NBER WORKING PAPER SERIES

AUCTIONS VERSUS NEGOTIATIONS IN PROCUREMENT: AN EMPIRICAL ANALYSIS

Patrick L. Bajari
Robert S. McMillan
Steve Tadelis

Working Paper 9757
http://www.nber.org/papers/w9757

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 2003

We thank Susan Athey, Tim Bresnahan, Jeremy Bulow, Igal Hendel, Matt Kahn, Pueo Keffer, Jon Levin, John McMillan, Paul Milgrom, Peter Reiss, Ilya Segal, Pablo Spiller, Bob Tatum and Oliver Williamson for helpful discussions. This research has been supported by the National Science Foundation, grants SES-0112106 and SES-0122747 (Bajari), and SES-0079876 (Tadelis) and by the Stanford Institute for Economic Policy Research. The views expressed herein are those of the authors and not necessarily those of the National Bureau of Economic Research.

Auctions Versus Negotiations in Procurement: An Empirical Analysis
Patrick L. Bajari, Robert S. McMillan, and Steve Tadelis
NBER Working Paper No. 9757
June 2003
JEL No. L0, D23, D82, H57, L14, L22, L74

ABSTRACT

Should the buyer of a customized good use competitive bidding or negotiation to select a contractor? To shed light on this question, we offer a framework that compares auctions with negotiations. We then examine a comprehensive data set of private sector building contracts awarded in Northern California during the years 1995-2000. The analysis suggests a number of potential limitations to the use of auctions. Auctions perform poorly when projects are complex, contractual design is incomplete and there are few available bidders. Furthermore, auctions stifle communication between buyers and the sellers, preventing the buyer from utilizing the contractor's expertise when designing the project. Some implications of these results for procurement in the public sector are discussed.

Patrick Bajari
Department of Economics
Stanford University
Stanford, CA 94305-6072
and NBER
bajari@stanford.edu

Robert S. McMillan
Department of Economics
Stanford University
Stanford, CA 94305-6072
rsmcmill@stanford.edu

Steve Tadelis
Department of Economics
Stanford University
Stanford, CA 94305-6072
stadelis@stanford.edu

1 Introduction

Manufactured goods, such as computers, washing machines and DVD players are mass produced, have standardized characteristics and are typically purchased at list price. Other goods, such as new buildings, fighter jets or consulting services are tailored to fit a buyer's needs. To procure these customized goods, the buyer hires a contractor who supplies the good according to a set of desired specifications.

An important decision that such a buyer faces is whether to award a procurement contract by using an auction or by negotiating with a seller. The theoretical literature emphasizes the benefits of competitive auctions as sale or procurement mechanisms (see, e.g., Bulow and Klemperer, 1996). These benefits, as well as arguments for equal opportunity and corruption prevention, provide a justification for statutes, such as the Federal Acquisition Regulations (FAR), that strongly favor the use of auctions in the U.S. public sector.

Interestingly, there is widespread use of *both* auctions and negotiations in the private sector. For example, from 1995 to 2000, forty-four percent of private sector non-residential building construction projects in Northern California were procured using negotiations, while *only eighteen percent* were procured using open competitive bidding. This paper offers a framework to compare auctions with negotiations and empirically examines procurement practices in the private sector of the building construction industry.

We begin our analysis by constructing a simple framework that guides our empirical analysis. In particular, we use a reduced form model that builds on the recent work of Bajari and Tadelis (2001), henceforth BT. They model the buyer's dual choice of contractual incentives and design completeness, when describing projects is costly and renegotiating *ex post* adaptations to the project involves potential frictions. They show that fixed price contracts provide good ex ante cost incentives but impose high frictions when ex post adaptations are needed. Cost plus contracts, on the other hand, better accommodate ex post adaptation but suffer from the lack of ex ante cost incentives. BT conclude that fixed-price contracts perform well for simple projects with few anticipated changes, while cost-plus contracts are better suited for more complex projects, for which many changes are anticipated.

Our first hypothesis follows from the analysis in BT. We argue that fixed price contracts lend themselves to competitive bidding while cost-plus contracts do not, implying that the choice between auctions and negotiations is bundled with the choice of contractual form. Thus, more complex projects—for which ex post adaptations are expected—

are more likely to be negotiated, while simpler projects will be awarded through competitive bidding.

This hypothesis is also consistent with conventional wisdom from the engineering management literature, which suggests that sealed-bid auctions stifle communication between the buyer and the contractor. In a sealed-bid auction, the principle piece of information that the buyer receives from the sellers is the bid. In negotiations, however, the buyer usually discusses the project in detail with the seller before the contract is signed. Sellers might have important information about appropriate construction practices and current materials prices that buyers can use when drafting the plans and specifications. Communication and coordination between the buyer and seller is more important in complex projects, offering an alternative explanation for the correlation between complex projects and the use of negotiations that is consistent with our first hypothesis.

A second hypothesis follows directly from standard auction theory: more potential bidders increases the benefits of using an auction. Thus, when contractors have more idle capacity, the benefits of an auction increase. On the other hand, during construction booms it may be difficult to find a contractor, lowering the benefits to auctions.

An indirect implication of our approach, which echoes the conventional wisdom of industry, is that a buyer should select a "reputable" contractor if a negotiation is used since firms differ in their ability to carry out complex projects at reasonable costs. Buyers should therefore rely on past performance and reputation to select a contractor for negotiations. Thus, a third hypothesis is that negotiated contracts are more likely to be allocated to more reputable sellers.

The hypotheses are tested using a data set of contracts awarded in the building construction industry in Northern California from 1995-2001. The empirical analysis appears to be consistent with the hypotheses. First, more complicated projects are more likely to be awarded by negotiation than by auction. Second, the use of auctions is counter-cyclical, consistent with the use of auctions when more contractors are available. Third, negotiated projects tend to be awarded to larger, more experienced contractors, consistent with the reputation hypothesis.

While the analysis is motivated by practices in the private sector, it offers implications for the public sector. Public sector statute which governs procurement, typically based on FARs, strongly favors the use of competitive bidding. In the data, for instance, ninety-seven percent of public sector building construction projects in Northern California are procured using competitive bidding. While competitive bidding does have the advantage

of unbiased awarding of projects, it fails to respond optimally to ex post adaptation. This suggests that public procurement of complex projects are suffering from efficiency losses.

This paper adds to a growing empirical literature on auctions and procurement. Recent empirical research on auctions, such as Hendricks and Porter (1995), Hendricks, Pinkse and Porter (2001) and Paarsch (1992) attempt to test whether observed bidding behavior is consistent with the predictions of information economics. Recent empirical work on the choice of contractual form, such as Crocker and Reynolds (1993), Corts (2002), Corts and Singh (2003) and Hendel and Lizzeri (2003) study the determinants of contractual form. However, one question that this literature has not addressed is when should a buyer award a contract using an auction or a negotiation, and how this may tie to the choice of contractual form. Our paper, to the best of our knowledge, is the first empirical study of this question.

Theoretical research on the choice of award mechanisms is also somewhat scant. Bulow and Klemperer (1996) show that a seller should prefer using a simple (no reserve price) auction to the best possible negotiation with one less buyer. They use this result to claim that, "No amount of bargaining power is as valuable to the seller as attracting one extra bona fide buyer" (p.180). Moreover, they claim that this argument should apply for procurement and regulation. Manelli and Vincent (1995) develop an alternative framework and show that in some cases sequential offers, which they call negotiations, may be better than an auction. While these are both interesting theoretical papers, we focus on distinct trade-offs between auctions and negotiations that lend themselves to empirical testing.

2 The Building Construction Industry

2.1 Overview

To understand the trade-off between different procurement practices, we begin with some background information on the construction industry. In 1992, there were 2 million establishments in the United States construction industry that completed $528 billion dollars of work. These firms directly employed 4.7 million workers and had a payroll of $118 billion dollars (Census 1992a,b,c). In 1997, the construction industry accounted for 8 percent of U.S. GDP and worldwide was a 3.2 trillion dollar market (Engineering News-Record 1998).

In the industry there is typically a division of labor between creating the designs for

the project and the actual construction. The buyer first hires an architectural firm to design the project and monitor the contractor during construction, while the contractor is liable to the buyer for project completion, and directs the work of subcontractors.[1]

Since every construction project is unique, the plans and specifications included in the contract may fail in the field and are therefore subject to change. If the plans and specifications are significantly altered, then the contract will be amended by filing a change order. Change is the source of acrimonious disputes. The buyer wishes to minimize the cost due to the change and may believe that the changes are due to inadequate workmanship by the contractor. The contractor, on the other hand, may believe that the changes are due the buyer's poor planning and incomplete specifications. In the engineering and construction management literature, coping with change plays a key role in selecting appropriate contract award procedures.[2]

2.2 Construction Contracts

The contracts used in private sector building construction are frequently standardized and typically contain six major parts: bidding documents, general conditions of the contract, supplementary conditions of the contract, specifications, drawings and reports of investigations of physical site conditions.

The specifications and drawings contain detailed engineering information about exactly how the project is to be completed. They are meant to be a sufficiently clear description of how the project is to be built so that the contractor may estimate costs in order to bid. Substantial deviations from the specifications and drawings will result in change orders to the project. The report on physical site conditions often contains geotechnical descriptions of subsurface soil and rock conditions, often including soil descriptions of soil borings from the project site.

The general conditions of the contract define, in general terms, the participants in the contract—i.e. owner (buyer), general contractor, engineer, subcontractors, etc.—

[1] Other possible organizational forms include design-and-build contracts, force accounting, and construction management among others. For general descriptions of the industry, contracting practices and project management see Bartholomew (1998), Clough and Sears (1994), and Hinze (1993).

[2] There are several common sources of change. First, design failures occur when drawings and technical specifications drafted by architects do not perform as expected in the field. Second, if actual site conditions differ from initial reports, then the costs and schedule may be affected. Third, if the general contractor and architect are working in an unfamiliar location, they may not be cognizant of all local rules and regulations which results in changed plans. Finally, bad weather conditions can slow down construction work resulting in scheduling problems and increased total project completion time.

and their roles, the process for amending the contract with change orders, the contractor's liability for on time completion of the contract and procedures for extending the completion date, terms describing how payments will be made, and conditions under which the contract may be terminated. In many cases, the general conditions are a "boilerplate" that is similar from contract to contract.

The standard form of contracts published by the *American Institute of Architects* (AIA) and the *Associated General Contractors* (AGC) are used in many building projects.[3] Because these contracts are widely used, the central clauses are well understood in industry and there exists a significant body of case law on interpreting these contracts. While there are many forms of alternative contractual arrangements, cost-plus (referred to as cost-plus a stipulated fee) and fixed price contracts appear to be the most commonly used. In a fixed price contract, the compensation for the contractor is agreed to in advance. In a cost plus contract, the general contractor is paid a fee and reimbursed for the costs incurred to complete the project. Competitive bidding is associated with fixed price contracts while cost plus contracts are frequently negotiated between a buyer and contractor.

2.3 Change Orders

The courts have recognized that contractors are entitled to compensation for changes to the plans and specifications in a fixed price contract (for a discussion of this see Sweet, 1994). Therefore, in a fixed price contract, the general contractor will not be willing to perform duties beyond those to which he is contractually bound without additional compensation. Two contractual procedures used to adjust compensation in fixed price contracts are called *change orders* and *change directives.*

A change order is a written amendment to the contract that describes additional work the contractor must undertake, and the compensation he will receive. AIA document A201 defines a change order as a "written instrument prepared by the Architect and signed by the Owner, Contractor and Architect, stating their agreement upon all of the following: (1) a change in the work; (2) the amount of the adjustment in the Contract sum, if any; and (3) the extent of the adjustment in the contract time, if any." The work and the conditions in a change order are generally determined by bargaining between

[3] According to the industry sources we have spoken with, these standard forms of contracts are more common among less experienced buyers. Very large and experienced buyers may design their own standard forms of contract for building construction.

the buyer, contractor and architect.[4]

2.4 Some Stylized Facts

Tables 2.1 and 2.2 are take from Hester et al. (1991), who summarize the results of six studies (reports) of procurement contracting in the construction management literature. Table 2.1 summarizes the effect of change on total project completion costs. In all of these studies, less than half of the projects are completed with changes of under two percent. While changes of five percent or more are not the norm, they do occur regularly. Table 2.2 summarizes the sources of change. The most common sources of changes are defective plans and specifications, changes in project scope and differing site conditions.[5]

Ibbs et al. (1986) quantify the impact of 96 different contract clauses on project performance in building construction. Their study consisted of a survey of buyers and contractors for 36 building construction projects. They claim to verify some conventional wisdoms about cost plus and fixed price contracting that are summarized in Table 2.3.

The first two facts are easily explained: the allocation of risk is obvious, and a multi-task model can explain how cost reducing incentives adversely affect quality (see Holmstrom and Milgrom, 1991). The other points imply that changes are more easily agreed upon under cost-plus contracting, while fixed price contracts require the buyer to invest more in design and specification. BT develop a theoretical model that offers an explanation for these facts. The essentials of their model, and it's adaptation to the question of choosing between auctions and negotiations is the focus of the next section.

[4] If the parties are unable to reach an agreement, in many contracts the architect has the power to issue a *change directive*. This is described as "a written order prepared by the architect and signed by the owner and architect, directing a change in the work and stating a proposed basis for adjustment... A construction change directive shall be used in the absence of total agreement on the terms of a change order." If the contract amount cannot be agreed to by bargaining between the parties, the contractor may be paid by what is called *force accounting*, which is described as follows: "If the contractor does not respond promptly or disagrees with the method for adjustment in the contract sum, the method and the adjustment shall be determined by the architect on the basis of reasonable expenditures and savings of those performing the work attributable to the change, including, in the case of an increase in the contract sum, a reasonable allowance for overhead and profit." (For more details on change orders, directives, and force accounting, see AIA document A201.) In practice, using change directives or force accounting will involve significant transaction costs. The working relationship between the buyer and the contractor is likely to be spoiled, much additional paper work will be required and the parties must spend time on frequently acrimonious renegotiation.

[5] Some of the totals in Table 2.2 sum to more than 100 percent because some studies allow multiple causes for a single change.

3 Auctions Versus Negotiations: Theory

This section lays out a reduced form model of the buyer's choice problem that is based on the BT model, and applies it to the method of contract award. Consider a buyer who wishes to procure a project from a seller. If the project is built according to his needs, the buyer will obtain a value of $\overline{v}$. For a project to be constructed the buyer must provide the seller with plans and specifications that describe the project. This is the buyer's first choice parameter: how much *design* to perform ex ante, where more design means a more detailed account of the plans and specifications. As Section 2.4 suggests, a more accurate design and description of a project reduces the need to renegotiate changes ex post.

It is instructive to consider a complete design as a list of blueprints and instructions that fully describe the project. Let $\tau \in [0,1]$ represent the fraction of instructions that are actually written down by the buyer, and interpret τ as the probability that *ex post* contingencies are covered by the contract's plans, and no ex post adaptation will be needed. With probability $1-\tau$ a contingency will arise for which their are no instructions, implying that the plan as specified will not result in the successful completion of the project, and the buyer will not obtain the value $\overline{v}$.

We interpret τ as the *contractual completeness* of the project's design. We suppress the state space model of BT and focus on its derived reduced form. In particular, let $T \geq 0$ be a scalar that represents the *complexity* of the project, where higher values of T imply a more complex project. One natural interpretation of T is the number of instructions required to completely specify the project.

It is costly to provide plans and specifications. In particular, providing a design of completeness $\tau \in [0,1]$ for a project of complexity T costs the buyer $d(\tau, T)$. BT derive three very intuitive properties of $d(\tau, T)$. First, for a given level of complexity T, the costs of design are increasing in the amount of design completeness τ. Second, the cost of guaranteeing a fixed probability of *ex post* specification τ is increasing in complexity T. Finally, the more complex a project, the higher is the marginal cost of increasing the probability of specification, so that $\frac{\partial^2 d(\tau,T)}{\partial \tau \partial T} > 0$.

The buyer's second choice is what cost incentives the seller should receive, where higher incentives mean that the seller bears more of the costs of production. Following BT we focus on two extreme contractual forms. Let $y \in \{0,1\}$ represent this choice variable, where $y = 1$ is a cost plus (low) incentive scheme, and $y = 0$ is a fixed price (high) incentive scheme.

If the design covers the *ex post* contingencies then the buyer obtains a payoff of $\overline{v}$ and incurs a cost of $c(y)$. Stronger incentives naturally imply a lower cost of production, so $c(0) < c(1)$.[6] In the event that the design does not cover the *ex post* contingencies (which happens with probability $1 - \tau$) then the buyer still incurs the costs $c(y)$, but obtains a lower payoff of $\underline{v}(y) \leq \overline{v}$. In the event that the design needs modifications then we a cost plus contract easily adapts to cover additional changes, where a fixed price contract would need to be renegotiated, which generally involves more haggling and friction. This idea is captured by the strict inequality $\underline{v}(0) < \underline{v}(1)$, which says that if changes are needed then the ex post surplus with a fixed price contract is lower than that with a cost plus contract. This is derived in BT by showing that in the presence of ex post incomplete information, fixed-price incentives dissipate *ex post* surplus due to costly renegotiation, whereas with cost-plus contracts *ex post* surplus is not reduced.[7]

We argue that this choice of incentives is strongly tied to the choice of award mechanism, namely, the choice between an auction and a negotiation. As most practitioners would readily agree, "[a] cost-plus contract does not lend itself well to competitive bidding." (Hinze, p. 144.) Indeed, "[m]ost negotiated contracts are of the cost-plus-fee type" (Clough and Sears, p. 10.)

One might suggest that bidders can bid over the "plus" portion of the contract. However, as the "plus" is often only a fraction of the costs, this can be quite a disastrous way to select a contractor under very reasonable assumptions. For example, if more cost efficient contractors have better outside options, then their reservation option would be inversely related to their cost effectiveness, and it is the *highest cost* contractor who will win such an auction. Furthermore, if complex projects that are tied to cost plus contracts require contractors that have more expertise, and thus are in higher demand for such projects, then again we would expect their reservation option to be higher than contractors with less expertise.

This suggests that if a cost-plus contract is chosen then it will be "normally negotiated between the owner and the contractor." (Clough and Sears, p. 137.) On the other hand, it is quite obvious that fixed-price contracts immediately lend themselves to competitive bidding, and the facts indicate that contracts procured through auctions are of the fixed-

[6] In BT this is generated by a standard moral hazard problem in which the seller will have stronger incentives to reduce costs when his payment is closer to a fixed-price contract where he bears all the costs. Some of these cost savings are enjoyed by the buyer.

[7] In BT there is an explicit cost of adaptation that is the contractors ex post private information, even though ex ante there was symmetric uncertainty about *ex post* adaptations.

price from. Thus, by choosing a cost-plus contract, the buyer is de facto choosing to negotiate, whereas by choosing a fixed-price contract the buyer can award the contract using an auction. In this way we *bundle the choice* of the award mechanism with the choice of contractual form.

Once fixed price contracts are associated with an auction, it is well known that the benefits from an auction will generally depend on the number of bidders who will participate. In particular, in independent private value auctions, which seem like a reasonable environment for construction building, more bidders will generate a lower expected bid. Thus, we would expect the costs $c(\cdot)$ that result from an auction to be decreasing in the number of participating bidders, N.[8]

When negotiation is considered, "[i]t is common practice for a private owner to forgo the competitive bidding process entirely and to hand-pick a contractor on the basis of reputation and overall qualifications to do the job." (Clough and Sears, p. 10.) Thus, we assume that cost-plus contracts are awarded by negotiation, and do not model the negotiation process.

To address the effect of N on negotiations we assume that fixed price incentives will lower production costs by *more* than from selecting the most reputable contractor with cost-plus incentives. In particular, we will make the extreme assumption that once a cost-plus/negotiation choice is made, then production costs $c(\cdot)$ are higher than if a fixed-price/auction choice is made. Incorporating this assumption with the fact that an auction results in costs that are decreasing in N, gives the following condition:

$$c(1,N) > c(0,1) > c(0,2) > \cdots > c(0,N) \text{ for all } N \geq 1\,. \tag{1}$$

We now have the buyer's objective as,

$$\max_{\substack{y\in\{0,1\}\\ \tau\in[0,1]}} u_B(y,\tau;T,N) = \tau\overline{v} + (1-\tau)\underline{v}(y) - c(y,N) - d(\tau,T)\,, \tag{2}$$

and monotone comparative statics imply the following (proven in the appendix):

[8]This can be easily shown for a second price auction since the second order statistic is decreasing in N. In this environment with risk neutral bidders there is a revenue equivalence theorem. It is well known, however, that the cost of preparing a bid is not trivial, and models of auctions with entry costs have been analyzed. One can argue that the costs of preparing a bid would depend on the complexity of the project, creating some correlation between τ and N. We assume that this can be neglected, and it seems that more detailed modelling can accommodate such a case.

Proposition 1: *Fixing the number of bidders, more complex projects are more likely to be negotiated, while simpler projects are more likely to be procured using auctions. Holding complexity fixed, an increase in the number of available bidders makes auctions more attractive.*

This generates two hypotheses: (*i*) more complex projects are more likely to be negotiated, and (*ii*) when less bidders are available, projects are more likely to be negotiated. There are, however, other factors beyond our simple theoretical model that may bear on the choice of award mechanism. In what follows, we spell out what we believe is a comprehensive list, given what we have learned from industry participants.

Our theoretical approach differs from the standard literature on procurement, where there is typically no uncertainty about the project characteristics but rather about the builder's *costs* for completing the project (see Laffont and Tirole, 1993). In the field, however, the plans and specifications in the contract are not always sufficiently detailed to successfully complete the project. Competitive bidding for fixed price contracts performs poorly when the product designs are incomplete because substantial ex post adjustments are required. This fact is extensively documented in the engineering and construction management literature (see Bartholomew (1998), Clough and Sears (1994), Hinze (1993) and Sweet (1994)).

Clearly, our theoretical framework abstracts away from other potentially important determinants of contractual form and award mechanism. For example, we ignore hidden information such as a contractor's ability to complete the job adequately, which may lead to problems of adverse selection (though we discuss some practices that help with such problems in section 5). In what follows below we describe some other determinants of the award mechanism that have been suggested by industry sources.

Coordination ex ante. Another limitation of auctions is that they stifle coordination between buyer and contractor before the plans and specifications are finalized, since the primary information that the buyer receives from sellers is their bid. This "[s]eparation of design and construction deprives the owner of contractor skill during the design process, such as sensitivity to the labor and materials markets, knowledge of construction techniques, and their advantages, disadvantages and costs. A contractor would also have the ability to evaluate the coherence and completeness of the design and, most important, the costs of any design proposed." (Sweet, 1994)

Furthermore, it is widely believed that when competitive bidding is used to award a fixed-price contract, the contractors strategically read the plans and specifications to

determine where they will fail. Suppose that contractor A sees a flaw in the plans that will cause a change leading to $1 million dollars of profits, and that the other $N-1$ contractors are unaware of this flaw. Contractor A will likely win the job since he would be willing to bid less than contractors who do not see the flaws in the plans. Competitive bidding may therefore leads to adverse selection, which is more problematic when projects are complex.

In negotiations, however, the buyer and contractor typically spend a good deal of time discussing the project before work begins. If the buyer can elicit the contractor's views about where the designs and specifications can be improved, then negotiations might be preferable to auctions. The industry literature suggests that one merit of cost plus contracting and negotiation is that buyers and contractors spend more time discussing the project and ironing out possible pitfalls before work begins.

Reputation. The preceding argument implies that benefits to the buyer from choosing negotiation will be greatest when the contractor reveals pitfalls with the plans and specifications. Therefore, we might expect the choice of negotiations to be correlated with the selected contractor's good "reputation" for partnering with buyers and architects in negotiated projects (recall the quote from Clough and Sears, p.10 mentioned above).

Red Tape. Industry sources have suggested that choosing a contractor using negotiation involves less "red tape" than competitive bidding. Awarding a project through competitive bidding usually begins with advertising the project in an industry periodical for a number of weeks. The contractors then pick up the plans and specifications from the buyer, prepare cost estimates and submit bids at the pre-specified time and place. In contrast, when a project is negotiated, there is no need to advertise and consequently a contract can be signed with considerably less delay. One implication of this story is that more experienced buyers should be more familiar with the bureaucratic procedures associated with competitive bidding and use competitive bidding more frequently, all else held constant.

Privacy. Another drawback of open competitive bidding is that a complete set of the buyer's plans and specifications for the project must be made available to all bidders. These plans and specifications may contain sensitive information about business strategy, such as markets in which the buyer wishes to expand. In such circumstances, the buyer will wish to maintain the privacy of these plans and specifications by using negotiation as the award mechanism.

4 The Data

4.1 General Description

Our data includes non-residential building construction projects in Northern California during the period 1995-2000. The data was purchased from Construction Market Data Group (CMD), a firm that sells information about upcoming projects to contractors through periodicals, its website, and access to local CMD reporters and plan rooms. For many contractors, CMD is a primary source of information for learning about construction projects.[9] The data consists of approximately 25,600 projects, of which roughly 4,100 were awarded in the private sector. We focus on the private sector jobs since most public sector projects are required by statute to use open competitive bidding.

The unit of observation in our data set is a non-residential building construction project. Each observation includes project characteristics such as the location of the project site, a detailed description of the work to be done, the estimated project value (an engineering cost estimate), the award mechanism (auction or negotiation), the number of bidders, the date that bids were due and bonding information. The data does not include any information on project outcomes or the form of contract that is used. However, as we argued earlier, industry sources have documented that most of the negotiated contracts are cost-plus, while practically all the auctioned contracts are fixed-price. In addition to the project characteristics, the data includes unique id numbers for the firms involved in the project (the buyer, the bidders, and all the other major roles), as well as their identity, allowing us to examine the dynamics of relationships between firms, how frequently certain firms are active, as well as other tests that we describe below.

Four award mechanisms are used to select contractors. The first is *open competitive bidding*, in which following a broad advertisement of the project, any contractor who is bonded is allowed to submit a bid. Notice that such bonds seriously reduce the hazards of adverse selection and moral hazard, which to some extent question the applicability of the mechanism design approach to procurement.[10] The second, *invited bidders*, is like

[9] CMD estimates that their coverage is approximately 85-90% of all projects in the building construction market during this period. According to CMD, the missing projects are usually those that are too small, or projects that the buyer does not want publicized.

[10] Three types of bonds are typically required by most owners. The first is a bid bond that is typically equal to ten percent of the bid. The surety, or bonding company, is liable for this amount if the contractor reneges on its bid after it is awarded the contract. The second is a performance bond, typically equal to the amount of the bid. The surety is liable up to this amount if the contractor fails to build according to the plans and specifications. Finally, there is a payment bond, typically equal to the amount of

open bidding except that only invited bidders are given contract information and are allowed to bid. The buyer should make sure that an invited bidder is in a sound financial position so that it has sufficient resources to pay subcontractors and material suppliers during construction and therefore will not file for bankruptcy while construction is taking place. Furthermore, the buyer should verify that the contractor has sufficient experience and free capacity to complete the project in a timely manner. The third, *pre-qualified bidders*, which "is not a common practice" (Hinze, p. 95), is like open bidding with an initial qualification stage. For this procedure, firms who wish to compete must submit specific information about their experience, financial stability and other characteristics before the buyer qualifies them as viable bidders. Finally, in *negotiation,* the buyer decides to forgo the bidding process altogether and picks a contractor directly.

4.2 Summary Statistics

In what follows, we begin by summarizing some key statistics in our data. Table 4.1 summarizes the size, value and other characteristics of the buildings in our data set. The project value is an architect's or engineer's estimate of the total project cost. Before construction begins, it is typical for the architectural firm that designs the plans and specifications to compute an estimated cost.

From Table 4.1, we see that there is a great deal of heterogeneity in project size. The average project value is approximately 9.5 million dollars with a standard deviation of 36 million dollars. The smallest project is near $10,000 in cost while the largest project is close to $800 million in cost. The variation in other project characteristics, such as floor area, floors above ground and parking spaces also demonstrates that our data set contains a diverse set of projects.

Table 4.2, summarizes the distribution of award mechanisms. Nearly half of the jobs are negotiated. Open competitive bidding is used for only 18 percent of the jobs, while invited bidders is used for 37 percent of these projects. Since buyers use invited bidders nearly twice as often as open competitive bidding, it appears that buyers frequently prefer to *restrict* the set of firms allowed to bid.[11]

---

the bid, which guarantees that all subcontractors and material suppliers will be paid. If a contractor is grossly negligent in performing its work, it will be very difficult for it to be bonded for future contracts, effectively shutting the contractor out of business. See Clough and Sears (1994, ch. 7) and Hinze (1993, ch. 8) for a more detailed discussion of bonding.

[11] Ye (2002) develops a model in which it is costly for bidders to learn their valuations, and in his setting it is typically optimal for the auctioneer to restrict entry into the auctions. Since it is far from

Table 4.3 summarizes the distribution of the number of jobs done by each firm in our data set. The construction industry is extremely competitive with high entry and exit rates that are commonly attributed to the low entry costs in construction, as compared with other industries. Nearly sixty percent of the firms in our data set only complete one job as a prime contractor.[12] Many of these small firms in the Northern California building construction industry work as subcontractors on other construction projects, work on smaller projects not contained in our data set or have a short life-span.

5 Auctions Versus Negotiations: Evidence

We use a discrete choice econometric model to evaluate the theories discussed in section 3. Most of the analysis will consist of logistic regressions with specifications that regress the choice of award mechanism on possible explanatory variables such as project complexity, the number of available contractors and buyer characteristics. We will later argue that when a project is negotiated, a more reputable contractor should be chosen.

We proxy for complexity using three project characteristics: the *(log) value* of the project, the *(log) square feet* of the project, and the *number of divisions*. The value of the project is a reasonable proxy for complexity since the number of hours to completely document the plans and specifications is generally higher for projects with large estimated values. Furthermore, projects that are more complex are typically more costly to construct. The log square feet of the building is a reasonable proxy for complexity by analogous arguments. The number of divisions indicates the number of sub-categories of work, as defined by CMD (such as electrical wiring, plumbing, dry walling, etc.) that are required to complete the project. In general, the complexity of the plans and specifications is also positively correlated with the number of divisions.

The "red tape" hypothesis asserts that the use of competitive bidding will be used more often by buyers who are more experienced and build frequently. We proxy for the buyer's experience with three variables. First, we use an "cumulative experienced buyer" dummy that is equal to one if the buyer has appeared in our data-set in at least one *previous* project. Second, we supplement our CMD data with credit data from Reference

trivial for contractors to discover their costs for a specific project, this may be a reason for the prevalence of invited bidder auctions. A concern for quality may also explain the prevalence of these auctions.

[12] This is consistent with findings about the size distribution of firms in other branches of the construction industry. Bajari and Ye (2002) report that in the highway construction industry, about half of the firms who bid never win a single large contract.

USA, a web-based firm whose rating considers an businesses number of employees, years in business, industry stability, census data, pay history, etc.[13] This data includes credit rating of a buyer (0-7) and a size measure of buyer (number of employees). We assume that these measures are positively correlated with a buyer's experience.

Our theoretical model in section 3 suggests that the choice between auctions and negotiations will also depend on the number of available contractors. In the late 1990's, there was considerable fluctuation in local construction activity which arose from the varying fortunes of high technology companies. We control for this by including the six month percentage change in the total volume of work awarded in the project's county. The construction industry is highly spatial. The majority of work performed by a contractor will be close to a contractor's headquarters. Since the number of contractors will not adjust instantaneously to local, short-run demand shocks, we believe that our control reasonably proxies for the number of available contractors.

Since we expect negotiations to be awarded to more reputable contractors, we proxy for the reputation of the contractor using similar experience measures that we use for buyer experience. We proceed to construct a dummy variable, "cumulative experienced contractor," which indicates whether the selected contractor has previously appeared in our data-set, and we also use the credit and size data from Reference USA.[14] Given the high turnover of firms in the industry, we believe that these are reasonable proxies for contractor reputation.

In table 5.1 we report estimates from a series of logit specifications as described above, where $y_i = 1$ if the project is negotiated $y_i = 0$ if the project is competitively bid. We define a project as "competitively bid" if it is awarded using invited bidders, pre-qualified bidders or open competitive bidding. To check our results, table 5.2 reports estimates from an ordered logit where the dependent variable is $y_i = 3$ if the project is negotiated, $y_i = 2$ if invited bidders are used, and $y_i = 1$ if open competitive bidding is used. This ordering of the dependent variable arises from that fact that using invited bidders, like negotiation, gives the buyer more discretion in the choice of contractor. We discuss the possible implications of this later.

[13] Reference USA information is compiled from public sources such as Yellow Pages, annual reports, 10-Ks and other SEC information, government data, Chamber of Commerce information, leading business magazines, trade publications, newsletters, major newspapers, industry and specialty directories and postal service information. There ratings are indicators of the financial strength of the business.

[14] The credit rating is a measure of credit "worthiness" that Reference USA computes.

5.1 Complexity

In table 5.1 we observe a positive and statistically significant relationship between our three measures of complexity and the use of negotiations. The specification in the first column only includes log-project value (lprojval) and log-floor area (lflarea) and does not include the number of divisions (divsum). This allows us a sample size of over 3000 projects, and the effects of complexity are significant when controlling for the cumulative experience of the owner/buyer (expowncum). The other specifications in Table 5.1 add our third proxy for complexity (divsum), which reduces the sample size to 682 projects. When we control for the buyer characteristics we obtain significance of our proxies of complexity in all but the last specification, in which the addition of the owner's size measure from Reference USA causes the sample to drop further to 465 projects. The results of the third specification are due to the reduced sample size.[15]

These results are consistent with the theory that suggests a positive correlation between negotiation and measures of complexity. From these results, however, it is not possible to distinguish the theory from the "ex ante coordination" story. From our conversations with industry sources and from reading the industry literature, it is our impression that both of the motivations for negotiating are important in practice.

Since all three of our measures of complexity involve the scale, or size of the project, an alternative explanation for the positive relationship between our proxies for complexity and the use of negotiation would be a budget constraint argument: the larger a project, the less there are contractors who have a "deep enough pocket" can compete for it. As a result, auctions may not induce sufficient competition, hence negotiations would represent a superior method in awarding the project. To test this hypothesis we regress the number of bidders on project covariates. Table 5.4 shows that the number of bidders *increases* with the value of the project, implying that the positive relationship between project value and the choice of negotiations does not appear to arise from a limited number of potential bidders. We run several specifications with dummies for low, medium and high value projects (lpil, lpim, and lpih) and verify that the positive relationship between project value and the number of bidders is maintained across all value ranges, implying that the "deep pocket" hypothesis is not born out in the data. This relationship is also prominent in the public sector as the two right columns of table 5.4 show.

[15] We ran the specifications of columns 2 and 3 on the sample of the last specification and the results were very similar.

Another alternative story consistent with our results is that auctions are not used in complex projects because buyers are more concerned about shirking on quality. In fact, Table 2.3 suggests that fixed price contracts are perceived as leading to lower quality. While contractors can shirk, the degree to which they can shirk is limited due to bonding requirements. When performing a fixed-price contract, the contractor must submit a performance bond obtained from a surety (bonding company). The surety is liable up to the amount of the contractor's bid if the contractor fails to build the project to plans and specifications. The surety has no incentive to provide a bond for a contractor who will shirk on quality, a practice that mitigates both adverse selection and moral hazard problems.

From table 5.2, we see that invited bidders is implemented more frequently than open competitive bidding for complex projects. We have found that this result is robust to changes in our specification, such as restricting attention only to the choice between invited bidders and open competitive bidders. The most obvious interpretation is that the when a project is more complex, the buyer may want to screen out those firms that lack the necessary competency, capacity or cash to complete the project by awarding the project using invited bidders. Furthermore, if submitting bids is more costly for more complex projects, which seems to be the case, then there are advantages to restrict the number of bidders (see Ye, 2002).

5.2 The Number of Bidders

In table 5.2 we find that an increase in 6 Month County Volume (chydiff) leads to an increased use of negotiations. We interpret this result in the following way: When there is an increase in the amount of work done in a county, the local contractors are busier, leaving fewer contractors to bid on new work since construction is a rather local activity. This is consistent with the prediction that negotiations are more attractive when fewer bidders are available.

In table 5.4, we find that the time dummies are statistically significant and decreasing over time. The years 1995-1999 correspond to a period of robust economic growth in the bay area, brought on by a strong demand for high technology products and the creation of many new high technology businesses. The year 1999 was the period of most rapid growth in Northern California, 1998-1997 was more rapid than 1995-1996. Overall demand for building construction rose sharply in these years. As a result, there was an average of one less contractor bidding on any given job in 1999 as compared to 1995-1996.

Not surprisingly, in Table 5.5, we see that open competitive bidding is only used for 10 percent of the projects in 1999 as compared to 18 percent in 1995. Overall, the results in Tables 5.4 and 5.5 indicate that the use of negotiations tended to be pro-cyclical while the use of auctions was counter-cyclical.

5.3 Reputation

In Table 5.3 we report results from logistic regressions of two reputation proxies (expbuild and expbuildcum) on project and owner (buyer) characteristics, as well as on dummies for the type of award mechanism treating open competitive bidding as the base-case. We see that for all four specifications, both prequalification and invited bidders select for more reputable builders, and negotiations exhibit the same selection but significantly more pronounced. This finding is consistent with our discussion in Section 3 that more reputable contractors should be selected when awarding a cost plus contract through the use of negotiation.[16]

It is often suggested in the construction management literature that fixed price contractors aggressively seek change orders since their overall profit will depend on revenues derived from changes. In this highly competitive environment, firms who do not aggressively seek changes will quickly be driven out of business. As a result, fixed price contractors and public sector contractors are perceived as more "ruthless" than firms who perform cost plus contracts.

In figure 5.1 we plot a histogram of the fraction of work that is done by a given firm in the private sector, and in figure 5.2 we plot a histogram of the fraction of work done through negotiated contracts within the private sector (only for firms who complete more than one contract). These results suggest that firms tend to specialize in either public or private work, and within the private sector in either negotiated or competitively bid work. According to industry sources, the most reputable contractors engage in cost plus contracting, less reputable contractors are awarded fixed price contracts in the private sector and the least reputable are awarded contracts in the public sector. This is further evidence, consistent with our discussion in section 3, that reputation plays a role

[16] Banerjee and Duflo (2000) also find a positive correlation between the reputation of software contractors and the use of cost plus contracts. Their interpretation is that the choice of contract is influenced by the seller's reputation, which differs from our story. Using our data it is hard to tease out the causal effects of reputation, but when we control for seller characteristics, both with and without spacial location as instruments, the significance of project and buyer characteristics shown in tables 5.1 and 5.2 still hold strong.

in matching contractors to award mechanisms.

Economic theory suggests that a long-term relationship between a buyer and a contractor can help to align the contractor's incentives with the buyer's. Therefore, one might conjecture that such long-term relationships are one explanation for the more frequent use of experienced contractors on negotiated projects. We found that pairings between the same buyer and contractor are very infrequent in the data. We also found that multiple pairings of the same contractor and architect are not very frequent. This is a limitation of our 6 year period, and we cannot therefore investigate the relationship between repeated interactions and the choice of award mechanism. (See Corts and Singh(2002) for an analysis of this sort).

5.4 Buyer Characteristics

The results in Tables 5.1 through 5.3 demonstrate that more experienced buyers are more likely to use competitive bidding. This is consistent with the "red tape hypothesis" since more experienced buyers are likely to have lower administrative costs for awarding a contract by competitive bidding. This result is significant at conventional levels in all of our specifications.

We have no direct evidence about the influence of privacy concerns in the auction or negotiation choice. However, according to CMD, who has a large staff of reporters that search for upcoming jobs, buyers are often concerned about privacy.[17] Buyers have an incentive to keep their plans and specifications a secret when a new technology is involved (e.g. when constructing a plant that will utilize a new manufacturing process) or when a buyer is expanding his business into a new territory.

6 Discussion

6.1 Contractual Choice and Award Mechanisms

In their analysis of auctions versus negotiations, Bulow and Klemperer (1996) write that for the sale of a company, "a single extra bidder more than makes up for any diminution in negotiating power. This means that there is no merit in arguments that negotiation should be restricted to one or a few bidders to allow the seller to maintain more control of the negotiating process, or to credibly withdraw the company from the market." [p.180].

[17] In the past, buyers got angry when CMD has advertised projects that they wished to keep secret.

Though their main application is for the sale of a company, they also note that "in a procurement context, competitive bidding by suppliers will yield lower average prices than negotiating with a smaller number of suppliers."

We believe that their conclusions are insightful for applications where the item being bought or sold is well defined, and there is no ex post stage where the ex ante committed price needs to be renegotiated. Our analysis suggests that this is not the case for many procurement projects, for which ex ante descriptions of the item may be incomplete, causing ex post adaptation to be an important feature of the transaction..

As we have argued, two channels can make negotiations more attractive than auctions. The first, which we highlight in our model, is the need for ex post changes. An optimal response to this problem is choosing cost-plus contracts, and these cannot be auctioned in a sensible way.[18] The second, which has been emphasized by some industry participants, is using the knowledge and experience of a contractor before the designs are complete and construction begins. As we have argued, if a project will be awarded using competitive bidding then a contractor has an incentive to hide information about possible design flaws, submit a low bid, and recoup profits when changes will be required.

Note that for this story of ex ante information sharing, weak cost incentives (like cost plus contracts) may be important. With a fixed price contract, strong incentives to conceal problems and ex post renegotiate changes are still present.

6.2 Implications for Public Sector Policy

In the public sector, statutes such as the FARs (and the many statutes that are modeled after the FARs) strongly favor the use of competitive bidding, and particularly open competitive bidding when feasible. For instance, in our data set, ninety-seven percent of the projects awarded in the public sector were awarded using open competitive bidding as compared to only eighteen percent in the private sector.

Competitive bidding is perceived to select the lowest cost bidder, prevent corruption and favoritism that are opposed to efficiency, and it offers a clear yardstick with which to compare offers. According to an Ohio Court, competitive bidding "...gives everyone an equal chance to bid, eliminates collusion, and saves taxpayers' money... It fosters honest competition in order to obtain the best work and supplies at the lowest possible price

[18] McAfee and McMillan (1986) introduce a model of adverse selection combined with moral hazard in which it is optimal for a buyer to solicit bids, and pay ex post depending both on the bid and the ex post realization of costs. They cannot have sensible bidding for cost-plus contracts, but in their model cost-plus contracts are never optimal.

because taxpayers' money is being used. It is also necessary to guard against favoritism, impudence, extravagance, fraud and corruption." (See Sweet (1994), pp. 379).

One recent case that caused a stir in California was a 95 to 126 million dollar no-bid contract that was awarded by California's department of information technology to Oracle for the long-term purchase of software database licenses. In a series of articles over the past two years in the San Jose Mercury News by Noam Levey, it was suggested that Oracle, through a series of contributions and lobbying efforts, had influenced the decision in their favor, and that ex post the contract was not considered an attractive deal to the state of California. More recently, the award of "rebuilding Iraq" to Bechtel has also raised concern about the transparency of awarding a huge contract (up to $680 million) through a process other than open competitive bidding, concerns that were exacerbated due to Bechtel's connections with the republican administration.

Our results suggest that for complex projects, there is a downside to the use of fixed-price contracts awarded through competitive bidding and that selecting a contractor and negotiating with it may be the favorable course of action. This downside of open competitive bidding can arise from a lack of input by contractors at the design stage, from the need to proceed quickly without the ability to complete detailed plans and specifications, and from the expectations that ex post haggling and frictions might occur when changes are needed. An important practical question for public procurement is whether one can design a set of objective rules for awarding negotiated contracts that minimize transaction costs, but that are not easily subject to manipulation, corruption or blatant favoritism.

6.3 Summary

Our paper offers three contributions. First, we believe that this is the first empirical paper to examine the choice between auctions and negotiations in procurement. Our empirical analysis is primarily descriptive, but it sheds some light on what we believe is an important factor in procurement: the relationship between project complexity and contractual response.

Second, we suggest some limitations of auctions, as compared to negotiations, that have not been emphasized in the literature. In procurement, the standard assumption of well defined products, which is central to the mechanism design and auction literature, is questionable. When ex post change is anticipated, the use of auctions, which often requires fixed price contracts, may be inefficient.

Finally, we question the efficiency of FARs that force public sector bureaucrats to award fixed-price contracts by competitive bidding. Our results suggest that there is room to consider alternative ways to prevent corruption, like more costly but effective monitoring, and then allow the public sector to award contracts with the flexibility and speed used by the private sector. Given the sheer volume of public sector procurement, it is clear that this approach begs for more serious research and evaluation.

References

Bajari, Patrick and Tadelis, Steven (2001) "Incentives Versus Transaction Costs: A Theory of Procurement Contracts." *RAND Journal of Economics,* Autumn 32(3) pp. 387-407.

Bajari, Patrick and Ye, Lixin, "Competition Versus Collusion in Procurement Auctions: Identification and Testing". Stanford University Working Paper.

Banerjee, Abhijit V. Duflo, Esther, "Reputation Effects and the Limits of Contracting: A Study of the Indian Software Industry", *Quarterly Journal of Economics* v115, n3 (August 2000): 989-1017.

Bartholowmew, Stuart H. (1998) *Construction Contracting: Business and Legal Principles,* Prentice-Hall, Inc.

Chamberlain, Gary (1980) "Analysis of Covariance with Qualitative Data," *Review of Economic Studies*, 47(1) pp. 225-238.

Clough, R. and Sears, G. *Construction Contracting,* New York: Wiley, 1994.

Corts, Kenneth (2002) "Fixed-Price vs. Cost-Plus: The Determinants of Contractual Form in Offshore Drilling," mimeo, Harvard Business School

Corts, Kenneth and Jasjit Singh (2003) "The Effect of Relationships on Contract Choice: Evidence from Offshore Drilling," mimeo, Harvard Business School

Crocker, Keith J. and Reynolds, Kenneth J. (1993) "The Efficiency of Incomplete Contracts: An Empirical Analysis of Air Force Engine Procurement," *Rand Journal of Economics,* 24(1), pp. 126-46.

Engineering News-Record, 11/30/98 "The World is a 3.2 Trillion Construction Market", pp35-68.

Hendel, Igal and Alessandro Lizzeri (2003) "The Role of Commitment in Dynamic Contracts: Evidence from Life Insurance," *Quartely Journal of Economics*, 118(1):299-328.

Hendricks, Kenneth, Joris Pinkse and Robert Porter (2001): Empirical Implications of Equilibrium Bidding in First Price, Symmetric Common Value Auctions," NBER Working Paper, No. 8294.

Hester, Weston T., John A. Kuprenas, and T.C. Chang, (1991) "Construction Changes and Change Orders: Their Magnitude and Impact," The Construction Industry Institute, Austin, Texas.

Hinze, Jim. (1993) *Construction Contracts*, McGraw-Hill Series in Construction Engineering and Project Management. Irwin/McGraw-Hill.

Holmstrom, Bengt and Milgrom, Paul, "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership and Job Design". *Journal of Law, Economics and Organization* v7, n0 (Special Issue, 1991): 24-52

Ibbs, C. William et al., (1986) "Determining The Impact of Various Construction Contract Types And Clauses On Project Performance: Volumes I and II." The Construction Industry Institute, Austin, Texas.

Laffont, Jean-Jacques and Jean Tirole (1993) *A Theory of Incentives in Procurement and Regulation*. MIT Press.

Manelli, Alejandro and Vincent, Daniel "Optimal Procurement Mechanisms," *Econometrica,* Vol. 63 (1995), pp. 591-620.

McAfee, R. Preston and McMillan, John (1986) "Bidding for Contracts: A Principal Agent Analysis" *Rand Journal of Economics,* Vol. 17:326-38.

Paarsch, Harry J., (1992) "Deciding Between Common Values and Private Value Paradigms in Empirical Models of Auctions." *Journal of Econometrics*, 51:191-215.

Porter, Robert (1995) "The Role of Information in U.S. Offshore Oil and Gas Lease Auctions," *Econometrica*, 63(1):1-28.

Sweet, J., *Legal Aspects of Architecture, Engineering and the Construction Process,* Minnesota: West Publishing Company, 1994.

U.S. Department of Commerce. Bureau of the Census. 1992a. Census of Construction Industries. United States Summary. Establishments With and Without Payroll. Washington DC: Government Printing Office.

U.S. Department of Commerce. Bureau of the Census. 1992b. Census of Construction Industries. General Contractors-Residential Buildings, Other Than Single-Family Homes.. Washington DC: Government Printing Office.

U.S. Department of Commerce. Bureau of the Census. 1992c. Census of Construction Industries. General Contractor-Nonresidential Buildings, Other Than Industrial Buildings and Warehouses. Washington DC: Government Printing Office.

Ye, L. (2002) "Indicative Bidding," mimeo, Ohio State University.

Appendix: Proof of Proposition 1

It is easy to see that $u_B(y,\tau;T,N)$ exhibits increasing differences in (y,T), $(-\tau,T)$ and $(-\tau,y)$ since

$$\frac{\partial u_B(0,\tau;T,N)}{\partial \tau} - \frac{\partial u_B(1,\tau;T,N)}{\partial \tau} = \underline{v}(1) - \underline{v}(0) > 0\,.$$

$\frac{\partial u_B(y,\tau;T,N)}{\partial T}$ is constant in y, and $\frac{\partial^2 u_B(y,\tau;T,N)}{\partial T \partial \tau} = -\frac{\partial^2 d(\tau,T)}{\partial T \partial \tau} < 0$. Similarly, $u_B(y,\tau;T,N)$ exhibits increasing differences in $(N,-y)$ since $u_B(0,\tau;T,N) - u_B(1,\tau;T,N)$ is increasing in N by condition (1). Finally, $\frac{\partial u_B(y,\tau;T,N)}{\partial \tau}$ is constant in N. $Q.E.D.$

Tables

Table 2.1: Changes as a Percent of Total Contract Price

Report	< 2.0%	2-5%	5-10%	10-15%	> 15%	Reduction
A.	44.5	31.0	13.9	3.4	4.2	3.0
B.	48.2	16.8	11.6	3.4	20.0	
C.	50.0	40.5		9.5		
D.	11.6	19.0	45.5	4.4	6.9	12.6

Table 2.2: The Frequency and Sources of Changes.

Cause	A	B	C	D	E	F
Defective Plans and Specifications	44.5	42.9	55.6	10.7	50.0	39.0
Changes in scope	44.7	13.5		44.8	40.4	17.0
Differing Site Conditions	74.0	14.3	19.9	20.7		15.0
Schedule Delays		12.7	16.1	7.0	26.9	
Value Engineering						4.0
Substitutions	29.1					
Others		16.7	8.5	16.8		13.0

Table 2.3: FP versus C+ contracts in Construction

	Fixed Price	Cost plus
risk allocation mainly on	contractor	buyer
incentives for quality	less	more
buyer administration	less	more
good at minimizing	costs	time
documentation efforts	more	less
flexibility for change	less	more
adversarial relationship	more	less

Table 4.1: Summary Statistics.

Variable	No. of Obs	Mean	Std. Dev.	Min	Max
Project Value	4085	9,506,236	3.60e+07	10,000	8.00e+08
Floor Area (sq.ft)	3030	187,894	2,750,522	300	9.00e+07
Floors above ground	4086	1.77	3.4	0.00	48.00
Parking spaces	4087	18.67	129.0	0.00	3,600

Table 4.2: Breakdown of Award Methods

Variable	No.of Obs. (Private Sect.)	Percentage (PrivateSect.)	No.of Obs. (Public Sect.)	Percentage (Public Sect.)
Invited Bidders	1,522	37.2	42	0.2
Prequalified Bids	44	1.1	394	1.8
Open Bidding	752	18.4	20,865	97
Negotiated	1,769	43.3	210	1
Total	4,087	100	21,511	100

Table 4.3: Distribution of firms by No. of jobs done, all jobs

No. of jobs done by firm	Number	Frequency %	Cum %
1	757	59.3	59.3
2-5	387	30.3	89.6
6-10	83	6.5	96.1
11-20	37	2.9	99.0
> 20	13	1.0	100

Table 5.1: Logistic regressions of award mechanism (negotiation =1) **on project and owner (buyer) characteristics**
(standard errors in parentheses)

lprojval	.1234	.3062	.3056	.1990	.2886
	(.0396)*	(.1039)*	(.1111)*	(.1216)	(.1131)*
lflarea	.1952	.3395	.3766	.6376	.3974
	(.0422)*	(.1099)*	(.1193)*	(.1385)*	(.1215)*
divsum		.0934	.1016	.1146	.0925
		(.0323)*	(.0345)*	(0.0412)*	(.0355)*
expowncum	−.2588	−.6862	−.3826	−.1579	−.4984
	(.0754)*	(.1715)*	(.1869)*	(.2289)	(.1954)*
creditown			−.1026	−.2182	−.0772
			(.0379)*	(.0640)*	(.0394)*
sizeown				−.00185	
				(.00057)*	
chydiff					.0437
					(.0220)*
Sample size	**3030**	**682**	**605**	**445**	**564**

Table 5.2: Ordered logistic regression for award mechanism
(Open Bidding=1, Invited Bidders=2, Negotiation=3)
(standard errors in parentheses)

lprojval	.1257	.1539	.1959	.2450	.2437	.2339	.2176
	(.0417)*	(.0464)*	(.0906)*	(.0885)*	(.0944)*	(.1086)*	(.0973)*
lflarea	.1816	.1857	.3771	.3906	.4245	.5484	.4609
	(.0434)*	(.0473)*	(.0926)*	(.0933)*	(.1004)*	(.1128)*	(.1043)*
divsum				.0774	.0842	.0940	.0825
				(.0316)*	(.0338)*	(.0400)*	(.0349)*
expowncum	-.1228	-.1473	-.0157	-.4490	-.1256	-.0506	-.2660
	(.0718)	(.0830)	(.1666)	(.1643)*	(.1801)	(.2156)	(.1886)
creditown		-.0776	-.1550		-.1094	-.2738	-.0798
		(.0164)*	(.0439)*		(.0359)*	(.0626)*	(.0373)*
sizeown			-.0002			-.0001	
			(.00008)*			(.0002)	
chydiff							.0427
							(.0194)*
Sample size	3004	2598	942	677	600	441	559

Table 5.3: Logistic regression of Builder experience on Project Value and Award Dummies
(standard errors in parentheses)

	expbuild	**expbuild**	**expbuildcum**	**expbuildcum**
lprojval	.0280	−.2102	.0430	−.1969
	(.0397)	(.1043)*	(.0386)	(.1038)
lflarea	−.0309	.1766	−.0135	.1919
	(.0425)	(.1060)	(.0413)	(.1072)
divsum		−.0394		−.0580
		(.0315)		(.0326)
expowncum	.7526	.1332	.7085	.1439
	(.0832)*	(.1774)	(.0840)*	(.1825)
Invited Bids	1.140	1.205	.8967	1.086
	(.1770)*	(.3812)*	(.1855)*	(.4011)*
Prequalif.	1.344	1.402	.9455	
	(.4227)*	(.9451)*	(.4425)*	
Negotiation	2.364	1.979	2.050	1.761
	(.1764)*	(.3836)*	(.1828)*	(.4020)*
Sample size	**3030**	**682**	**3030**	**677**

Table 5.4: Regression of Number of Bids Received on Project Value and Year Dummies
(standard errors in parentheses)

	bidsrec (private)	bidsrec (private)	bidsrec (public)	bidsrec (public)
lprojval	.1903		.2810	
	(.0751)*		(.0294)*	
1997-8	−.8534	−.8406	−.5875	−.5834
	(.2235)*	(.2268)*	(.0755)*	(.0761)*
1999	−1.039	−1.015	−.6455	−.6392
	(.3301)*	(.3371)*	(.0911)*	(.0917)*
2000-1				
lpil		.3513		.3522
		(.1483)*		(.0326)*
lpim		.3149		.3466
		(.1318)*		(.0280)*
lpih		.3138		.3143
		(.1212)*		(.0306)*
Sample size	**306**	**306**	10,703	10,703

Table 5.5: Award Method over Time (Private Sector Only)

Year	1995	1995-6	1997	1998	1999	2000-1
Invited Bidders	45.5%	47.5%	47.2%	43.1%	40.8%	41.4%
Negotiated	36.4%	39.6%	41.4%	46.3%	48.0%	40.0%
Open Competitive Bidding	18.1%	11.8%	10.7%	9.1%	10.5%	16.6%
Prequalified Bidders	0.0%	1.1%	0.7%	1.5%	0.6%	2.0%
Number of obs.	11	442	439	518	475	467

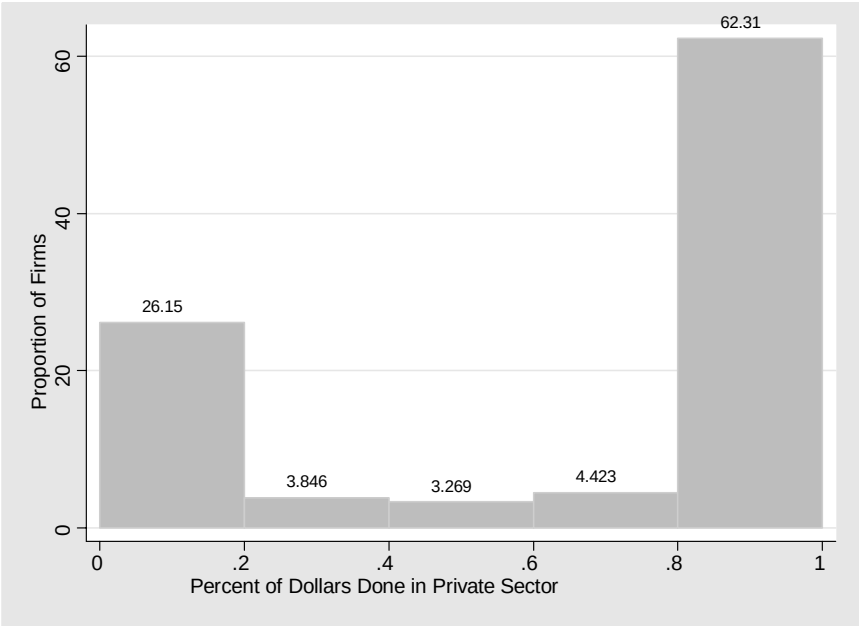

Figure 5.1: Fraction of work (in dollar value) done in the private sector for firms with more than one job.

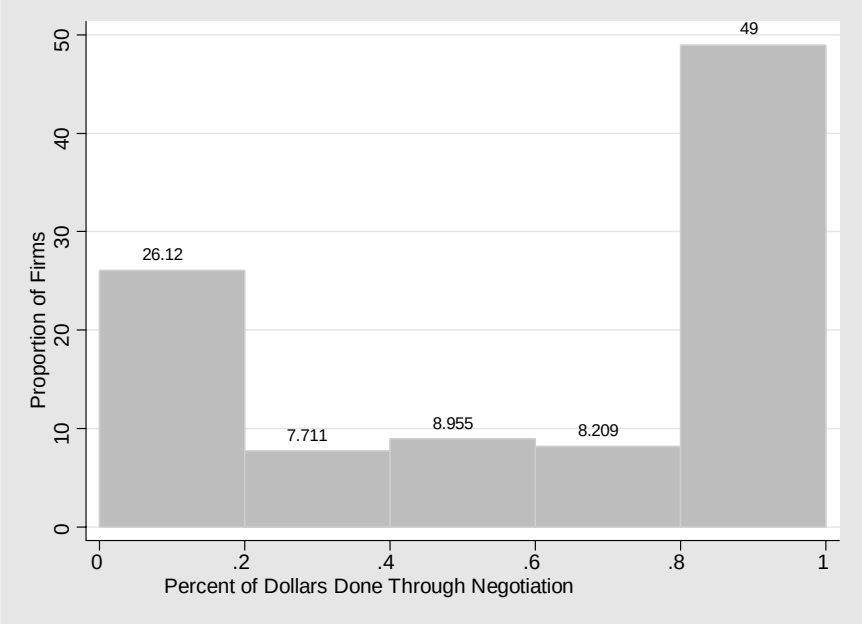

Figure 5.2: Fraction of work (in dollar value) that is negotiated in the private sector for firms with more than one job.