability for winning the contract is low, because they are awarded the contract only when other vendors are of even lower quality. If the potential revenue is small, they do not tender bids. As willingness-to-pay increases, potential revenue increases, increasing the project's attractiveness to low quality vendors. Increased participation by lower quality vendors deteriorates the average quality of bidders. This is shown in Figure 2, where vendors' expected profit is shown as a function of quality (with parameters: n=10, c=2, c_T=0.5, and q_s~U[0,1]), for different levels of v. From Figure 2 greater willingness-to-pay lower the break-even quality level that bids, decreasing average bid quality and increasing the expected number of bids.

INSERT FIGURE 2 HERE

These observations form the core of our empirical investigation. Because clients with higher valuation for the requested service can expect lower quality vendors to tender bids, we posit that:

Hypothesis 1: Clients with high value projects attract, on average, lower quality providers.

We test this hypothesis by investigating the relationship between project value, bidder feedback ratings and other proxies for vendor quality. However, a more easily conducted test of our model predictions is to examine the number of bids. Unlike quality assessment, which is likely to be imperfect, the number of bidders is objectively measurable. With the number of bidders monotonically decreasing in the break-even vendor quality (from $n_b=n(1-F(q_m))$, a decline in q_m yields an increase in the expected number of bidders. Thus, we test the second implication of our model:

Hypothesis 2: Projects with higher values receive more bids.

Our model predicts that more expensive projects attract lower quality vendors and a greater number of vendors. Increased participation with lower average quality has two negative effects for the buyer: increased cost of evaluating more bidders and greater difficulty in discerning vendor quality. Together these could lead to more instances where the buyer opts not to consummate trade.

Our model is only one explanation why higher value project induce greater participation. It may be that some high quality vendors bid solely on high value project. This potential explanation and other alternatives are considered and analyzed in Section V.

IV. Empirical Analysis

IV.A. Data

The data for this study includes all Software Development RFPs posted and closed on a prominent online service market from January 1, 2000 to August 24, 2001. This site was chosen because it was one of the few sites that has a comprehensive history of projects and bidding available online. Moreover, the market appears sufficiently developed to evaluate equilibrium bidding behavior. In all, 5,587 software development projects were posted in the chosen timeframe. Of these projects, we omitted projects with incomplete data, "invitation only" projects restricted to only a few vendors, projects that received no bids, and those at the extreme end of the value range (below $10 or greater than $100,000).[11] The result was a dataset with a total of 4,887 observations. Of these projects, detailed data on bidding (e.g., bidder feedback) is available for only 3,761 projects due to the way the site retains bid information on some older projects, so some analyses are necessarily restricted to this subset.

Table 1 presents descriptive statistics for our data. Overall, the descriptive statistics indicate that the market is viable and able to attract a wide variety of software projects. The majority of RFPs sought application development services, although a significant number involved database projects as well. More complex areas (e.g., handhelds) were significantly less common.

INSERT TABLE 1 HERE

The average project in this market receives 15 bids (from a pool of ~3,500 unique bidders) at an average price of $2,480. Median project value is, however, slightly less than $600, which indicates that the bulk of the projects are of low value. Figure 3 shows the distribution of project values. This low median price is consistent with the argument that the lower costs in this electronic market might be particularly attractive to clients with small projects that could not be economically outsourced by other means. Of the 4,887 projects in the study 1,828 (38%) culminate in contracts in which the buyer chooses one of the bidding vendors. The average price for awarded contracts is $800. Auction length, an important factor in studying market

[11] Projects at the low end of the range likely do not represent regular project prices – either because they represent an hourly rather than a by-project rate, or they represent a non-market price. Very large projects (above $100K) are rarely transacted in this market and are sufficiently large that it is unlikely that this market is the only forum in which the project is open for bid.

participation, indicates that vendors can bid for a little over nine days, on average. The average expected time for project completion was nearly 39 days. Inspecting the final project price, we find that, on average, buyers pay 20% less than the average bid. Feedback ratings in this market are sparse and uncommonly high. Less than half the vendors earned feedback while the average score is 4.6 out of 5. Upward bias in feedback is a result of buyers' only rating vendors they have selected and approved, and vendors' incentives to build positive reputations (Dellarocas, forthcoming).

INSERT FIGURE 3 HERE

Variation in our sample stems from the wide range of services desired. On the low-end, some of the RFPs solicit bids for simple programming tasks – attracting average bids of less than $100. On the high-end, other buyers are interested in development of complete e-commerce sites with bids of over $10,000.

Variables from our theoretical analysis in the previous section, variables prevalent in the literature, and variables crucial to this emerging market provide the basis for our econometric model. The following is a list of these variables, with some discussion of each variable.

Number of Bids (n_b) is the number of bids per project. Our theoretical model makes direct predictions about the number of bids as a function of other project variables.

Average Bid (v) is the average bid price (across vendors) for a project. There are a number of possible metrics to evaluate project value. We choose averaging vendors' bids on the project as a proxy for project value.[12] We use the natural log of this variable.

Market Maturity (M) is the overall age of the online market (in days) at the time of project posting (starting date of the auction). It is used to measure changes in market structure over time, such as positive network effects and growth in the number of participants. We use the natural log of this variable.

Auction Length (T) is the duration (in days) over which the auction is open for bidding. The length of an auction determines the number of vendors that have an opportunity to see the

12 We would prefer to use a measure of client value, such as an Initial Estimate of the project's cost. This variable, however, is available for only a small subset of projects, in the first six months of our dataset. The rank-order correlation between Initial Estimate and Average Bid, in this subsample, is 0.78 (p<0.01).

posting and bid on the project. As the buyer lengthens the auction, more bids should be expected if bidders arrive by some sort of random process. We use the natural log of this variable.

Project Length (*P*) is the stated length of the project in days. The model discussed in Section 3 implies that the project's value depends only on the buyer's benefits from the project. In a heterogeneous data set, as the one in our analysis, project complexity may also drive expected price. If it is more difficult to complete a more complex project, then its price may increase. To identify the impact that buyer value has on the number of bids, we would like to control for project complexity. In this data set, we can use project length as a proxy for complexity. This is also consistent with payment based on project duration, where longer projects are more expensive. We use the natural log of this variable.

Feedback is the average rating of the vendors participating in an auction. Each participating bidder may have zero or more feedback instances (on a 0-to-5 scale) received from prior projects. Hypothesis 1 postulates that low quality vendors are more likely to participate on higher valued projects. One metric for measuring vendor quality is the feedback they receive in the online market. To compute the feedback measure for a project, we average feedback scores across participating bidders with feedback. With less than half of the vendors having any feedback instances, this variable is missing for many projects. One alternative measure we consider is the fraction of bidders that have non-zero feedback as another indicator of quality. Other variables are also considered to gauge this effect (see Results section).

Sub-category (S_j) is the type of project as categorized by the client. We control for five important sub-categories within the market for software development services. This control variable allows us to understand sub-markets which may have different values of the exogenous parameters of the theoretical model (especially n and $F(q)$). The sub-categories used are: Application Development, Database, Engineering & CAD, Handheld Devices and Other Software Services (used as the baseline).

"Preferred" Vendor is a binary variable reflecting a special status that a vendor may opt to subscribe to. Those that elect preferred status must pay greater membership fees, undergo a background check, and are generally held to higher standards of conduct (for example, they must agree to use a dispute resolution service). The online market provider sets the terms and fees of this status.

“Preferred” Project is a binary variable that reflects whether only “preferred” vendors are allowed to bid. A buyer may opt to designate a project as such, limiting participation.

IV.B. Econometric Specification and Estimates

IV.B.i. Project Value and Quality (Hypothesis 1)

Testing Hypothesis 1 is difficult with the type of data available from an online market. Proper estimation of the relationship between project value and average vendor quality requires comprehensive metrics for vendor quality. The supposed relationship is that higher project values induce participation by lower quality vendors (Proposition 1). Given that it would be prohibitively expensive for the market facilitator to comprehensively and objectively assess quality, quality cannot be determined conclusively.

However, we can use a number of measures as a proxy for vendor quality. The first and most common metric is the feedback rating given to the vendors by the clients who use the online market. Feedback ratings in this market are uncommonly high with the project-average quality score of 4.6 out of 5.0 for those vendors that do have feedback. Furthermore, less than half of the vendors have any recorded ratings in the system at all. The rank-order correlation between average feedback and project value is negative (r=-0.13) and significant (p<0.01), as suggested by Hypothesis 1.[13] Because buyers only rate vendors they have chosen it is quite common for these systems to be biased towards high ratings, reducing their information content.

A second proxy for a vendor's quality is the presence of a feedback rating for that vendor. The presence of a rating suggests that the vendor has surmounted at least three tests of quality: they were screened by another client, won a prior auction, and completed a prior project. If we use the fraction of participating bidders with feedback as a sign of quality of the bidder pool, we also find a negative correlation (r=-0.10, p<.01). We find similar results using measures constructed from the proportion of vendors with average feedback greater than a threshold (e.g., greater than 4.75 or greater than 4.5 on average).

The comprehensive information available in this online market allows us to investigate various other measures of vendor quality and to verify the hypothesized relationship between project value and quality (See Table 2). Two useful metrics in this analysis are the number of

[13] Throughout this sub-section, we report rank-order correlations. Rank-order correlations avoid the problems of skewed variables and of biases arising from extreme values.

bids submitted by a vendor in all projects, and a vendor's propensity for winning. Both of these metrics support our hypothesis. Higher valued projects induce participation by more active vendors, on average (r=0.40, p<0.01) and these vendors win contracts less often (r=-0.42, p<0.01), on average.[14] A third measure of potential vendor quality is tenure in the market. We again find that larger projects tend to attract vendors with less time in the market (r=-0.05, p<0.01), suggesting greater possible problems with vendor opportunism due to a lack of reputational capital at risk.

INSERT TABLE 2 HERE

IV.B.ii. Project Value and the Number of Bidders (Hypothesis 2)

In addition to predicting that the quality of the bidder pool decreases with increasing project value, our model also suggests that the number of bids increases with increasing project value (Hypothesis 2). In many respects, this hypothesis is easily tested because the number of bids is objectively measurable, and our model yields a specific relationship between number of bids and project value. To derive our estimating equation, we take the natural logarithm of both sides and rearrange equation (3) to find a structural relationship between project value and the number of bidders:[15]

$$n = 1 + \frac{\ln(v-c)}{-\ln(F(q_m))} + \frac{\ln(\frac{c_T}{q_m})}{\ln(F(q_m))} \quad (3a)$$

In this equation, only n and v vary by project. The quantities c and c_T are assumed constant across projects and bidders, and the quantities related to the cutoff value (q_m and $F(q_m)$) are characteristics of the market (conditional on n and v), but not an individual project. Thus, we can transform this equation by taking the Taylor expansion of the first (non-constant) term in Equation (3a) to yield our base estimating equation. To this equation we add additional control variables for market maturity, auction length, and project length (complexity) to yield a structural equation (index i refers to projects):

Model 1: $n_{b,i} = b_0 + b_1 ln(v_i) + b_2 ln(M_i) + b_3 ln(T_i) + b_4 ln(P_i) + e_i$ (4)

[14] These correlations represent the relationship between Average Bid and the average score for all vendors that bid on the project, similar to the correlation between Average Bid and Feedback discussed earlier.

[15] Note that $F(q_m)$ is a cumulative density function, so $ln(F(q_m))$ is negative.

Column (a) of Table 3 contains the estimates of Equation (4). The results support our hypothesis that buyers' willingness to pay increases participation by vendors. If bidding were costless, we would expect the number of bids to depend only on the service required, not on the buyer's project value. The coefficient on project value is positive and significant, with a value of approximately 1.65. This coefficient translates into the increase in bidding associated with an increase in project value. A $100 project receives approximately 12 bids, on average, while a $1,000 project receives almost 16 bids, on average.

INSERT TABLE 3 HERE

Other important results from Column (a) in Table 3 are that the number of bids is increasing with increases in auction length (consistent with a random arrival explanation), and that as the market ages, more bidders participate (consistent with the presence of positive network effects). We also find that project length is significant, suggesting that this variable is successfully capturing at least some of the heterogeneity in project size, as intended.

One possible confounding factor in this analysis is that the overall software development market is not monolithic. Instead, the online market that we study is actually comprised of a number of smaller sub-markets with different numbers of potential bidders, distribution of quality, or arrival rate of bidders to the market. One way to control for these effects is to include control variables for each subcategory ($S_{j,i}$) to yield:

Model 2: $n_{b,i} = b_0 + b_1 ln(v_{,i}) + b_2 ln(M_i) + b_3 ln(T_i) + b_4 ln(P_i) + \Sigma b_j S_{j,i} + e_i$ (5)

The results of Model 2 appear in Column (b) of Table 3. The results again support our hypothesis that higher valued projects induce more bidder participation with almost identical coefficients on the project value variable. Our previous results regarding the importance of market maturity, auction length and project duration also hold. From the additional controls, it is evident that each subcategory has different bidding rates, but that this variation is largely orthogonal to the relationship between value and number of bids. There is more bidding (than in the baseline category of Other) in Application Development and Databases, while bidding is limited in the small categories of Engineering and Handheld Devices. These results indicate that bidding activity is consistent with project posting. More active sub-markets have a larger community and thus more bids.

Even more generally, it may be possible that the responsiveness of bidding to project value differs across sub-markets. For instance, the distribution of bidder quality and the optimal cutoff value (q_m) may differ across sub-markets, yielding a different degree of correlation between project value and bidding according to the formulation in Equation 3. The impact of different sub-markets within the software development market may go beyond the fixed-effects analyzed in Model 2. Model 3 interacts sub-category with our key independent variable, Average Bid. This allows us to evaluate whether ***bidding responsiveness*** varies across sub-markets.

Model 3: $n_{b,i} = b_0 + b_1 ln(v_i) + b_2 ln(M_i) + b_3 ln(T_i) + b_4 ln(P_i) + \Sigma b_j S_{j,i} + \Sigma b_j\, S_{j,i} {*} ln(v_{,i}) + e_i$ (6)

When we allow the value-bidding relationship to vary by market (shown in Table 3 column c), we find that there is a similar heterogeneity in the responsiveness of bidding to value. All sub-markets except Engineering show a positive relationship between number of bids and project value.[16] Since the Engineering sub-market is small, both in terms of number of projects and number of bidders, these results do not change our assertion that higher value projects attract more bids.

The inconsistent results for the Engineering domain may indicate that some service markets demonstrate behavior similar to commodities markets where participants self-regulate their bidding activity. If the vendor qualification for Engineering projects vendors is easy to assess before choosing a vendor, vendors without the required competencies are unlikely to bid, even on high value projects. Future research should ascertain whether certain domains behave similar to commodities markets.

V. Project Awards

The richness of our data set allows up to explore another important aspect of participation in the market, buyer participation and awards of contracts. We model buyer evaluation in Stage 3 as providing perfect information regarding vendor quality. In this market, with limited data on vendor competencies, buyer evaluation may yield imperfect signals regarding vendor quality. If so, buyers may choose the wrong vendor, yielding lower than expected profits. The realization that evaluation mistakes are possible and the direct cost of evaluating bids lead some buyers to

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[16] When regressing only Engineering projects, Average Bid has a negative coefficient (-0.227) that is not significant (*p*>0.5).

forego bid evaluation and opt not to contract after the auction closes. It is reasonable to hypothesize that the cost of choosing the wrong vendor increases with willingness-to-pay, both because of the buyer's increased need for quality and opportunistic bidding by low quality vendors. We posit that:

Hypothesis 3: Clients with high value projects are less likely to award the project via the auction

Tests of this hypothesis also enable us to examine the most likely alternative hypothesis to our model. An alternate premise is that participants are self-regulating with higher value projects generating participation by higher quality vendors. One possible justification is that high-quality vendors require greater compensation for their service, bidding only when buyers indicate greater willingness-to-pay. This alternate premise implies that higher value projects increase the chance of awarding the contract. These two predictions can be clearly distinguished empirically.

Returning to Figure 3, we find that the probability of contracting in the Software development market decreases with project value. In our sample, while 38% of all RFPs culminate in contracts, this proportion is 47% for projects under $1000, but only 24% for projects over $1000.

To test this relationship formally, we use a logistic (Logit) regression of the probability of awarding a contract as a function of the average bid size. Table 4 presents these results, with and without controls for sub-markets, as discussed earlier. The coefficient on "Average Bid" is consistently around –0.25 and significant across all models. Overall, these results indicate that the pool of vendors tendering bids for higher valued projects is *not* of higher quality (as perceived by the client) than those participating in lower valued projects. This result supports our original theoretical prediction that low quality bidders opportunistically bid on high value projects leading to high bid evaluation costs. From inspection of the interaction effects of sub-markets and project value it appears that this result holds across the different markets with similar propensity for not contracting (Table 4, Column c). All interaction terms have negative and insignificant coefficients, except for Handheld Devices.[17] Because of the sparseness of data for this sub-market it is difficult to ascertain whether this is a systematic difference.

[17] The Handheld Devices seems to behave differently, with a positive coefficient for the interaction term. When analyzed separately, the coefficient is positive (0.29) but insignificant (p>0.1).

INSERT TABLE 4 HERE

A difficulty of drawing strong conclusions from this supplementary analysis is that buyers might behave opportunistically, utilizing the online market as a way of gathering data without intending to actually enter into a contract, or may bypass the market and contract directly with their preferred vendor[18] (Weber, 1994). We could hypothesize that buyers might use the auction for price discovery but not for awarding contracts, and then pursue the transaction internally or through other channels. Because the marginal value of better information on vendor pricing and the incentive to bypass the market are likely to increase in the size of a project, this type of opportunistic behavior would be more prevalent for large projects. In addition to this behavior biasing our tests of Hypothesis 3, it is also of significant practical importance – opportunistic buyers create both deadweight loss and a wealth transfer out of the market, which is costly to all market participants.

Without knowing buyers' intentions or being able to observe their offline behavior, it is difficult to ascertain whether this type of buyer opportunism is widespread. However, we can examine whether it affects our results by examining different segments of the market where we expect these opportunistic behaviors to be less prevalent. Within our data, we can identify two segments that meet these criteria. First, we can restrict our analysis to buyers who transact through the market. Under the assumption that opportunistic behavior by buyers is an inherent trait, this trait is less likely to be present in firms that have demonstrated they will complete transactions. Table 5 column (a) reports the results for the 3,002 projects from buyers with at least one completed contract event throughout our dataset. We find that the effect of project value on the probability of contracting is essentially the same rate as across the entire population.

Alternatively, we can consider buyers who register their projects for "preferred" status, which restricts bidding to "preferred" vendors. If a buyer was using the market for information to obtain leverage over another outside supplier in negotiation, it is in their best interest to have as many bids as possible. Thus, opportunistic buyers would skew auction conditions to attract low cost and low quality suppliers. Therefore, we would not expect buyers that restrict the auction to "preferred" status vendors to be entering the market opportunistically. Again, results in Table 5

18 The online market we investigate charged commission from vendors based on the size of the contract awarded. This offers an incentive for participants to bypass the market, avoiding these commissions.

column (b) show that even these buyers for the 648 projects requiring "preferred" status are more hesitant to contract for higher value projects, with a coefficient of –0.9.

INSERT TABLE 5 HERE

VI. Discussion and Conclusion

Online service markets have demonstrated that, despite a variety of potential problems, it is viable to transact for services in anonymous markets. Overall, nearly 2000 projects with an average value of $800 per signed contract were executed over the 20-month period considered. Moreover, the average price of the selected vendor was 20% lower than the average submitted bid, suggesting a substantial and measurable benefit of utilizing this market. Growth in this market attests to the market's success, as well. Our target site grew from about 100 projects posted per month for the first three months of our sample period, to about 500 projects per month 18 months later -- an annualized growth rate of nearly 200%.

Current market design and strategic behavior, however, are likely to reduce the efficiencies of this market due to excessive bidding by vendors and the attendant costs of bid evaluation. While this provides the appearance of an active market, it has negative consequences. If bid evaluation were perfect and costless the loss from costly bidding would be due only to the direct cost of bidding. However, in the presence of costly evaluation there are two additional sources of welfare loss on the buyer's side: the direct cost of bid evaluation and the social cost of buyers with potentially surplus-creating projects opting out of the market. These factors cause reduced participation in the market by both buyers and vendors. Such a market is especially likely to lose those buyers with preferences for high quality (and high cost) projects and those high-quality vendors who would serve these projects. Thus, costly bidding and evaluation, and the strategic responses to them, may limit the liquidity of these markets for larger transactions.

Our model suggests that an online market can remedy this situation by some combination of screening the quality of vendors, decreasing the cost of bid evaluation for clients, or increasing the cost of bidding to vendors. For instance, the site could invest in additional external audits or ratings, or perhaps require offline references or certifications to augment the somewhat sparse online feedback. Technological solutions provided by the market could also speed the process of bid evaluation. Greater standardization of the RFP and bidding process could lead to partial automation, which reduces human labor. Such tools could help clients reject large numbers of low quality bids, score the top candidates, and focus evaluation efforts on high quality candidates. Alternatively, the site could impose a bidding charge that discourages low quality bidders and indiscriminate bidding. It would raise the minimal quality that participates, but the client would still have to evaluate remaining bidders.

Our analysis is principally focused on vendor participation and the types of analyses that can be performed observing bidding and transaction behavior in a non-experimental, nearly anonymous, setting. There are a variety of other interesting and important issues, both theoretical and empirical, that can be examined in these markets including equilibrium buyer participation behavior (including the optimal disclosure of information in a RFP), bidding behavior of vendors, mechanisms that induce truthful revelation of private value, and the effectiveness of screening technologies for evaluating bids, especially feedback systems which have proven useful in online auctions for physical goods. While theoretical analysis of these questions is possible through formal techniques similar to ours the challenge will be to design the appropriate real experiments or identify suitable natural experiments which enable otherwise hidden factors such as private project valuation, true project structure or vendor capability to be objectively assessed apart from transaction behavior.

Our results highlight both the opportunities and the challenges that might be expected transacting services through online markets. As many types of services produce digital products and do not require large-scale production capital that drives the formation of large firms, the service industries should be even more amenable to increased outsourcing and the erosion of firm boundaries. Especially in the IT domain, technologies that promote interoperability (e.g, object oriented techniques) and best management practices, for example the desire to subdivide larger projects into smaller milestones (McConnell, 1996), also favor the outsourcing of small-scale projects. However, the ability of online services to augment or displace other governance structures relies on the ability to handle larger transactions sizes. Our results suggest that the “sweet spot” for projects in this market is relatively small, being in the lowest decile of typical IT projects (c.f. footnote 2), a concern that might be reduced if issues of costly bidding and bid evaluation could be more effectively addressed. However, there are also other concerns of larger projects that might arise, especially vendor opportunism, which we have not considered in our analysis.

Given the early stage of these online markets, it is difficult to make robust conclusions about how such markets might evolve when they are orders of magnitude larger than they are now. It should be noted that this market is currently small, with only about $1.5 million transacted during the study period, but is growing rapidly. Given the overall size of the IT services industry (over $100Bn in the US alone), these markets have the potential to grow by many orders of magnitude provided that larger projects (which likely make up most of commercial IT contracting) can be effectively transacted online. Yet, clients would not want the number of bids to grow by orders of magnitude. Clearly, online markets need to consider scalability and the natural laws by which patterns of participation change as a function of market size. If these markets are managed correctly, however, they have an opportunity to dramatically change the methods of procuring services.

Appendix 1: Notation

Variable	**Description**
n	Number of vendors
$V(q,p,C_B(R,n_b))$	Client's multi-attribute utility function
Q	Quality of service received
P	Price paid for service
n_b	Number of vendors that bid in the auction
$C_B(R,n_b)$	Cost of evaluating bids
R	Technology for evaluating bids
v	Client's quality valuation, measured empirically by average bid
q_s	Inherent quality of vendor s
p_s	Price charged by vendor s
q_L	Lowest possible quality
q_U	Highest possible quality
$F(q)$	Continuous c.d.f of vendor quality
cq_s	Cost of providing quality service q_s
c_T	Cost of placing a bid
$C_s(q)$	Cost of providing service and placing a bid
$P_s(p_s,n)$	Probability of acceptance for a vendor of quality q_s
$p_s(q_s)$	Expected profit for a vendor of quality q_s
q_m	Break-even quality level
M	Market maturity (in days)
T	Auction Length (in days)
P	Project Length (in days)
S_j	Sub-category j; j=[0..4]

Appendix 2: Proof of Proposition

From equation (3) in subsection III.C.:
$p_s(q_m) = (vq_m - cq_m)\,[F(q_m)]^{n-1} - c_T = 0$

To show the $q_m > q_L$ we show that for the lowest quality expected profit from bidding would be negative, while for the highest quality, expected profit is positive. Coupled with monotonicity of $p_s(q_m)$ and the Fixed-point Theorem, this assures that their exists a break-even quality $q_m > q_L$.

For the lowest quality $F(q_L)=0$, $p_s(q_L) = -c_T$. For the highest quality $F(q_U)=1$. When only the highest quality participates, $p_s(q_U) = (v\,q_U - c\,q_U) - c_T > 0$, by assumption.

Investigating the monotonicity of profit, the sign of the first derivative of the break-even bidder's profit, with respect to quality, is positive (noting that $v > c$):

$p'_s(q_m) = (v - c)[F(q_m)]^{n-1} + (vq_m - cq_m)(n-1)[F(q_m)]^{n-2} f(q_m)$

The other results arise from investigating the expected revenue for the break-even quality bidder, $(vq_m - cq_m)[F(q_m)]^{n-1}$, and the cost, c_T, of submitting a bid.

Define a given parameter vector (n^0, c^0, v^0, c_T^0) such that $p_s(q_m^0) = 0$.

If $n^1 > n^0$ then $[F(q_m^0)]^{n_1-1} < [F(q_m^0)]^{n_0-1}$ and $p_s(q_m^0) < 0$

If $c^1 > c^0$ then $(v\,q_m^0 - c^1 q_m^0) < (vq_m - c^0 q_m^0)$ and $p_s(q_m^0) < 0$

If $v^1 < v^0$ then $(v^1 q_m^0 - c\,q_m^0) < (v^0 q_m^0 - c\,q_m^0)$ and $p_s(q_m^0) < 0$

If $c_T^1 > c_T^0$ then $p_s(q_m^0) < 0$

For any of these changes (an increase in n, c, c_T or a decrease in v) the vendor of quality q_m^0 earns negative profit from participating. From the monotonicity of $p_s(q_m)$ and $p_s(q_U) > 0$ the break-even quality level under each of these changes increases.

QED

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Table 1 - Descriptive Statistics

	Variable	Notation	Number of Obs.	Mean	Standard Error	Median
	Number of Bids	n_b	4,887	15.1	13.25	11
	Average Bid ($)	v	4,887	$2,480	6785	$594
	Market Maturity (Days)	M	4,887	400.6	157.15	435
	Auction Length (Days)	T	4,887	9.2	10.05	7
	Project Length (Days)	P	4,887	38.9	68.16	21.0
	Avg. Feedback (Scale of 0 – 5)		2,938	4.6	0.431	4.7
	Contract Awarded		4,887	0.38	0.485	0
	Winning Bid (when contracted)		1,828	$787	2861	$200
	Preferred Vendor		4,109	0.37	0.353	0.29
	Preferred Project		4,832	0.12	0.328	0
Sub-Categories	**Application Development**	S_1	4,887	0.56	0.496	1
	Database	S_2	4,887	0.21	0.405	0
	Engineering	S_3	4,887	0.029	0.169	0
	Handheld Devices	S_4	4,887	0.028	0.164	0
	Other	S_0	4,887	0.16	0.366	0

Variable	Correlation Matrix						
	Number of Bids	**Average Bid ($)**	**Market Maturity**	**Auction Length**	**Project Length**	**Contract Awarded**	**Feedback**
Number of Bids	1.000	0.163***	0.074***	0.270***	0.127***	-0.094***	-0.080***
Average Bid ($)	0.163***	1.000	-0.012	0.103***	0.198***	-0.144***	-0.041***
Market Maturity (Days)	0.074***	-0.012	1.000	-0.130***	0.033**	-0.035**	0.441***
Auction Length (Days)	0.270***	0.103***	-0.130***	1.000	0.247***	-0.237***	-0.100***
Project Length (Days)	0.127***	0.198***	0.033**	0.247***	1.000	-0.123***	-0.047**
Contract Awarded	-0.094***	-0.144***	-0.035**	-0.237***	-0.123***	1.000	-0.006
Feedback	-0.080***	-0.041**	0.441***	-0.100***	-0.047**	-0.006	1.000

* $p< 0.1$; ** $p<0.05$; *** $p<0.01$

Figure 2 – Vendor Profit as a function of Quality

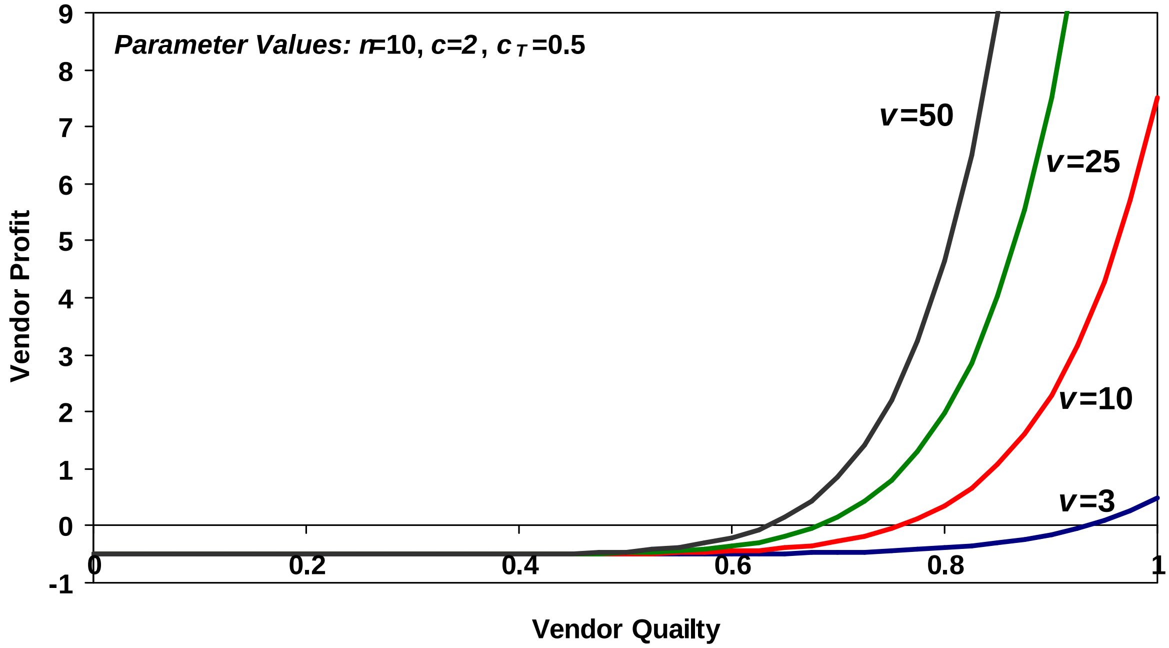

Figure 3 – Distribution of Project Values

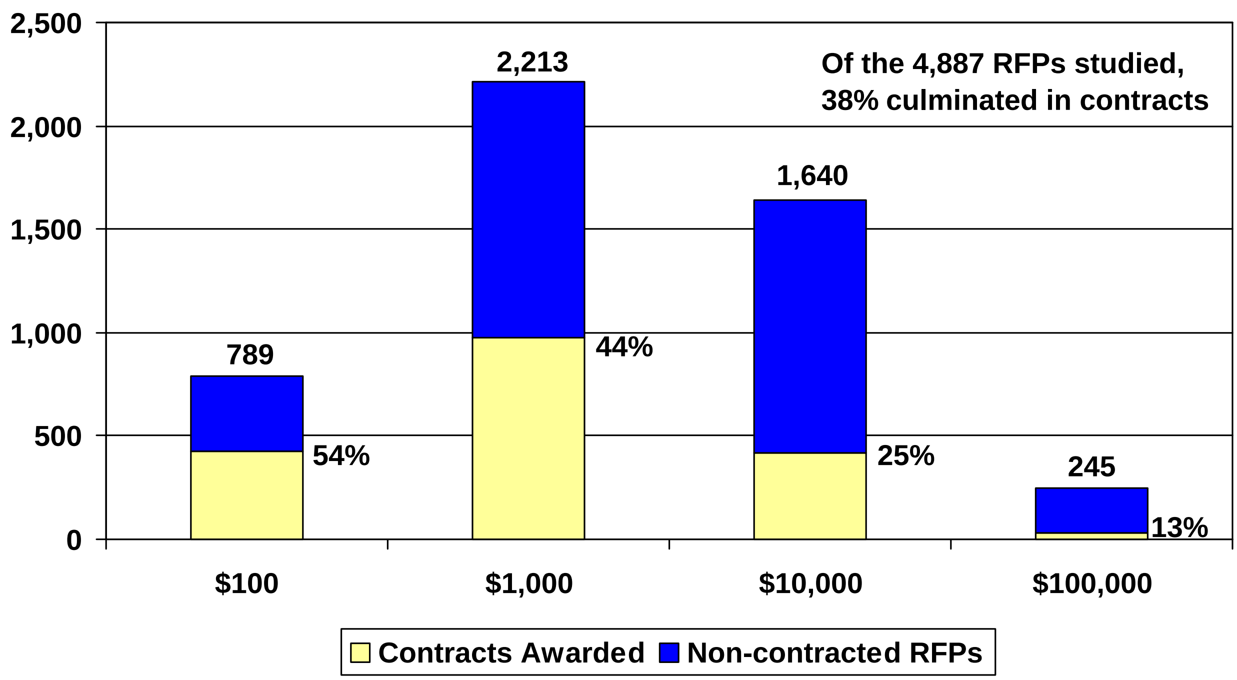

Table 2 – Correlations between Project Value (Average Bid) and Vendor Characteristics

Rank-order Correlations

Variable	**Feedback**	**Number of Ratings**	**Number of Bids**	**Winning Propensity**
Correlation	-0.132***	-0.186***	0.40***	-0.41***
N	3,471	3,739	3,739	3,739

Table 3 – Statistical Analyses

Dependent Variable - Number of Bids

	Variable	**Model 1 (a)**	**Model 2 (b)**	**Model 3 (c)**
	Constant	-19.83*** (1.598)	-24.03*** (1.533)	-18.71*** (1.866)
	ln(Average Bid)	1.65*** (0.117)	1.62*** (0.109)	0.71*** (0.216)
	ln(Market Maturity)	2.44*** (0.248)	2.42*** (0.233)	2.43*** (0.232)
	ln(Auction Length)	3.90*** (0.236)	4.31*** (0.220)	4.35*** (0.219)
	ln(Project Length)	0.74*** (0.224)	0.53** (0.209)	0.46** (0.208)
Sub-Categories	**Application Development**	---	3.95*** (0.441)	-2.27 (1.543)
	Database	---	11.95*** (0.518)	-0.62 (2.034)
	Engineering	---	-4.69*** (1.003)	4.73 (3.964)
	Handheld Devices	---	-2.99*** (1.036)	-8.90 (5.535)
Interaction	**Application Development*ln(Average Bid)**	---	---	1.05*** (0.245)
	Database*ln(Average Bid)	---	---	2.05*** (0.320)
	Engineering*ln(Average Bid)	---	---	-1.32** (0.590)
	Handheld Devices*ln(Average Bid)	---	---	0.990 (0.740)
	N	4,887	4,887	4,887
	R^2	0.195	0.304	0.312
	Regression F-Stat	295.85***	266.53***	184.56***
	ΔR^2		0.109***	0.08***

Standard Errors in parentheses
* $p< 0.1$; ** $p<0.05$; *** $p<0.01$

Table 4 – Impact of Project Value on RFP Outcome

Dependent Variable – Probability of a contract being awarded

	Variable	Model 1 (a)	Model 2 (b)	Model 3 (c)
	Constant	3.15*** (0.303)	2.86*** (0.312)	2.78*** (0.388)
	ln(Average Bid)	-0.25*** (0.023)	-0.26*** (0.023)	-0.25*** (0.048)
	ln(Market Maturity)	-0.15*** (0.046)	-0.13*** (0.047)	-0.13*** (0.047)
	ln(Auction Length)	-0.87*** (0.048)	-0.86*** (0.048)	-0.87*** (0.048)
	ln(Project Length)	0.14*** (0.043)	0.13*** (0.043)	0.13*** (0.043)
Sub-Categories	**Application Development**	---	0.41*** (0.091)	0.53 (0.328)
	Database	---	0.34*** (0.106)	0.77* (0.432)
	Engineering	---	-0.117 (0.224)	0.007 (0.877)
	Handheld Devices	---	0.22 (0.228)	-3.04** (1.212)
Interaction	**Application Development*ln(Average Bid)**	---	---	-0.02 (0.055)
	Database*ln(Average Bid)	---	---	-0.07 (0.071)
	Engineering*ln(Average Bid)	---	---	-0.02 (0.139)
	Handheld Devices*ln(Average Bid)	---	---	0.44*** (0.162)
	N	4,887	4,887	4,877
	AIC	5699.278	5681.586	5679.444
	-2 Log L	5689.278***	5663.586***	5653.444***

Asymptotic Standard Errors in parentheses
* $p < 0.1$; **$p < 0.05$; ***$p < 0.01$

Table 5 – Impact of Project Value on RFP Outcome for Certain Groups of Buyers

Dependent Variable – Probability of a contract being awarded

	Variable	**Model 4** [1] Transacting Buyers **(a)**	**Model 5** [2] "Preferred" Projects **(b)**
	Constant	3.05*** (0.494)	11.27 (7.758)
	ln(Average Bid)	-0.25*** (0.060)	-0.90** (0.455)
	ln(Market Maturity)	-0.12* (0.062)	-0.84 (1.146)
	ln(Auction Length)	-0.80*** (0.059)	-0.77*** (0.142)
	ln(Project Length)	0.28*** (0.058)	0.25* (0.132)
Sub-Categories	**Application Development**	0.21 (0.411)	-4.48 (3.161)
	Database	0.52 (0.572)	-3.954 (3.377)
	Engineering	-0.39 (1.189)	-0.44 (10.760)
	Handheld Devices	-3.75** (1.521)	-6.19 (3.880)
Interaction	**Application Development*ln(Average Bid)**	0.01 (0.068)	0.67 (0.466)
	Database*ln(Average Bid)	0.02 (0.093)	0.60 (0.493)
	Engineering*ln(Average Bid)	0.07 (0.188)	-0.13 (1.622)
	Handheld Devices*ln(Average Bid)	0.54*** (0.206)	0.95* (0.539)
	N	3,002	648
	AIC	3626.726	736.795
	-2 Log L	3600.726***	710.795***

Asymptotic Standard Errors in parentheses
* $p< 0.1$; **$p<0.05$; ***$p<0.01$

(1) Subset of those buyers that have at least one transaction in the market
(2) Subset of projects where participation was limited to "Preferred" vendors