CONTRACTING IN THE SHADOW OF THE LAW

SURAJEET CHAKRAVARTY AND W. BENTLEY MACLEOD

ABSTRACT. Economic models of contract typically assume that courts enforce obligations on the basis of verifiable events. As a matter of law, this is not the case. This leaves open the question of optimal contract design given the available remedies that are enforced by a court of law. This paper shows that standard form construction contracts can be viewed as an optimal solution to this problem. It is shown that a central feature of construction contracts is the inclusion of governance covenants that shape the scope of authority, and regulate the *ex post* bargaining power of parties. Our model also provides a unified framework for the study of the legal remedies of mistake, impossibility and the doctrine limiting damages for unforeseen events developed in the case of Hadley vs. Baxendale.

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And other things of this sort should be known to architects, so that, before they begin upon buildings, they may be careful not to leave disputed points for the householders to settle after the works are finished, and so that in drawing up contracts the interests of both employer and contractor may be wisely safe-guarded. For if a contract is skillfully drawn, each may obtain a release from the other without disadvantage.

Vitruvius, "Ten Books on Architecture" , Chapter 1, Book 1, circa 1st Century B.C.

1. Introduction

Economic models of contract typically assume that courts enforce obligations that are a function of verifiable events. Yet, as first year students of contract law know, there are many examples of cases where the courts do not enforce well defined contractual obligations. This leads naturally to the question of how legal constraints affect the form and structure of observed contracts.[1] In this paper we show that the American Institute of Architects (AIA) form construction contracts can be viewed as an *efficient* solution to the problem of completing a large, complex building project at the lowest cost given current legal institutions. This question is of intrinsic economic interest because these form contracts are responsible for regulating billions of dollars of resources in the United States. Moreover, many of the features of the AIA form contracts are also found in form construction contracts used worldwide.[2] Second, we show that efficiency is achieved with a contract that uses available legal instruments to appropriately allocate bargaining power between the buyer and the seller. Finally, we use our model to provide a general rule for optimal contract damages that includes expectation damages and the doctrines of mistake and impossibility as special cases.

It is well known that contracts for complex projects, such as construction, are necessarily incomplete because it is impossible to specify in detail performance for all possible contingencies.[3] The early literature on incomplete contracts, including Rogerson (1984), Grout (1984), Hart and Moore (1988) and Tirole (1986), has shown that the need to renegotiate an incomplete contract can make it impossible to provide incentives for efficient relationship specific investment.[4] A key feature of these models is the assumption that the bargaining power of parties is exogenous during *ex post*

[1]Mnookin and Kornhauser (1979) describe the role played by the law in constraining negotiation. In their case, they focus upon divorce agreements.

[2]See Odams (1995) for a collection of papers that compare building contracts in various jurisdictions.

[3]Williamson (1975) explicitly makes this point. He discusses informally the problems that arise due to opportunistic behavior when there is idiosyncratic exchange between a buyer and seller.

[4]See Che and Hausch (1999) for a general formulation of this result.

renegotiation, while the contract determines the default payoffs of parties, should renegotiation be unsuccessful.

However, there are many ways that parties may use contracts to manipulate the default payoffs to achieve efficient trade. MacLeod and Malcomson (1993) consider the case in which risk neutral parties, at some cost, are able to buy or sell the goods they are trading on an open market. When the market acts as an outside option in the sense of Shaked and Sutton (1984), then this ensures that parties cannot receive payoffs that are worth less than their market values. More importantly, it also ensures that the parties cannot use the outside option as a threat to obtain *more* than their market valuation. MacLeod and Malcomson (1993) show this implies that prices are rigid and renegotiated if and only if an outside option is binding, and that in turn ensures efficient incentives for relationship specific investment in a variety of trading situations.

In the case of risk averse buyers and sellers Chung (1991) and Aghion et al. (1994) have shown that if the courts use the legal remedy of *specific performance* for breach of contract, then it is possible to design a contract that achieves the first best. By specific performance one means that the courts assess damages to any party who breaches that are larger than any possible gain from contract breach. This ensures that no party would ever voluntarily choose to breach an agreement.

As a matter of law the courts do not routinely use specific performance when adjudicating a commercial contract. A good example is the famous case of Jacob & Youngs Inc. v. George E. Kent.[5] In this case Kent hired Jacob & Youngs to build a house, and in the building contract specified the brand of wrought iron water pipe to be used (Reading Co.). After the pipe had been installed and encased in the walls Kent learned that some of the pipe was of a different brand, and he then refused to make the final payment of $3,483.46 to Jacob & Youngs. The contractor Jacob & Youngs sued Kent for the final amount owed.

At the trial, Jacob & Youngs were barred from submitting evidence that the pipe installed was equivalent in quality to the one in the contract. In fact, Kent's architect was on site as the pipe was being installed, and did not notice the substitution. Hence, the substitution was not an opportunistic action by the contractor to reduce costs, but rather an error that had little impact upon the final quality of the house. The trial judge ruled against Jacob & Youngs, saying that he had clearly not performed as specified in the contract, and therefore Kent was under no obligation to make the final payment until Jacob & Youngs installed the pipes as required in the contract.

[5]Jacob & Youngs Inc. v. George E. Kent, 230 N.Y. 239, N.Y., 1921.

Jacob & Youngs appealed the decision based upon the fact that they were barred from submitting evidence regarding the quality of the installed pipe. The appellate court overruled the trial court decision, with Judge Cardozo writing the majority decision. He argued that the lower courts were in error, and that since the difference between the actual performance and that required in the contract is trivially small, the seller is deemed to have performed, and Kent has an obligation to make the final payment. In this case the courts are applying the remedy of *expectation damages,* namely a measure of the loss arising from the breach of contract.[6] In this case the loss in value was so small, that the courts ordered Kent to make the final payment required under the contract.

At the time, the decision was very controversial because the contract specified that Kent would not have to make the final payment until the project was completed as specified in the plans for the house. In the view of Judge McLaughlin, who wrote the dissenting opinion, this rule would in the future undermine the ability of individuals to write binding agreements, a viewed echoed in the work of modern legal scholars, such as Alan Schwartz (1979). Whether or not one agrees with the courts, this ruling implies that economic models of contract that rely upon the enforcement of specific performance by the courts cannot explain *observed* contracts. Parties with rational expectations regarding the behavior of the courts should design contracts taking into account how the courts actually behave, and not how they should or might behave.

Inattention to the role of the law may partially explain why, as Maskin and Tirole (1999) have observed, there is a distance between the predictions of contract theory and observed contract forms. In this paper, we introduce a model of the procurement process that explicitly takes as given that the standard common law remedy for contract breach is expectation damages - a court determined measure of the loss suffered by the plaintiff. We shall show that the optimal procurement contract, given this legal constraint, is not only consistent with the main features of the AIA form contracts, but can implement the project at the lowest, feasible, *ex ante* cost.

The agenda of the paper is as follows. In section 2 we introduce a model of complex procurement that builds upon Bajari and Tadelis (2001)'s insight that one can endogenize contract completeness by supposing that planning for the future is a relationship specific investment.[7] We suppose that

[6] This definition is unfortunately vague. In practice, the determination of expectations damages is quite complex, and can entail the hiring of expert witnesses, such as economists, to create measures of lost value. See Fuller, L. L. and Perdue, William R., Jr. (1936) for a classic discussion of the issue. In the context of the model, the concept is well defined in terms of the monetized value of utility loss when there is breach.

[7] Important early models include Tirole (1986) and Hart and Moore (1988).

the preferences of the buyer are observed by neither the seller nor the courts. Incomplete planning is modeled as a shock to buyer preferences during contract execution, that in turn require the renegotiation of the project's design. In addition, we allow for relationship specific investment by the seller into cost reduction, and show that there is a trade-off between the cost of production and allowing for *ex post* flexibility in design. Finally, we characterize the efficient allocation.

The problem of implementing the efficient allocation in the shadow of the law is addressed in section 3. We show that the efficient contract is constructed from a set of *contractual instruments*.[8] These correspond to specific terms in the form construction contracts sold by the American Institute of Architects (AIA), each of which is legally binding and enforceable in US courts. Together these instruments ensure the project is completed at the lowest cost. The AIA published the first set of form contracts in 1888, and since then has continually improved these contracts in the light of both technical developments in the construction industry, and legal developments arising from court decisions involving construction disputes.[9]

The study of these contracts provides two useful lessons. First, these forms have systematically been modified in the light of experience with adjudication, hence they are examples of contracts that are *enforceable* under U.S. law. Second, they are relatively *complete*, in the sense that they explicitly provide for a process of adjudication should there be a dispute, regardless of the circumstances.

Early work on incomplete contracts, beginning with Williamson (1975) and later Anderlini and Felli (1994), observes that it is not possible to write a complete contract due to the sheer number of possible future contingencies. MacLeod (2002) explores the role that norms and informal enforcement can play in regulating incomplete contracts in this case. However, informal enforcement cannot regulate disputes that involve high stakes. The solution that the AIA has discovered relies upon carefully allocating authority over *ex post* modifications to the buyer or the seller that depend upon the nature of the task in question.[10] This can be done in a way that greatly reduces the number of situations in which the courts may be asked to intervene.

This practice is consistent with recent theoretical developments by Chung (1991) and Aghion et al. (1994). They demonstrate that the appropriate allocation of authority at the final stage of

[8]The concept of a contractual instrument is developed in the on going work of W. B. MacLeod and L. Kornhauser.
[9]The AIA publishes compendiums of courts cases, along with a discussion of their implications for contract adjudication (see Stein (2001)).
[10]There are several form contracts. The main contract or *keystone* contract is form A201-1997 that deals with the regulation of the relationship during construction. Below we discuss some of the other forms.

a relationship can ensure the implementation of an efficient allocation. Using the AIA contracts as a guide, we extend this result to more general model of Bajari and Tadelis (2001) to show that the efficient project is implemented by a contract that carefully structures control rights *ex ante,* before the contract is signed, at the *interim stage,* while production is in progress, and at the final, *ex post* stage. In section 3 we derive this contract, and show how each contractual instrument in the complete contract relates to specific features of the AIA form contracts.

In practice, parties are free to write any contract they wish. Given the complexity of writing an optimal contract, this implies that many contracts are poorly drafted and not enforceable as written. In these cases, the courts may be asked to intervene and to supply the terms missing from the agreement. Beginning with Goetz and Scott (1977), the modern view on legal default rules is that courts should use defaults that would be part of an optimal contract had the parties received the appropriate advice during contract formation. This is consistent with Posner (2003)'s view that one can understand the evolution of law as evolving rules that provide an efficient solution to the cases brought before the courts.

Section 4 discusses the implications of our results for the structure of legal defaults. We show that the decision in the controversial case of Jacob & Youngs v. Kent is consistent with optimal contract design. We also discuss the famous case of Peevyhouse v. Garland Coal Co.[11], where Garland Coal breached its obligation to grade a farmer's land at the cessation of operations for a strip mine.

In this case, the courts awarded the Peevyhouses the diminution in value to the land ($300) resulting from leaving the land ungraded compared to having the land graded. Under a rule of specific performance, the courts would have awarded the cost of grading ($29,000). Observe that grading land is an engineering project, and hence is covered by forms that are similar to the AIA forms.[12] Here we discuss how the AIA form contracts could have been used to achieve performance in this case. This case illustrates the point that parties do in practice may write contracts that are neither efficient nor enforceable.

The implications of our analysis, and the contributions to the literature are discussed in the final section of the paper. We conclude by observing that our results are consistent with the hypothesis that the American Institute of Architects form construction contracts have evolved over the last

[11]Peevyhouse v. Garland Coal & Mining Co., 382 P.2d 109, 114 (Okla.1962)

[12]The National Society of Professional Engineers also sell their own form contracts, similar in structure to the AIA forms, but tailored to the needs of engineering projects such as roads and bridges. The provision we cite in the AIA forms would also be present in these contracts.

hundred years to provide an efficient solution to the problem of procuring a complex good, such as large a building.

2. A Model of Procurement

This section introduces a model of procurement that captures several of the salient features of complex real world procurement. When complete contracts are possible and enforceable then contract theory has little to say regarding the form of observed contracts. This is because many different contract forms can implement the same efficient allocation. For example, suppose a seller agrees to supply a good at a price P. If all contracts can be enforced then one may pay an amount P_1 in advance, and P_2 upon delivery. The distribution of payments is indeterminate and all one can say is that $P_1 + P_2 = P$.

This simple example illustrates the important point that the economic theory alone cannot explain all of the observed features of a contract. In order to have a theory with some empirical bite, one needs to introduce some specific market imperfections, and then show how the theory restricts the set of observed contract forms in these cases. Our model has a number of specific market imperfections that have been identified as important in the procurement process. In this section we derive the optimal allocation taking these imperfections as given.

We have selected the smallest set of market imperfections or transaction costs that are sufficient to explain the main features of the AIA form contracts. Each of these costs have been studied in the contract theory literature, but for the most part in isolation from other transaction costs. Together these transaction costs can help explain the design of the AIA form contracts - why they are built up from a set of contractual instruments, and how each instrument is designed to achieve very specific allocative goals.

More precisely, our model supposes that both the buyer and the potential sellers are risk neutral. The project is assumed to require significant relationship specific investment by both parties, and therefore a contract is required to protect and promote these investments.[13] The details of the economic environment are as follows:

[13]See Klein et al. (1978) for a discussion of why contracts are needed in the presence of relationship specific investment. See also Hart and Moore (1988).

(1) The preference ordering of the buyer over project characteristics is private information. Hence, the buyer must be induced to voluntarily reveal her most preferred project given the cost.

(2) Investment into planning by the buyer is assumed to be observable by the potential sellers, but not contractible. Bajari and Tadelis (2001) observe that project design provides a concrete example of a relationship specific investment that is observable by both parties *ex post,* but cannot be explicitly contracted upon (Grossman and Hart (1986)). It is well known in the construction industry that contractors use information on the quality of project design when setting their bids.[14]

(3) Following Laffont and Tirole (1986) it is assumed that the *ex post* cost of production is observed, but not the *ex ante* investment by the seller into cost reduction.

(4) The project is *complex,* in the sense that it is built up from a set of components, such as the foundations of a building, the window frames, the roof, electrical system and so on. This complexity implies the design is incomplete in two dimensions. First, it may be necessary to change the specifications of a component *ex post.* Second, the buyer may wish to add components or elements to the project that were not anticipated at the time the contract was signed.

Providing a precise definition of complexity is difficult, and certainly controversial. Here we follow the literature and use the notion of complexity in two senses. The first notion is due to Bajari and Tadelis (2001). Their insight is to recognize that investment in design affects the probability that the buyer will desire a change to the specifications of a project component. For example, one might realize that a paint color does not look quite right once applied, and hence the buyer may request a change. The key feature of the Bajari and Tadelis (2001) model is that the likelihood that the design will be changed is anticipated by the seller, hence the seller can take these risks into account when bidding for a project.

A project may also be complex because the buyer may require the addition of components to the project that were unforeseen at the time of the design. For example, in the case of the Getty Museum in Los Angeles, the Northridge earthquake occurred during construction. From this event the builders learned that they had to make substantial changes to the structure. Given that earthquakes

[14] We thank George Lefcoe for pointing this out to us.

are common to Los Angeles, this event was not unforeseen. The real issue is that it is costly to learn the detailed consequences of such an event. In this case, what was unforeseen is the incompleteness of their knowledge regarding the effect of an earthquake upon the existing structure. The engineers believed that their planning was adequate until the earthquake occurred. So, an event occurred that resulted in further *learning* regarding the best plan. Accordingly, we explicitly model unforeseen events as a form of learning regarding one's true preferences over project specifications.

Given that both the buyer and seller have made relationship specific investments, it is cheaper to have the current seller carry out unforeseen modifications. However, due to the asymmetric information that may exist between the buyer and seller, this may lead to inefficient *ex post* renegotiation. *Ex ante* there are such a large number of possible events that may require renegotiation that it is not worthwhile to provide a contingency plan for each one of these events. This leads to what MacLeod (2002) calls *ex post holdup.*

Ex ante hold-up, as modeled by Grout (1984) and Bajari and Tadelis (2001), arises from the fact that the parties may share in the rents from decisions taken *ex ante.* In our model investments in planning and cost reduction both face the hazard of *ex ante holdup.* In contrast, *ex post holdup* arises from unexpected rents that are created *ex post* through any unexpected need to change the specifications of the project *ex post.* Such an unexpected need creates inefficiencies when there is private information regarding the value of the change. A contract can lower these costs through the appropriate design of the contract renegotiation process.

The next section contains the formal description of the model. The procurement process is divided into three major stages, *ex ante, interim* and *ex post.* The *ex ante* stage encompasses the initial planning of the project and the selection of a suitable seller. The *interim* stage consists of a sequence of actions by the seller to carry out the construction of the project, while the *ex post* stage entails the final settling up of payments, including possible litigation. Subsection 2.2 provides a characterization of the optimal allocation subject to the informational constraints of the environment.

2.1. **The Procurement Process.**

Ex Ante Stage. This stage consists of two steps. First, the buyer invests in project design by hiring an architect or engineer. Next, she designs a contract and procedure for selecting a seller from a set of potential sellers. In this section we describe the basic features of the project that are common knowledge to both the buyer and the seller at the time a procurement contract is signed.

The project, whether it is a building, a bridge, or a weapons systems, is built from a set of components, each of which have a well defined specification. Let $T = \{1, ..., N\}$ denote the set of possible components, where t is a typical component. This might be a type of door, along with a specification of the type of wood to be used and the finish. However, there is always some uncertainty regarding design. For example, a building project might specify door handles, but fail to specify the model or color.[15]

In other cases, the buyer may acquire information that leads her to change the specification of a project component after the contract is signed. For example, the design may call for a dividing wall to be in a given location. Upon inspection of the ongoing work the buyer may realize this was a mistake, and ask for a change. Or the cost of a particular material increases in an unexpected manner. In that case the seller may request for the right to use a less expensive material.

Another example is the Getty Museum in Los Angeles that suffered a major earthquake during construction. This unanticipated event resulted in major design changes, the cost of which were born by the Getty Trust. Given that earthquakes are very common in Los Angeles, the event itself was certainly foreseeable. It was the myriad consequences for the design of the building that were unforeseen. This point illustrates that even with a well financed project with good designers, planning is likely to be incomplete.

Finally, the buyer may decide to add components to the project that were not foreseen at the time the contract was signed. In principle, the new components could be viewed as a new project requiring a new auction to select a potential supplier. However, given that the incumbent supplier has already sunk costs into the construction process, it is likely more efficient for him to build the additional components. If so, then the use of an auction to set the price is likely to be inefficient.

This is because the market price would include both the marginal costs of adding the components, and the fixed costs of bringing in a new supplier. For this reason, an efficient contract should include contractual instruments that regulate the price for any new component that is added to the project.

More formally, we suppose that the buyer and seller pay fixed costs $A^B, A_i^S > 0$ to implement the project. For simplicity, the subsequent costs and benefits from the project are assumed to be

[15]This example came from a discussion with a building contractor.

additive by component. This allows considerable simplification of the model. In this case contractual instruments can be tailored to specific components or groups of components, and then simply added on to the contract. Thus, without loss of generality, we suppose that the initial design consists of a single component t^C. This is the initial scope of the project. In addition, after the planning period, the buyer may learn that she wishes to add an additional unforeseen component t^U. Given that this is taken from a potentially large set, there are no explicit contract terms for this component. Rather, the contract specifies a mechanism or renegotiation procedure that is to be followed for the addition of such unforeseen contingencies.

Hence, the initial planning stage is concerned only with the foreseen component t^C. Both parties recognize that the specifications determining the characteristics of the component may change after the fact. We denote the implemented foreseen component by $q \in \{0, 1\}$, where $q = 1$ denotes that the component is executed as originally designed, while $q = 0$ denotes a change in the original design. Changes in the design can occur as a result of shocks to the buyer's preferences or due to the realized cost of implementation. These shocks are observed after the seller has made relation specific investments, but before the project is implemented. The shock to buyer's preferences is denoted by $z \in \{0, 1\}$, where $z = 1$ means the original design is preferred, while $z = 0$ implies that the buyer would like to change the specification of the component. The buyer's payoff from this component is $u(q, z)$. The cost of implementing the specified design is detailed in the next section.

The likelihood of a design change *ex post* is a function of the buyer's investment into design, given by $d \geq 0$. The probability that $z = 1$ is given by $\rho(d)$. It is assumed that in the absence of any planning there is a 50% chance the buyer will change her mind ($\rho(0) = 1/2$), while an increased investment into planning reduces the likelihood of a design change - formally, $\rho' > 0$, $\rho'' < 0$ and $lim_{d \to \infty} \rho(d) = 1$. It is assumed that the sellers can observe d before a contract is signed.

In addition, at the time the contract is written, the buyer anticipates that she may wish to add a component t^u to the project, though both the nature and value of the component are unknown *ex ante*.[16] She will learn both the nature of the component and its utility, u^u, during the period of project implementation. The seller cannot observe u^u. Let $q^u = 1$ if an unforeseen component is added to the project, and $q^u = 0$ otherwise.

[16] One could put this into a more formal Bayesian framework with a large space of possible components, all having equal *ex ante* probability of being added. When this space is sufficiently large, there is no benefit from adding conditions for specific components. See MacLeod (2002) and Segal (1999) for formal models of this effect.

Potential sellers, upon observing d and the conditions of the procurement contract, make production plans and bid for the right to carry out the project using the selection mechanism designed by the buyer. Let $A_i^S > 0$ be each seller i's fixed cost of production, $i = 1, 2, ...$ This fixed cost is the only source of variation between sellers. Moreover, it is assumed that *ex ante* these costs are independently distributed across sellers and unobserved to the buyer, and satisfy the regularity condition of Myerson (1981). This ensures that a Vickrey auction with a reserve price is the efficient mechanism for choosing a seller.[17]

Interim Stage. During the interim stage the selected seller prepares for the execution of the project by making investments into cost reduction. First the costs of production and the buyer's preferences are realized. Then, if necessary, the project design is renegotiated, with the appropriate modifications to the price using the procedures given by the contract. Finally, the project is completed.

The cost c of completing a foreseen component takes on one of two values: $c \in \{c_L, c_H\}$, where $c_H > c_L$. The probability that the low cost, c_L, is realized is determined by the seller's pre-production effort: $e \geq 0$. This probability is given by $\rho(e) \in (\frac{1}{2}, 1)$. For simplicity this is the same function as for the buyer's planning costs. This latter assumption saves on notation and can easily be relaxed. Should the parties agree to have the design changed ($q = 0$) then the expected cost is assumed to be $\hat{c} = (c_H + c_L)/2$. Let $\triangle c = c_H - \hat{c} = \hat{c} - c_L$ parametrize the size of the potential costs savings arising from the efforts of the seller.

At the same time, the buyer realizes her preference shock $z \in \{0, 1\}$. In addition, the buyer may realize a value, u^u, and a cost, c^u, for the unforeseen component that are independent of other parameters of the model. Thus the *state* of the project just before it is realized is given by $\omega = \{z, c, u^u, c^u\}$. Recall that both z and u^u are assumed to be unobserved by the seller and the courts. If necessary, the contract terms are renegotiated, and the project $Q = \{q, q^u\}$ is realized.

Ex Post Stage. This is the final settling up stage. In the absence of a pecuniary transfer the payoffs to the buyer and seller given the state, ω, and the realized project, $Q(\omega)$, are:

$$U^B(\omega, Q, d, e) = u(q, z) + q^u u^u - d - A^B,$$

[17]See page 66, expression 5.1 of Myerson (1981). In addition to assuming the distribution of values are independent, the regularity adds a monotonicity condition that ensures the existence of an efficient solutions under a Vickrey auction.

$$U_i^S(\omega, Q, d, e) = -\hat{c} - q\{c - \hat{c}\} - q^u c^u - e - A_i^S.$$

The contract terms, including any renegotiated price, determine the monetary transfer between the buyer and the seller. In addition, if there has been a lawsuit then it may result in additional payments between parties that are determined at this time. Let P denote the net transfer; then the exchange concludes with the buyer and seller realizing their final payoffs $U^B(\omega, Q, d, e) - P$ and $U_i^S(\omega, Q, d, e) + P$ respectively.

2.2. **The Efficient Allocation.** An efficient allocation is a choice of seller, a set of investment levels, and a design plan, denoted $\pi = \{i, Q(\omega), e, d\}$, where $\pi \in \Pi$ is the set of feasible allocations, that maximize the social surplus:

$$E\{S_i(\omega, Q(\omega), d, e)\} = E\left\{U^B(\omega, d) + U_i^S(\omega, e)\right\}.$$

Let us assume that the preferences of the buyer (z and u^u) are observable. Given that there are a finite number of potential sellers and that the probability function $\rho(.)$ is continuous, it is straightforward to show that an efficient solution exists. The remainder of this section characterizes this optimal solution as a function of model parameters and provides some comparative static results. We also show how the efficient project design $Q^*(\omega)$ can be implemented under the assumption that the buyer's preferences are not observed.

Unforeseen Components. Consider first the implementation of unforeseen components. Even though both the buyer and the seller engage in planning, it is not possible to anticipate every need. An unforeseen component is one for which neither the buyer nor the seller have done any planning. Rather, during the *interim* stage the buyer learns that she would like to add an extra component with value u^u. Under the assumption that costs are observable, the buyer can ask the seller to produce a binding estimate c for the cost of the component. It is efficient to add this component to the project ($q^{u*}(\omega) = 1$) if and only if $u^u \geq c^u$.

Foreseen Components. Consider now the design decision. Given the preference shock z, it is efficient to keep the original design if and only if :

(1) $$u(1, z) - u(0, z) \geq c - \hat{c}.$$

The cost difference satisfies $c - \hat{c} = \pm\Delta c$ depending upon whether the realized costs are either high or low. Let $\Delta u_0 = u(0,0) - u(1,0) > 0$ and $\Delta u_1 = u(1,1) - u(0,1) > 0$ denote the gains to the buyer from choosing the best design given her preference shock z. The analysis is significantly simplified if we suppose that the marginal gain from altering the design is independent of z and we let:

$$\Delta u = \Delta u_1 = \Delta u_0 > 0.$$

The optimal design is now a function of the parameter $\beta = \{\Delta c, \Delta u\}$ and is fully characterized by two cases:

1. If $\Delta u \geq \Delta c$, then the foreseen component is *buyer biased* and the optimal design satisfies:

$$q^*(\omega) = \begin{cases} 1 & if\, z = 1, \\ 0 & if\, z = 0. \end{cases}$$

2. If $\Delta u < \Delta c$ then the foreseen component is *seller biased* and the optimal design satisfies:

$$q^*(\omega) = \begin{cases} 1 & if\, c = c_L, \\ 0 & if\, c = c_H. \end{cases}$$

Observe that a simple governance structure can ensure *ex post* efficiency, even in the presence of asymmetric information. Suppose that the price does not vary with the choice of design. In that case efficient design can be implemented by giving the control right over the choice of q to the buyer when a component is buyer biased, and to the seller when it is a seller biased component. This mechanism ensures *ex post* efficiency, however, this does not necessarily lead to *ex ante* efficient investment. We now characterize the optimal investment into planning and cost reduction as a function of the characteristics of the foreseen component.

Buyer Biased Foreseen Components. Under the assumption that the efficient project is always implemented, the social surplus from a buyer biased component ($\Delta u \geq \Delta c$) as a function of design d and effort e is:[18]

(2) $$S_B(d,e) = u(0,0) - \hat{c} + (F(d)+1)\left(u(1,1) - u(0,0) + F(e)\Delta c\right)/2 - d - e.$$

[18]This is derived using the expected *ex post* gains from trade:

$$\rho(d)\left\{\rho(e)(u_{11} - c_L) + (1-\rho(e))(u_{11} - c_H)\right\} + (1-\rho(d))(u_{00} - \hat{c}).$$

where $F(x) = (2\rho(x) - 1)$ is a measure of the *foreseeability.* When $x = 0$ then $F(x) = 0$, corresponding to an unforeseeable outcome - $z = 0$ and $z = 1$ are equally likely. As x increases then $F(x)$ approaches 1, and which design will be efficient is more predictable.

By assumption, the foreseeability function is strictly concave, and hence if it is efficient to have some planning the unique investment levels are uniquely characterized by:

$$F'(d^*) = \frac{2}{uu + F(e^*)\Delta c}, \tag{3}$$

$$F'(e^*) = \frac{2}{(F(d^*) + 1)\Delta c}, \tag{4}$$

where $uu = u(1,1) - u(0,0)$ is the difference in utility at the two most preferred designs. Namely, the difference between the utility when they prefer no design change, and this is implemented, and if they wish a design change and this is implemented. Ex ante we might expect this difference to be relatively small.

Notice that investment in planning and in cost reduction are *complements* - an increase in planning, d, increases the benefit from investing in cost reduction and vice-verso. Let $m = F'(0) > 0$ be the marginal impact of planning upon foreseeability at zero investment.

Suppose that $\frac{2}{uu} > m$ (planning gain is small enough), then, when the cost savings, Δc, are sufficiently small it is efficient to engage in no planning and make no effort into cost reduction. Conversely, for large enough cost savings, it is efficient to plan, $d^*, e^* > 0$. Finally, planning is increasing in Δc until $\Delta c = \Delta u$. These results are summarized in the following proposition:

Proposition 1. *Suppose* $\Delta u \geq \Delta c$ and $\frac{2}{uu} > m > \frac{2}{\Delta c}$, *then optimal cost reducing effort,* e^*, *is strictly positive, while optimal planning,* d^*, *is zero. Keeping the benefit to planning,* Δu, *fixed, increasing costs,* Δc, *results in increased effort* e^*. *Planning is strictly positive if and in only if* $\frac{2}{uu+F(e^*)\Delta c} > m$. *In that case, an increase in* Δc *leads to an increase in planning.*

The condition that uu be small implies that *ex ante* there are a number of designs that are acceptable. What is expensive is to have a divergence between the implement design, and the desired design. This corresponds to a large value for Δu relative to changes in costs, Δc. An increase in Δc increases the benefit from planning and cost reducing effort, up to the point that the effect of costs overwhelm the consequence of a design change. When $\Delta c > \Delta u$, one is in a situation for which it is always efficient to modify the design in the case of an adverse cost shock. Components with this property are called *seller biased components.*

Seller Biased Components. For a seller biased ($\Delta c > \Delta u$) component the efficient design always entails choosing the low cost option. In this case the expected *ex post* surplus is given by:

$$S_S = (u(0,0) + u(1,1) + \Delta c - \Delta u)/2 - \hat{c}$$

$$+ F(e)\Delta c/2$$

$$F(e)\Delta c/2 + +F(d)\left(uu + F(e)\Delta u\right)/2 - d - e \tag{5}$$

Hence, the first order conditions for design and effort are given by:

$$F'(d^*) = \frac{2}{uu + F(e^*)\Delta u} \tag{6}$$

$$F'(e^*) = \frac{2}{\Delta c + F(d^*)\Delta u} \tag{7}$$

As before, the first order conditions uniquely determine design and effort when they are positive.

Proposition 2. *Suppose that component t^C is seller biased ($\Delta c > \Delta u$), $\frac{2}{uu} > m > \frac{2}{\Delta c}$, and there is no benefit to planning ($\Delta u = 0$), then cost reducing effort, e^*, is strictly positive, while planning, d^*, is zero. As the benefit to planning, Δu, increases then the optimal investment into cost reduction increases. If the marginal benefit to planning is sufficiently high ($\frac{2}{uu+F(e^*)\Delta u} > m$) then this also leads to an increase in planning.*

As in the case of buyer biased components, investments into planning and cost reduction are complementary. If the gain from cost reduction is sufficiently small, then there is no benefit from planning at all.

Summary. An efficient project is characterized by an optimal amount of planning into design that in turn guides the investment into cost reduction by the seller. Components that are not in the original plan are added later, though at a higher cost than if they had been included in the original plans, as seller effort at reducing the cost of the foreseen component does not affect the cost of producing the unforeseen component. The amount of planning by the seller and the buyer depends upon the extent of the potential cost savings. In general, investment into planning and cost reduction are complements for both buyer biased and seller biased components. Given that the design for the unforeseen component is not anticipated when the contract is signed it does not affect the level of relationship specific investment (see Hart (1990)).

3. Efficient Contractual Instruments

In this section we discuss the legal instruments that are supplied by the AIA form contracts that implement the efficient allocation, given the legal remedies that are supplied by US courts. The first stage entails the planning for the project, and the choice of the contractor. The second stage entails the completion of the project, which may include changes to the original plan.

3.1. **Ex Ante: Seller Choice.** Contractors are typically selected by some form of sealed-bid auction. Normally, the owner chooses the lowest bid, although they have the legal right to choose any bidder they wish, and often they do not choose the lowest bid.[19] The reason is that some sellers may be either technically or financially incapable of executing the project, and hence may make unrealistically low bids. The problem is addressed by requiring bidders to pre-qualify. The bidding then occurs among the qualified bidders.

The standard economic rationale for the use of a bidding procedure is to learn which seller has the lowest cost of supplying the good (see McAfee and McMillan (1987)). In the context of complex procurement, the use of an auction also plays an important role in providing the buyer with the appropriate incentives to invest in design, and thereby solving a significant source of holdup. Any investment into design that leads to lower costs results, under the hypothesis that design is observable, to lower bids by prospective sellers. This in turn provides the buyer with first best incentives to invest in design.

More formally, suppose that the buyer chooses a contract $k \in K$ and design d. Given this information sellers offer to carry out the project for a base price P. In addition, the contract k has clauses that allow additional transfers T to occur that are a function of events that occur as the project is implemented. Let $i \in S$ be a potential seller from a set of potential sellers, whose payoffs

[19] *Universal By-Products Inc. v City of Modesto* (1974), 43 CA3d 145). The city of Modesto was sued for not granting the contract to the lowest bidder. The court ruled in favor of the city.

are assumed to be given by:

$$U_i^S(k,d,P) = E\left\{U_i^S(\omega, Q(\omega,k), d, e^*(k,d)) + T(\omega, Q(\omega,k), d, e^*(k,d)) | k, d\right\} + P.$$

The buyer's payoff is given by:

$$U^B(k,d,P) = E\left\{U^B(\omega, Q(\omega,k), d, e^*(k,d)) - T(\omega, Q(\omega,k), d, e^*(k,d)) | k, d\right\} - P.$$

In both cases $Q(\omega,k)$ is the realized design chosen under the contract given the state ω, while $e(k,d)$ is the effort chosen by the seller as a function of the contract and the quality of the design d. The additional transfer required by the contract is denoted by $T(\omega, Q(\omega,k), d, e^*(k,d))$.

In this model, the only asymmetric information among the sellers is their privately observed fixed cost of doing the project. Under the regularity condition of Myerson (1981), a second price auction ensures that the seller with the lowest cost is selected:

Proposition 3. *If the buyer allocates the project to the winner of the second price auction then*

$$P = -U_i^S(k,d,P) + \delta,$$

where $\delta = A_{i'}^S - A_i^S > 0$ *is the difference in the bids between the lowest and second lowest bid. This is the lowest price the buyer can obtain conditional upon design* d *and contract* k*. Given this equilibrium, the buyer chooses* k*,* i *and* d *to solve:*

$$max_{k\in K, d\geq 0, i\in I} E\left\{S_i(\omega, d, e(k,d)) | k, d\right\}. \quad (8)$$

These results follow from the observation that in the second price auction it is optimal for the seller to bid a price P that makes him indifferent between participation or not. Given that the only variation among sellers is the fixed cost of participation, and that the winning seller is paid the second lowest price, then the winning seller receives his valuation U_i^S plus the rent $\delta = A_{i'}^S - A_{i'}^S$. Given that the rent is independent of the contract offered and the investment into design, and given that for each contract offered by the buyer, there exists a well defined payoff to the seller, the buyer will choose the contract $k \in K$ and design d that maximizes the social surplus, as given by (8). Note that from the revenue equivalence theorem, as long as the fixed costs A_i^S are independently distributed across sellers, then a first price auction would also yield the same expected price and payoff.[20]

At this point we do not prove that a solution to (10) exists. We demonstrate this by construction - we show that there is a contract that is built up from a number of contractual instruments that corresponds to clauses in AIA form contracts, and that together these instruments implement the first best.

An essential ingredient for a successful auction is that once a winner has been selected, the winner will in fact proceed to carry out the contract under the agreed upon terms. One problem is that the winner now knows that he supplied the lowest bid, and might attempt to renegotiate the price terms. In addition, once the project has begun, and there are substantial sunk investments, the seller may try to holdup the buyer for better terms.

The AIA form contracts have a number of contractual instruments that explicitly address this issue. Form A701 provides instructions to bidders. In order to deal with the threat of non-performance, contractors are required to post bonds, as detailed in forms A310 and A312. Form A310 is the bid bond that ensures that the winning seller does not renege upon their bid. Form A312 contains two bonding provisions. There is a *payment bond* that ensures that subcontractors are paid in the event that the contractor does not complete payment to them. This is necessary for the owner because subcontractors can impose a mechanic's lien against the building if the contractor fails to make a payment.[21] The second part is a *performance bond*. This bond ensures that should the contractor not complete the job, there are sufficient funds available to find another contractor who would be able to complete the work.[22]

Under form A312 the courts would never be asked to enforce performance per se. If a dispute arises and there is stoppage of work by the contractor, the buyer would ask the bonding company to provide the funds to complete the work. Should the bonding company refuse to pay, the buyer would recover damages from the bonding company under the rule of expectation damages. Note how the introduction of a bond effectively ensures specific performance event though the courts

[20] See Myerson (1981).

[21] These liens are covered by state and local law, and provide a simple way for contractors to ensure that they are paid for work completed. In practice, this usually means that, if the property is sold, the lien holders can make a claim against purchase price before the original owner is paid.

[22] The first clause of A312 states: "The contractor and the Surety, jointly and severally, bind themselves, their heir, executors, administrators, successors and assigns to the Owner for the performance of the Construction Contract, which is incorporated herein by reference."

limit damages to expectations. This is because the bond explicitly states that it will pay for work should the original contract default, and hence the value of expectations is the cost of the work, and not the value to the buyer.

Thus the bond effectively releases the need for the courts to measure performance, but rather the courts enforce (via expectation damages) a sequence of monetary transfers.

The AIA contracts also provide protection to the contractor from the buyer. Buyers are required to make payments as work proceeds as a function of the contractor's costs. Hence, the amounts owed to the contractor at any point in time are limited. In this way the contract is carefully structured so that bargaining power can be reallocated between the parties as a function of who is in breach of the contract.

3.2. **Interim: Performance.** In this section we discuss the contractual instruments that ensure the efficient implementation of the different types of components in the project - those unforeseen at time the contract is signed, seller biased foreseen components, and buyer biased foreseen components. If the only goal were to ensure *ex post* efficiency then, as discussed in section 2, there are simple governance structures that implement the efficient design. The issue is more complex due to the interaction between the unobserved investment into cost reduction by the seller and the unobserved preferences of the buyer. For each type of component we show that there exists a contractual instrument that implements the efficient allocation. Moreover, each instrument has an analogue in the AIA form contracts. This is consistent with the hypothesis that these forms are an *efficient* solution to the procurement problem in the shadow of the law.

3.2.1. *Unforeseen Components.* The procurement of a complex good, such as a large building, necessarily entails adding components that were unforeseen at the time the plans were created. Given that the incumbent seller is on site, he is likely to be the most efficient supplier of the new component. Hence, if the desired modification leads to a significant gain to the buyer, the seller may attempt to extract a rent from the buyer during renegotiation. Given that the buyer's preferences are not observed, this rent extraction may lead to a social loss.[23]

Costs are assumed to be observable, and hence efficiency can be achieved if the buyer has the right to make changes as she wishes, with the only obligation being that she compensates the seller for costs. This is precisely the solution suggested by article 7 of AIA form A201. Normally, changes

[23]Namely, modifications whose true costs are less than their value to the buyer might not be implemented.

to a project are carried out via *change orders,* as specified by article 7.2 of A201-1997. A change order consists of details of how the project is to be modified, and an agreement regarding the price. Normally, the buyer has an architect acting on her behalf who is well versed in what are likely to be reasonable costs. Moreover, by being a written document produced by design professionals it is intended to provide a clear statement of the seller's obligation that, if necessary, can be verified by a court.

This, combined with the requirement that the seller produces detailed accounts, implies that we may suppose that the buyer is informed of the true cost of the change, and then decides whether or not it should be implemented. Once the order has been issued, then it becomes a binding obligation for the seller. More formally, the change order instrument is defined as follows:

COI: Change Order Instrument:

(1) The buyer requests a new component, $q^u = 1$.

(2) The seller reports the verifiable cost c^u.

(3) The buyer then decides whether or not to proceed.

(4) If the buyer decides to proceed, the seller agrees to supply the component and the price P is adjusted upwards by c^u.

This contractual instrument corresponds to a cost plus contract under which the seller agrees to carry out the requests of the buyer, and in return is reimbursed for out of pocket costs.

Proposition 4. *The change order instrument results in the addition of a component with value u^u if and only if $u^u \geq c^u$. Moreover, this instrument efficiently implements any foreseeable component for which effort is zero* ($e = 0$.)

Observe that if there is no benefit from planning, then it is efficient to use a cost plus contract even if the component is foreseen (as also observed by Bajari and Tadelis (2001)). Here we have supposed that the costs are easily observable, and agreed upon by both parties.

Given that the seller is on site, then as we have discussed above, it is likely to be more efficient for this seller to supply the new component than an outside seller. In this case the incumbent seller may use the threat of a delay in production to secure a better price. To ensure that authority remains with the buyer, article 7.3 of AIA form A201-1997 allows the buyer to use a *change order directive.* This contractual instrument clearly establishes an authority relationship between the buyer and seller by putting into writing what the seller is expected to do. The writing requirement ensures that should the dispute be litigated there will be a clear statement of the seller's obligation that the courts can use to determine whether or not breach of contract has occurred. As long as the changes are within the scope of the project, the seller has an obligation to complete the requested changes or be in breach of contract.

This removes the ability of the seller to threaten with a delay. He must comply with the changes, or face a penalty. This power is further reinforced by the bonding form A312 that gives the buyer the right to seize all equipment and material on the site for the completion of building should the seller refuse to complete the work.[24] The seller is still protected because he may ask the courts for additional compensation to cover any costs of compliance with the directive. More formally this contractual instrument is defined as follows:

COD: Change Order Directive:

(1) The buyer requests a new component $q^u = 1$.
(2) The seller produces the component and submits the verifiable cost c^u.
(3) The buyer or the courts adjust the contract price P upwards by c^u.

In the case of Jacob & Youngs v. Kent, had Kent discovered the pipe substitution at the time it occurred, then he could have asked for immediate action. In that case, given that the cost of compliance would have been relatively low, Jacob & Youngs would have been obliged to comply. More generally, this rule ensures that the buyer is able to obtain the changes she wants in a timely fashion, which in turn reduces the cost of construction, while still providing the seller with protection. We now turn to the more difficult case of foreseen components where the contract must provide appropriate incentives for investment into cost reduction.

3.2.2. *Buyer Biased Components.* Consider now a component that is foreseen to be part of the project, and for which there is a chance of a design change. For example, the buyer might wish to change a paint color, or the location of an outlet. Clause 4.2.8 of A201 gives the right to the buyer/architect to carry out minor changes at no penalty. We call this contractual instrument *changes within the scope of the project* or COS:

COS: Changes within the Scope:

[24]This confiscation is consistent with Oliver Hart's observation that authority also includes control over physical assets — see Hart (1995) page 58.

(1) If t^c is buyer biased and foreseen, then the buyer may, with no price consequence, select any $q^c \in \{0,1\}$as long as the change is both minor and within the scope of the project.

This has two effects. Given the design, the sellers can anticipate this behavior, and thus increase their bids for projects that have a high probability of design change. This in turn provides an incentive to the buyer to invest in design. When design is of high quality, then the seller does not expect a large number of design changes *ex post,* and he correspondingly makes a greater relationship-specific investment into cost reduction. Second, since design changes have no effect on price, the buyer now selects her preferred change, which is efficient given that the component is buyer biased. Thus we have:

Proposition 5. *If a buyer-biased component is governed by the contractual instrument COS, then the seller chooses effort e at the efficient level conditional upon design d, and hence the lowest cost of production conditional upon d is achieved.*

Under COS there is no price consequence for the buyer's choice, and therefore, *ex post,* the buyer chooses her preferred design. Given that the component is buyer biased, this is also the efficient choice *ex post.* The expected payoff of the seller at the time effort is chosen is:

$$\begin{aligned} U^S(e|d) &= P - \rho(d)\{\rho(e)c_L + (1-\rho(e))c_H\} - \\ &\quad (1-\rho(d))\hat{c}. \\ &= P + (F(d)+1)\{(F(e)+1)\Delta c - c_H\}/2 - \\ &\quad (1-F(d))\hat{c}/2. \end{aligned}$$

If one compares this expression with the social surplus in (2), one can see that $\frac{\partial U^S}{\partial e} = \frac{\partial S_B}{\partial e}$, and hence under COS the seller will choose effort that maximizes social surplus. This result, combined with the fact that the buyer is a residual claimant implies that design is chosen at the efficient level whenever COS is included in contract k for buyer biased components.

Note that this contract clause is quite different from the fixed price contract typically studied in the literature, as in Hart and Moore (1988). The typical assumption is that the contract specifies both price and quantity, with changes in either corresponding to contract breach. This clause is equivalent to allowing the buyer to make a unilateral change in the quantity, and face no penalty. As long as the seller can anticipate the likelihood of this change, then allowing changes within the scope of the project ensures efficient investment into cost reduction. If one enforced the contract at the specified quantity, then under expectations damages the buyer would have to compensate the seller for any cost consequence. This would result in *over-investment*, as Rogerson (1984) has shown.

Thus the AIA's inclusion of a term that allows minor changes to design at no cost is not merely a convenience that reduces the costs of renegotiation, it also induces efficient effort into cost reduction and design. A testable implication of this proposition is that one would expect, conditional upon job characteristics, bids for home improvement projects done without the aid of an architect will be higher than those with an architect, since they are likely to need more changes *ex post*.

3.2.3. *Seller Biased Components.* Consider now the case of a seller biased component with the feature that it is always optimal to carry out the less expensive design. This would be a feature of components that do not impinge upon the aesthetic qualities of the final project. For example, the design might call for pipes to be in a particular location behind a wall - yet it may be less expensive to deviate from the plan. In addition, the contract might not specify exactly how the project would be executed, even though the buyer may care about this.

In these cases it is efficient to deviate from the default rule that gives the buyer overall control of the project. The AIA form contracts address this issue in section 3 of A201-1997. This section outlines the responsibilities of the seller/contractor, with clause 3.3.1 stating that:

> "The Contractor shall be solely responsible for and have control over construction means, methods, techniques and procedures and for coordinating all portions of the Work under the Contract, unless the Contract Documents give other specific instructions concerning these matters."

Thus, the buyer does *not* have the right to directly control the employees of the contractor, and hence the construction relationship is not a form of employment relationship. Furthermore, under section 5 of A201-1997 the seller has the right to hire subcontractors subject to approval by the owner. More generally, the seller has broad control over how to perform the work in the most efficient way possible:

SCR: Seller Control Rights - the seller may change the design or execution of components that have no impact upon buyer welfare ($\Delta u = 0$).

This contract clause is efficient for seller biased components for which no design is optimal. A necessary condition for this to be the case is that

$$F'(0) \leq \frac{2}{uu + F(e^0)\Delta u}, \tag{9}$$

where $e^0$is the efficient level of effort by the seller when there is no design. It is uniquely defined by $F'(e^0) = 2/\Delta c$ if it is strictly positive, otherwise it is zero. If condition (9) is not satisfied, then the buyer will choose $d > 0$. If $e^0 > 0$, then the optimal effort given $d > 0$ now depends upon Δu. In that case, giving the seller control rights in the absence of a countervailing adjustment to the contract price is *not* efficient. These observations are summarized in the following proposition:

Proposition 6. *The contractual instrument SCR induces the efficient implementation of a seller biased component if (9) is satisfied. In that case it is efficient for the buyer to engage in no design* ($d^* = 0$) *and the seller chooses the efficient level of investment* $e^* = e^0$. *Conversely, when* $e^0, \Delta u > 0$, *this condition is also necessary for SCR to be efficient.*

Consider now the case of seller biased components where the gain from design satisfies:

$$\Delta c \geq \Delta u > \bar{\Delta u} = (2/m - uu)/F(e^0), \tag{10}$$

The final equality follows from (9). In this case, it is still efficient to give seller the control over *ex post* design, however the seller should also internalize the cost to the buyer from such a change. This can be achieved if the price is adjusted to reflect the loss to the buyer. A common example of this problem is a minor defect, that might be expensive to correct but has little consequence for the overall project.

Such defects are effectively choices by the seller (even if inadvertent) that depend upon how closely employees are monitored. If the defect is major, then under section 12 of A201-1997, the seller is expected to correct it at his own cost. However, section 12.3 explicitly allows the buyer to accept non-conforming work combined with a reduction in the contract price. If parties cannot agree upon a price reduction, then courts would set the reduction equal to its best estimate of the loss in value to the buyer. Formally, article 12.3 of A201-1997 corresponds to the following contractual instrument:

BRR: Buyer remediation rights - if the seller alters the design, then the buyer should be compensated by an amount equal to the loss in anticipated use value.

The open issue is exactly how one should determine the anticipated use value. Suppose that when the seller decides to set $q = 0$, a penalty of l is paid to the buyer. In that case the expected utility of the seller is:

$$\begin{aligned} U^S(d,e) &= P - \rho(d)\left\{\rho(e)c_L + (1-\rho(e))(\hat{c}+l)\right\} \\ &- (1-\rho(d))\left\{\rho(e)c_L + (1-\rho(e))(\hat{c}+l)\right\} - e. \end{aligned}$$

From this expression we can derive the seller's first order condition for effort under the hypothesis that the buyer has chosen design efficiently:

$$F'(e^*) = \frac{2}{\Delta c + l}. \tag{11}$$

Comparing (7) with (11) it follows that the seller will choose efficient investment if $l = F(d^*)\Delta u$. Thus we have the following proposition.

Proposition 7. *If $\Delta c \geq \Delta u > \bar{\Delta u}$ then the contractual instrument BRR induces the efficient implementation of a component when the damages, l, for a design change by the seller are equal to the harm to the buyer, Δu, times the foreseeability of the design, $F(d^*)$.*

We have assumed throughout that the preferences of the buyer are not observed by the seller, nor by the courts. Hence, in order to achieve an efficient allocation that buyer would have to specify in advance the damages to be paid. If these are not specified in advance, then we are in a situation where the courts may be asked to set the appropriate damages. In section 4 we show that this rule implies a number of existing common law damage rules.

3.3. **Summary.** A complex project is in practice built up from a large number of specialized components that contribute in different ways to the overall value of the project. We have shown that it is optimal to tailor contract terms, including the allocation of control rights, to the characteristics of the components in a project. Each of these clauses are *contractual instruments* that together ensure the efficient implementation of a complex project. We have shown that each contractual instrument has an analogue in the American Institute of Architects form construction contracts. The contractual instruments we have discussed are summarized in the following table:

Table 1. Contractual Instruments

Contractual Instrument	Period Enforced	Goal
A310 - Bid Bond	*ex ante*	Ensure seller does not renege on winning bid.
A312 - Payment Bond	*ex post*	Ensure sub-contractors are paid.
A312 - Performance Bond	*ex post*	Ensure project is completed if seller cannot perform.
A210-7.2 - Change Order	*interim*	Ensure that seller makes requested changes at cost.
A210-7.3 - Construction Change Directive	*interim*	Obliges seller to make change.
A210-7.4 - Minor Changes	*interim*	Minor modifications create no change in price.
A210-3.3.1 - Seller Control	*interim*	Seller has right to organize production.
A210-12.3 - Remediation	*ex post*	Buyer can accept price reduction for non-conforming design.

For the most part these clauses have clear meanings, and hence whether or not there has been a breach of contract is clear. In some cases, particularly in the case of the remediation clause (A210-12.3), parties may not agree regarding whether there has been breach, and if so what are the remedies. We address these issues in the next section.

4. Ex Post: Remedies for Contract Breach

In contrast to what is typically assumed in economics, the fact that parties have entered into an agreement with clear and verifiable terms does not imply that the contract is enforceable.[25] This can only be determined by an actual court case. The American Institute of Architects has published a compendium of courts cases involving contract disputes (see Stein (2001)). From these one can learn whether or not particular contract clauses would be enforced as agreed upon. Court cases can also clarify the meaning of text when it can have several interpretations. The AIA form construction contracts are carefully constructed to take into account these legal decisions, and are modified regularly in light of legal developments.

In this section we discuss some actual cases to illustrate how contracts are enforced in practice. We show that the optimal remediation rule, $l = F(d) \times \Delta u$, can be viewed as a default rule that encompasses a number of well known legal doctrines. We consider in turn the enforcement of the authority relationship, the choice between specific performance and expectations damages, and finally, rules that limit legal liability.

[25]The enforceability problem is not limited to construction contracts. For example, the courts won't enforce a contract in which a patient, prior to receiving treatment, agrees not to sue a health care provider for medical malpractice that may occur during the treatment. See *Tunkl v. Regents of Univ. of Ca.,* 383 P.2d 441 (Cal. 1963).

4.1. **Authority.** The authority provided by change orders and change directives in AIA form contracts is very different from the standard assumption one makes in contract theory. To see this, suppose that a buyer and seller have agreed upon a contract to exchange q^0 units of a good at a price P^0. Further suppose that this requires significant relationship specific investment by the buyer (for example, the buyer might be a utility, who has built a train line to the mine supplying coal). Now suppose that the buyer would like to increase the amount purchased. Models that allow for renegotiation, such as Hart and Moore (1988) or Aghion et al. (1994), suppose the contract (q^0, P^0) acts as a default for negotiation, with the buyer and seller sharing any rents that arise from contract renegotiation.

Most importantly, under this contract the seller would have the right to refuse to increase supply. The authority relationship in the AIA form contract gives the right to the buyer to *unilaterally* change the quantity specified, say to q^1. Moreover, the cost of this must be equal to the seller's marginal cost of increasing supply. So, in practice, for supply contracts one typically has clauses that allow for changes in the quantity given that this is a very common event. The difficulty in the case of construction is that one cannot always anticipate whether the design will be changed. Change orders and change directives address this by providing the buyer with the unilateral right to change the design at cost. This right was affirmed in *Karz v. Department of Professional and Vocational Standards* (1936), 11 CA 2d 554, in which the owner and the contractor did not agree on the price for the extra work but the contractor was required to perform the extra work or be considered in breach of contract. Specifically the judge in this case ruled:

> "Where a contractor refuses to complete a building when the owners thereof refuse to pay for "extras" as they orally agreed, and the oral contract for "extras" is an independent covenant that does not go to the whole consideration of the written contract for the erection of the building, but is subordinate and incidental to its main purpose, the breach by the owners of said oral contract does not constitute a breach of the entire contract, and does not warrant a rescission of the entire contract by the contractor, whose only remedy for the breach is compensation in damages."

As we show above, the allocation of authority to the buyer is efficient because it provides first best incentives to the buyer to reveal her true preferences. This right is not a general right that applies to all buyers, however. For example, the lead contractor is often responsible for the hiring and supervision of subcontractors. Moreover, these subcontractors may be asked to carry out additional work under a change directive. As a matter of law, the subcontractor is *not* obliged to carry out the work in the absence of an agreement regarding payment.

In *Framingham Heavy Equipment v. Callahan & Sons* (2004), 61 Mass. App.Ct. 171, 807 N.E.2d 851, the subcontractor, Framingham Heavy Equipment, refused to complete work on a school building until they had received payment for extra work carried out under a change directive. In this case the courts ruled that in refusing to complete the work due to non-payment they had not breached the contract, and that in fact Callahan & Sons had breached by not making installment payments for the work as it proceeded. This case illustrates that buyer has authority over the contractor, but not over subcontractors. This is consistent with the subcontractors making few relationship specific investments, and being called in on the job as needed.

These cases illustrate that the courts do enforce agreements, and moreover, the authority relationship that exists between the buyer and lead contractor on a construction project is enforceable. We now move on to those cases where the courts appear to be less deferential to the text of the contract.

4.2. **Specific Performance versus Expectation Damages.** The allocation of authority allows one party to make decisions during the execution of the project that have the force of law, and hence in most situations are respected by the other party. In practice, if there is a disagreement and a case is litigated it arrives in court long after the project has been completed or abandoned. In that case, the question before the courts is not the enforcement of the contract per se, but the determination of damages. The standard rule is expectations damages, namely compensating the harmed party for the losses that occurred as a result of the contract breach.

A very controversial question is whether or not the courts should use the rule of *specific performance* as a measure of damages.[26] By this one means providing the harmed party with sufficient funds that they can in fact have the contract terms executed. Most economic models of contract, implicitly or explicitly suppose, as in Aghion et al. (1994), that the courts use specific performance. In this section we discuss two famous cases where it would seem that specific performance is the natural remedy, but the courts awarded much smaller expectations damages. These decisions are very controversial because they are interpreted as undermining the ability of parties to write binding

[26]See Schwartz (1979) for example.

contracts. We shall show that in the context of our model of the procurement of a complex good these decisions are consistent with *efficient* procurement.

The first case is *Jacob & Youngs Inc. v. George E. Kent*, 230 N.Y. 239 (1921) that was discussed in the introduction. At issue was whether or not the contractor breached a construction contract by not installing the agreed upon brand of water pipe, and thereby releasing Kent from the obligation to make the final payment upon the house.

The lower court ruled in favor of Kent, and disallowed evidence regarding the quality of the installed pipes. Upon appeal, Justice Cardozo ruled that Jacob & Youngs had indeed breached the contract, but that the damage was negligible, and hence Kent was obliged to make the final payment to Jacob & Youngs. The decision was controversial, with one judge dissenting, because it would seem to imply that the courts are unwilling to enforce clear contract terms.

In the context of our model, the decision is consistent with *efficient* contract enforcement. First, in terms of damages, if the contractor carries out non-conforming work then the optimal rule is to set damages equal to $F(d)\Delta u$. In this case design is foreseeable, and hence $F(d) = 1$. Given that the pipes called for in the design were equivalent in quality to the pipes installed, then $\Delta u = 0$, so that damages should be nominal, as in the ruling by Cardozo.

There is an additional reason why this ruling is efficient that relates to the division of authority between the buyer and seller. From the court documents it is clear that one reason Kent did not make the final payment was the result of a general dissatisfaction with the work of Jacobs & Youngs.[27] The project was not completed on time, and there were some minor details that needed correction after the completion of construction. Thus, in essence Kent use the technical requirement that the pipes be of the Reading brand to justify the non-payment. Given that Kent was not substantially harmed by the change of pipe brands, and did not plan to change the pipes, the non-payment could be viewed as *opportunistic* behavior in the sense of Williamson (1975).

One can view the SCR, or seller control rights contractual instrument as solution to opportunistic behavior on the part of the buyer. It will often be the case that during production a seller may take shortcuts, either inadvertent or consciously, that lower costs in a way that have a minimal impact upon buyer welfare. In cases such as *Jacobs & Youngs v. Kent*, the buyer may attempt to use the existence of a technical breach of contract to extract rents out of proportion with the harm. If the

[27]See the discussion in Danzig (1978), page 120.

courts were to support such behavior then it would lead to higher costs *ex ante,* and less efficient contracts. Hence, the decision in *Jacobs & Youngs v. Kent* is not only the correct decision in the context of our model of procurement, it is consistent with efficient procurement.

However, there are cases where the non-enforcement of specific performance seems very problematic. A good example is the well known case of *Peevyhouse v. Garland Coal*, 382 P.2d 109, 114 (Okla.1962), also mentioned in the introduction. In this case, the Peevyhouses were a farming couple who entered an agreement with Garland Coal Co. to allow strip mining upon their land. As a condition of the contract, the Peevyhouses insisted that the land be regraded upon completion of the mining operations. The coal company breached this term in the contract, with the consequence that the Peevyhouses sued them for an amount of $25,000, though the estimated cost of remediation was about $29,000.

It is worthwhile observing that the Peevyhouses crossed out a term in the agreement that would have allowed Garland not to grade the land in exchange for damages of $5,000.[28] Hence, the agreement clearly stated that Garland had an obligation to repair the land. As in *Jacob & Youngs v. Kent*, the issue was not whether there had been a breach of contract, but what the appropriate damages should be. The lower court awarded $5,000 rather than the $25,000. Upon appeal, it was found that the reduction in value of the land from not grading was $300, and hence the damages were reduced from $5,000 to $300!

The case was very controversial because the courts refused to enforce a clear contract condition. As Maute (1995) discusses, there was also a hint of impropriety because there appeared to be a relationship between one of the judges and the law firm representing Garland Coal. With regards to this latter point, it highlights the fact that when parties write a contract they must do so given the behavior of the courts in their jurisdictions, and not based upon an idealized court.[29] The question then is whether or not the Peevyhouses could have written an enforceable contract given that the court uses expectations as a measure of damages, and also might be swayed by a tint of favoritism?

The AIA forms, specifically A312, provide a solution via the *performance bond.* It is a common requirement that sellers post a bond. This bond ensures that should the seller default, then the bonding company or *surety* will step in and hire another supplier if necessary. It is worth emphasizing that the role of the surety is quite different from that of the courts. The court merely awards

[28]See Maute (1995).
[29]See Djankov et al. (2003) for some evidence on how courts operate in practice.

damages based upon a measure of expectations, while the surety completes the construction of the project. This is possible because the surety is a company that specializes in the provision of such services, and hence is able to supervise the completion of a construction process.

Should the surety not perform, given that the financial liability is clearly specified, the application of expectation damages is straightforward, and will always equal the cost of completion (i.e., specific performance). This demonstrates that in practice the fact that courts limit themselves to expectations damages does not imply that parties cannot enforce performance. The issue is that the enforcement of specific performance is a complex task, entailing the use of the various contractual instruments we have discussed above.

In the case of Peevyhouse v. Garland Coal Co., if the contract had included a bonding provision, then grading, up to the limits of the bond, would have been enforceable. It is also the case that while it is option for the buyer to accept a price reduction in lieu of performance, this can only occur if agreed upon by the seller or the surety. The courts would be obliged to award the buyer damages equal to the value of performance only in the case that the surety defaults upon its obligation, otherwise the default is to have the work completed by the surety.

If Kent, in *Jacob & Youngs v. Kent,* wished to have Reading pipe for reasons other than the transport of water, then the contract should have included explicit liquidated damages in the case of non-performance. Given that the courts in the US will not enforce liquidated damages that are deemed unreasonable, the buyer would also have to explain why the brand of pipe is so important. In that case, if the seller were to default and install a different brand, the courts again need only apply the rule of expectations damages, and use the liquidated damage clause as the basis of the award. Thus, these damages can play a useful role by providing information to the seller regarding the buyer's preferences *ex ante.* The seller is then clearly aware of the consequences of any decision to breach the contract.

4.3. **Unforeseeable Events, Mistakes and Impossibility.** There are a number of legal default rules that deal with events that are unforeseen at the time a contract is agreed upon. The first of these limits liability to damages that are *foreseen,* as established in the the famous case of *Hadley v. Baxendale* (1854), 9 Exch 341.

In *Hadley v. Baxendale,* the court ruled that liability should be limited to losses arising "according to the usual course of things" or losses that "have been in contemplation of both parties, at the time they made the contract, as the probable result of the breach of it." The Hadley brothers, owners of City Flour Mills, wanted a broken shaft to be shipped by Pickford & Company, a common carrier, of which Baxendale was the managing director. The shaft was to be sent to Joyce & Co., Greenwich, manufacturers of the mill's steam engine. The broken shaft was supposed to be a model for a new shaft without which the mill could not operate. The shaft, which was supposed to be delivered by May 15, 1854, was not delivered until May 21. Baxendale was not informed about the high value of the product to Hadley, and therefore Baxendale did not take special precaution to ensure an on-time delivery. Hadley then sued Baxendale for the lost profits due to the delivery delay.

The court held that Baxendale was not liable for Hadley's lost profits since the loss was due to unusual circumstances, and that the damages to Hadley were unforeseen by Baxendale. In this case, it was agreed that the damages due to the late delivery, $\Delta u = u_{11} - u_{01}$, were large, possibly larger than the cost of taking action to avoid late delivery. However, these losses were unforeseen by Baxendale. In the context of our liability rule, this is modeled explicitly by the degree of foreseeability, $F(d)$. Formally, an event is *unforeseen* if $F(d) = 0$, and hence the damages due are $l = F(d^*)\Delta u = 0$.[30]

This result generalizes the analysis of Ayres and Gertner (1989) and Bebchuk and Shavell (1991). They observe that the rule of *Hadley v. Baxendale* provides incentives to buyers to reveal information regarding the value of a service, which in turn induces sellers to take appropriate precautions. In our model, the degree of planning is fully endogenous, and allows for partial foreseeability.

This damage formula is also consistent with the legal rule that limits liability in the event of a mistake. If an error in the contract leads to faulty performance or if the contracting parties have differing understandings of the transaction, then non-performance may be excused. An example of this rule is the case of *Mannix v. Tryon* (1907), 152 C 31, in which the court found that the decolorization of the building arose due to the specifications in the contract about the method used to mix plaster. The contractor was not held liable for the defect. Similarly in *McConnell v. Corona City Water Co.* (1906), 149 C 60, the contractor was excused for the collapse of the tunnel since the contractor had followed the drawings, which were defective. In each of these cases, the harm

[30]We model unforeseeability as there being an equal chance of one of two events occurring. This idea generalizes to more events, and simply captures the idea that the seller will not invest in lowering costs if he does not know which of several possible actions is the most efficient action.

was significant, but the design was inadequate, corresponding to $F(d) = 0$, and hence no liability for the seller.

5. Discussion

The economics of contract theory is concerned with explaining the structure of a contract given the constraints imposed by transactions costs. Despite the many recent advances, Tirole (1999) has observed that there remains a significant gap between the theory and the evidence. One reason for this gap is that economic models of contract typically assume the courts enforce performance that is clearly specified in a contract. Under this rule, Chung (1991) and, Aghion et al. (1994) provide general conditions under which the first best can be achieved.

Given that the courts have only the power to impose monetary penalties, specific performance as used in these models implies that the courts must be willing to use sufficiently high penalties that deter the seller from contract breach.[31] In practice, the common law rule in both America and the United Kingdom is expectations damages. This corresponds to the court's monetary estimate of the loss suffered by the harmed party. In many cases the use of this rule results in damages far below the level necessary to enforce specific performance. This leaves open the question of whether or not it is possible to design an efficient contract *given* the rule of expectations damages.

More generally, the lesson of mechanism design theory, as developed Maskin (1999) and Myerson (1979), is that feasible resource allocation mechanisms are constrained by the information available to parties. Similarly, rational parties who wish to write an *enforceable* agreement would also take into account the constraints imposed by the legal system of the jurisdiction responsible for enforcing the contract. Hence, a theory of observed contract form must incorporate not only the constraints arising from transactions cost, such as asymmetric information and hold-up, but also limits upon the set of legally enforceable contracts.

In this paper we introduce a model of complex exchange and show that it is possible to write a contract that is efficient and enforceable under the rule of expectation damages. The optimal contract consists of a collection of *contractual instruments* - specific clauses that apply at different stages of the project, and for different contingent events. We show that each of these instruments have analogues in the the American Institute of Architects (AIA) form construction contracts. This

[31] The one exception to this general rule is the title to an idiosyncratic good, such as a work of art. Given that market alternatives are not readily available, the courts may enforce contracts that call for the transfer of such a title.

result is consistent with the hypothesis that these form contracts provide an efficient and legally enforceable solution to the problem of contracting for the supply of a complex good, such as a large building project.

The fact that the AIA form contracts have evolved over one hundred years illustrates that contracts are themselves complex products that are subject to innovation and change. Thus, it is not surprising that parties who write contracts without the benefit of experience or hindsight are likely to make errors. In these cases, the courts may be called upon to adjudicate disputes involving these poorly crafted agreements. Our model is consistent with the hypothesis that the courts in the United States (and in some case the United Kingdom) have evolved efficient default rules in these cases.[32] Specifically, the rule of Hadley v. Baxendale limiting damages to those that are foreseen, the doctrines of impossibility and mistake that excuse the breaching party from performance are optimal within the context of our model.

Of course, this analysis is only a starting point for a fuller investigation into how the law can shape the form of observed contracts. As Djankov et al. (2003) show, there is enormous variation across countries in the way courts adjudicate contract disputes. It is likely the case that some legal systems are more efficient than others, but such a statement is extremely difficult to evaluate in practice given the wide disparity in local conditions. Thus, while we have shown that the AIA form construction contracts in the US can be viewed as an efficient solution to the problem of implementing complex trade, it is not clear if these forms would be efficient in other jurisdictions, especially in cases where, as discussed in Johnson et al. (2002), parties have increased reliance upon informal enforcement.[33]We need a great deal of further work in order to understand the complex interplay between contract form, transactions costs, and the limits of legal enforcement.

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[32]This is consistent with Posner (2003)'s view that American common law has evolved an efficient solution to the problem of adjudicating disputes.

[33](see MacLeod (2007) for a review of this literature)

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School of Business and Economics, University of Exeter, Exeter, UK

E-mail address: S.Chakravarty@exeter.ac.uk

Columbia University, Department of Economics, 420 West 118th, MC 3308, New York, NY 10027-7296, USA

E-mail address: bentley.macleod@columbia.edu