CONTRACTING IN THE SHADOW OF THE LAW

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Abstract. Economic models of contract typically assume that courts enforce obligations based on 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. As first year students of contract law know, there are many examples of situations where the courts do not enforce well defined contractual obligations. This leads naturally to the question of how the law affects 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, both *ex ante* and *ex post,* 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.

Our analysis begins with the observation that planning for a complex project, such as a large construction process, is necessarily incomplete. Hence, the implementation of any contract must include a mechanism for determining performance, and appropriate compensation, when unforeseen events occur. The literature on incomplete contracts, including Rogerson (1984), Grout (1984), Hart and Moore (1988) and Tirole (1986), supposes that in states where a contract is incomplete or inefficient, parties play a renegotiation game, where it is typically assumed that no trade is the

[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.

default should renegotiation fail.[3] In addition to providing a coherent model of contract incompleteness, this literature makes precise Williamson (1975)'s insight that contract incompleteness can lead to inefficient allocations.

Subsequent work by Chung (1991), MacLeod and Malcomson (1993) and Aghion et al. (1994) makes the point that in addition to determining terms when an anticipated event occurs, a contract also regulates the *ex post* bargaining power of parties through the appropriate manipulation of the default terms. These papers show that appropriate renegotiation design can extend the set of conditions under which it is possible to implement an efficient incomplete contract.

When contract terms are missing or incomplete, parties may ask a court of law to clarify the contract terms. The early work on the economics of contract law by Shavell (1984) and Rogerson (1984) considers the case in which contracts are silent regarding damages should one party breach.[4] They consider three legal rules that the courts might use in setting damages: expectation damages (the pecuniary value the harmed parted expected from performance), reliance damages (the costs borne by the harmed party from entering into an agreement) and specific performance (an order to the defendant to perform as promised). Shavell and Rogerson find that in general none of these rules achieve the first best, though specific performance is generally preferred to the other rules.

MacLeod and Malcomson (1993) (Proposition 6) show in a model with repeated trade and two-sided specific investment that if the set of contractible states is sufficiently rich, then it is possible achieve the first best with a contract that does not rely upon the use of any damages for contract breach. This result is consistent with the practice of indexing the price in long term coal contracts so that it tracks the market price, as documented by Joskow (1988). This result provides an illustration of how a legal restriction, in this case the cost of enforcing stipulated damages, may explain observed contracting behavior.

Chung (1991) and Aghion et al. (1994) show that one can extend these efficiency results to the case of risk averse agents by appealing to another legal rule - *specific performance.*[5] Specifically, they show that if the courts enforce the level of trade that individuals have contracted upon *ex ante,* then

[3]See Che and Hausch (1999) for a rather general model illustrating the point that contract incompleteness leads to inefficient allocations.

[4]More precisely, it is assumed that contracts do not have stipulated damages - the damages to be paid in the event of breach. Under US law such damages are subject to judicial review, and may be struck down if they are considered inappropriate. This is known as the penalty doctrine - see Farnsworth (1999), section 12.18.

[5]See also Edlin and Reichelstein (1996), who show that specific performance extends the set of situations where efficiency can be achieved in the MacLeod and Malcomson (1993) model.

parties can agree upon a price-quantity pair that in effect allocates all the *ex post* bargaining power to one agent. This in turn is shown to ensure efficient *ex ante* investment. In practice, one cannot move the clock backwards, and hence for any project that depends upon timely performance, as is the case with construction, the courts cannot literally force a contractor to perform as promised. Aghion et al. (1994) suggest that this can be achieved in practice with the use of large penalties for the delay of a project.[6]

More generally, economic models that rely upon the use of specific performance implicitly assume that should a party not perform as promised, then she will face a penalty that is much larger than any possible gain from breach. In practice, such contract terms run afoul of the penalty doctrine - under US law such penalties are *not* enforceable, even if they are clearly stated in the contract.[7] The efficiency benefits of specific performance has led some scholars, such as Alan Schwartz (1979), to conclude that the courts *should* apply the rule of specific performance more widely, and hence courts should enforce stipulated damage clauses, even if they seem large relative to the damage caused by breach.

This conclusion very much depends upon the hypothesis that individuals correctly anticipate the consequences of their actions, and behave accordingly. It is worthwhile observing that the issues faced by a court are very different from those faced by rational parties entering into an agreement. When parties write a contract, they design it taking into account the transactions costs that characterize their situation. In contrast, courts of law are governance structures that must be prepared to adjudicate *any* case that comes before them, including poorly designed and executed contracts. This distinction is particularly relevant when it comes to the doctrine of specific performance.

Economic models of specific performance, as in Aghion et al. (1994) or Edlin and Reichelstein (1996), suppose that should a party not perform as promised, then the courts would impose a large penalty that would make such non-performance unprofitable. Under such a rule rational parties would never breach. It follows that if such a case were to arrive in court one would have to conclude that either one party was not rational, or that an error has occurred.[8] If that were the case, then even if specific performance is the default rule, the courts would adjudicate the case on its own

[6]See proposition 2.1 of Aghion et al. (1994).
[7]See footnote 4.
[8]The issue here is akin to the problem of defining rational choice off the equilibrium path, as discussed in Reny (1992).

merits, with the consequence that the courts have evolved several doctrines that excuse parties from performance in specific situations.

For example, the court may choose not to use specific performance if circumstances for the seller make it impractical/impossible to perform or if using specific performance is inefficient, and hence damages in form of monetary transfer is more efficient.[9] The legal doctrines of frustration of purpose and impracticality have arisen precisely to deal with these cases. Frustration of purpose refers to situations where, for reasons beyond the control of the buyer, she cannot accept the goods - say she contracted for construction of a house but was denied a building permit for reasons beyond her control. The doctrine of impracticality would arise in a situation where a seller promised to supply a good, but her manufacturing plant was destroyed by fire. In both cases, parties might have agreed to large penalty clauses to ensure performance, but left out contingencies to deal with situations where performance is clearly undesirable or impossible.

A well known example is the controversial case of Jacob & Youngs Inc. v. George E. Kent.[10] In this case Kent hired Jacob & Youngs to build a house that included the requirement that all the wrought iron water pipe used in the house be manufactured by Reading Co. After the completion of construction, Kent learned that some of the pipe was of a different brand, and hence Jacob & Youngs had clearly not performed as required by the contract. The contract specified that the final payment of $3,483.46 to Jacob & Youngs was conditional upon completion of the project. Given the evident breach, Kent refused to make this payment unless the contractor replaced the pipes with the ones specified in the contract. However, given that the pipes were encased in the walls, the cost of replacement would have far exceed the value of the final payment.

Jacob & Youngs sued Kent for the final payment based because the substituted pipes were equivalent in quality to the ones made by Reading Co. Jacob & Youngs were barred from submitting this evidence, and the trial judge ruled that Kent was under no obligation to make the final payment until Jacob & Youngs performed as required by the original contract. However, Jacob & Youngs were successful upon appeal. Judge Cardozo, writing the majority decision, argued that the lower court was in error in not allowing the submission of the evidence on the quality of the installed pipes. Moreover, since the difference between the actual performance and that required in the contract

[9] See White (1988) for a good discussion of these principals, and their relationship to damages.
[10] Jacob & Youngs Inc. v. George E. Kent, 230 N.Y. 239, N.Y., 1921.

was trivially small, the seller was deemed to have performed, and Kent had an obligation to make the final payment.

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 Schwartz and Scott (2008). Notice that enforcing specific performance does not necessarily entail an inefficient *ex post* allocation. Suppose Jacob & Youngs were obliged by the courts to install the desired pipes and the *ex post* cost of these repairs exceeded the value Kent attached to them. In this case, the parties could renegotiate the contract, with Kent accepting damages in lieu of performance.

The difficulty is that renegotiation is occurring in the face of asymmetric information. As we know from Myerson and Satterthwaite (1983), when each party's gain from trade is private information, then *ex post* renegotiation is often inefficient. In this model, the default if there is no trade is assumed to be exogenous. McKelvey and Page (2002) have made the general point that efficiency can be enhanced if a third party, such as the courts, can select a default that is expected to be efficient. In the case of Jacob and Youngs v Kent, the courts believed that the efficient outcome was not to change the pipes. Moreover, the difference in opinion between Jacob and Youngs and Kent regarding whether there had been performance led to costly and unnecessary negotiation. Hence, the court's ruling is consistent with reducing costs that arise from renegotiation under asymmetric information, and provides a potential explanation of why the courts do not consistently use the rule of specific performance.

One cannot conclude from this ruling that courts do not in general enforce contracts. In the case of Kanga v. Trust (1982)[11],the court chose to use monetary damages rather than specific performance in a case of a breach by the seller. Mr. and Mrs. Trust were able to recover from a contractor when he blatantly violated the plans, engaged in poor workmanship and constructed the basement of the house with a height that was 4 inches shorter than required by the plans. In particular, even though the Trusts eventually sold the house, the court ruled that damages of $20,000 be assessed against Kanga due to the special value that the Trusts assigned to the basement ceiling height. In this case, the judge ruled in a way that was inconsistent with the rule established in Jacob and

[11]110 Ill.App 3d 876, 441 N.E.2d 1271, Ill.App. 2 Dist.,1982.

Youngs v. Kent. The difference is that in Jacob and Youngs v Kent there was no evidence that the contractor's action significantly impaired the value of the house, while in the Trust case there was evidence that the Trusts attached special value to the height of the basement ceiling, and thus damages should reflect this lost value.

These examples illustrate that the courts do not as a matter of course enforce clear contract terms. This has lead many scholars, such as Schwartz and Scott (2008), to argue that US courts impede the ability of individuals to write efficient contracts. This is only true if parties are unable to write some contract that achieves an efficient outcome, and is consistent with current law. Our contribution is to present a model of complex trade that is informed by current practice in construction, and to show that under the appropriate conditions current law is consistent with the implementation of efficient production and trade of complex goods and services in this important industry.

Goldberg and Erickson (1987) observe that industry practice is a useful starting point for understanding efficient contract design. This is because skilled business persons have developed contractual instruments for their industry in the "shadow of the law". In this we study the American Institute of Architects form construction contracts because they are a paradigm example of enforceable contractual instruments. They have several features that make them a particularly useful vehicle for understanding contract design and enforcement in practice.

First, the construction industry is a very large and important sector (about 9% of US GDP), with well understood methods that have evolved steadily over many years. Second, construction contracts are standardized - most projects in the United States either use the AIA forms, or form contracts that are very similar to these forms. Third, the AIA form contracts have been in existence since 1881, and currently the American Institute of Architects (AIA) sell at a modest price (currently at \$3.50 to \$18 per form) almost 100 different copyrighted forms designed for the different stages of the construction project. Hence these forms are likely to conform to the economist's presumption that parties choose efficient terms. Finally, the contracts have evolved in the shadow of the law. The AIA carefully follows courts cases that involve construction and publish a compendium of cases relevant to the AIA forms (see Stein (2001)).[12]

In the next section we introduce a model of complex procurement that is informed by the structure of these contracts, and builds upon Bajari and Tadelis (2001)'s insight that one can endogenize

[12]This is in stark contrast to the other major class of form contracts, name contracts for the sale of goods and services. As Macaulay (1963) documents, parties routinely ignore the terms of these agreements.

contract completeness by supposing that planning for the future is a relationship specific investment. They show that the choice between two classic pricing schemes, fixed price contracts and cost plus contracts, inevitably involves a trade-off between encouraging *ex ante* investment into cost reduction, as provided by a fixed price contract, and ensuring *ex post* efficient production, as provided by a cost plus contract.

This result follows from several assumptions that are not consistent with observed practice. First, contraction contracts are rarely purely fixed price, they are instead complex hybrids of fixed price and cost plus terms. Even the form contracts that are ostensibly fixed price always include terms that provide for additional fees when there are the inevitable changes to the original design. Second, consistent with the early literature on hold-up, Bajari and Tadelis (2001) assume that the bargaining power of parties is exogenous[13]. The main AIA form (A201), that is used in all agreements using AIA forms, carefully allocates bargaining power and authority between the parties to the agreement. Finally, Bajari and Tadelis (2001) assume the legal rule of specific performance, which in general is not used in the United States. In contrast, the AIA forms rely upon the rule of *expectation damages,* and as a consequence they are legally binding and enforceable in US courts.

In section 3 we show that the AIA forms specify, within the context of our model, an *efficient* mechanism for the procurement of a complex project. Namely, they are able to achieve efficient production, even though they are restricted to the use of expectations damages. In section 4, we discuss 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.[14], where Garland Coal breached its obligation to grade a farmer's land at the cessation of operations of a strip mine. There we show that the contract signed by the parties was not consistent with the structure of the AIA form contracts, and even though the contract appeared to have clear contingencies, by not taking into account the constraints imposed by the courts, the result was an unenforceable (and inefficient) agreement. The AIA forms include some contractual instruments that would have ensured that Garland Coal Co performed as desired by the Peevyhouses. The final section contains a further discussion of these issues.

[13]Bajari and Tadelis (2001) explicitly assume that the buyer has all the bargaining power and observe that if the seller held all the bargaining power, then the first best could be achieved. See page 395 regarding the use of specific performance.

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

2. A Model of Procurement

Consider a risk neutral buyer who wishes to contract with one of several potential risk neutral sellers for the supply of a project that entails significant relationship specific investments by the selected seller.[15] The key ingredients of the procurement process are as follows:

(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.[16]

(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 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 after construction begins request a color change. This change might have been avoided if the buyer had spent more time building prototypes of the project. The key feature of the Bajari and Tadelis (2001) model is that

[15] 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).

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

the investments into design are observed by the seller, hence the seller can anticipate the likelihood of a design change *ex post*.

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. 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 are common to Los Angeles, the possibility of an earthquake 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. 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 the seller have made relationship specific investments, it is cheaper to have the current seller carry out any unforeseen modifications. However, due to the asymmetric information that may exist between the buyer and seller, this may lead to inefficient *ex post* renegotiation. In addition, given the design, the seller can make non-contractible relationship specific investments that reduce production costs. The goal of the contract between the two parties is to ensure efficient investment into both the design and execution of the project.

The next section provides a time-line for the model, followed by a detailed description of each step.

The Time-Line for the Procurement Process. 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. The time line for the procurement process is as follows (in figure :

(1) Ex Ante Stage
   (a) Buyer invests d into planning for the design of a component t^c.
   (b) Two sellers bid for the project described by characteristic q^c that includes a mechanism for the governance of future design changes.

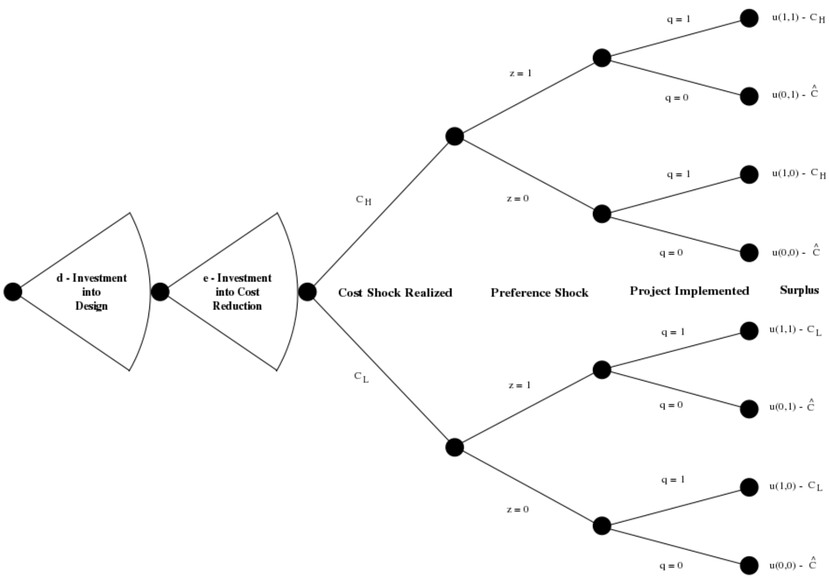

FIGURE 1. Time Line of Decisions and Events

   (c) The low cost bid is selected.

(2) Interim Stage
   (a) Seller invests e into cost reduction, and cost $c \in \{c_L, c_H\}$ of construction is realized.
   (b) Buyer receives new information and design is changed to $Q = \{q^c, q^u\}$, where q^u is a new component to be added that was not anticipated at the design stage.
   (c) Seller builds the project.

(3) Ex Post Stage
   (a) Agreed upon payments are made, resulting in a net payment P from the buyer to the seller.
   (b) Any remaining disputes are addressed, in court if necessary.

Ex Ante Stage. At step 1 (a) the buyer invests in project design by hiring an architect or engineer at a fixed cost A^B. The project, whether it is a building, a bridge, or a weapons system, 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.[17] The uncertainty due to design leads to two ways in which the existing contract may have to be changed later. One, an existing component specification may be changed and two, an additional component may be added on to the existing set of components.

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. Both parties recognize that the specifications determining the characteristics of this component may change during the interim stage. We denote the implemented foreseen component by $q^c \in \{0,1\}$, where $q^c = 1$ denotes that the component is executed as originally designed, while $q^c = 0$ denotes a change to the original design. Changes in the design can occur because of shocks to the buyer's preferences or due to the realized cost of implementation. These shocks are observed after the seller has made relationship specific investments, but before the project is implemented. The shock to the 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 $u(q^c, z)$. 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 bidding for a contract.

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*.[18] 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.

At stage 1(b) the potential sellers are given the design characterized by $\{t^c, q^c, d\}$, along with the conditions of the procurement contract. They make production plans and bid for the right to carry

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

[18] 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.

out the project using the selection mechanism designed by the buyer. Let $A_i^S > 0$ be seller i's fixed cost of production, $i = 1, 2$. This fixed cost is the only source of variation between the two 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.[19] Finally, at stage 1(c) the buyer selects the winner of the Vickrey auction.

Interim Stage. At stage 2(a) the selected seller makes an investment e into cost reduction. This determines the probability $\rho(e) \in (\frac{1}{2}, 1)$ that the cost c of completing a foreseen component is $c = c_L$, otherwise the cost is $c = c_H$. 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 ($q^c = 0$) then the expected cost is assumed to be $\hat{c} \equiv (c_H + c_L)/2$. Let $\Delta c = c_H - \hat{c} = \hat{c} - c_L$ parametrize the size of the potential cost savings arising from the efforts of the seller. We assume that ex post cost c is observed - it is a feature of all the standard form construction contracts that the seller has an obligation to keep good records that establish the cost of production.

At stage 2(b), after the seller's investment, the buyer realizes a shock to her preferences. She learns $z \in \{0, 1\}$ that determines whether she prefers the component t^c to be executed as originally planned ($q^c = 1$) or whether she prefers a change ($q^c = 0$). In addition, the buyer may realize a value, u^u at a cost c^u, from the addition of an unforeseen component t^u. 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. Let $q^u = 1$ if the component t^u is added to the contract, and zero otherwise.

Finally, at stage 2(c) the project $Q = \{q^c, q^u\}$ is realized.

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

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

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

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

At stage 3(a) the contract terms, including any renegotiated price, determine the monetary transfer between the buyer and the seller. At stage 3(b) parties may choose to file a lawsuit. This may result in additional payments between the parties that are determined at that 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.

The Efficient Allocation. An allocation is a choice of seller, a project plan, and a set of investment levels, denoted $\pi = \{i, Q(\omega), e, d\}$, where $\pi \in \Pi$ is the set of feasible allocations. An allocation, $\pi^* = \{i^*, Q^*(\omega), e^*, d^*\}$ is *efficient* if it maximizes 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 $Q^*(\omega) = \{q^*(\omega), q^{u*}(\omega)\}$ can be implemented under the assumption that the buyer's preferences are not observed.

Unforeseen Components. Consider first the implementation of unforeseen components. At stage 2(b) the buyer learns that she would like to add component t^u that has value u^u. Under the assumption that costs are observable, the buyer asks the seller to produce a binding estimate c^u for the cost of the component. It is efficient to add this component to the project if and only if $u^u \geq c^u$. Thus the efficient action $q^{u*}(\omega) \in \{0, 1\}$ is defined by $q^{u*}(\omega) = 1$ if and only if $u^u \geq c^u$, otherwise the component is not built.

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

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

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

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

The optimal design of component t^c is a function of $\{\Delta c, \Delta u\}$ 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 even in the presence of asymmetric information, a simple governance structure can ensure *ex post* efficiency. 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^c 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, though this does not necessarily lead to *ex ante* efficient investment. Given efficient *ex post* production, we now characterize the optimal planning and cost reducing investment levels for the cases of buyer biased and seller biased components.

Buyer Biased 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 planning d and effort e is:[20]

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

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

$$\rho(d)\left\{\rho(e)(u(1,1) - c_L) + (1-\rho(e))(u(1,1) - c_H)\right\} + (1-\rho(d))(u(0,0) - \hat{c}).$$

where

$$F(x) = (2\rho(x) - 1) \tag{3}$$

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:

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

$$F'(e^*) = \frac{2}{(F(d^*) + 1)\Delta c}, \tag{5}$$

where $\Delta u^* = u(1,1) - u(0,0) \geq 0$ is the difference in utility between the utility the buyer receives when she prefers no design change, and this is implemented, and if she wishes a design change and this is implemented. 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-versa. The marginal impact of planning upon foreseeability at zero investment is $F'(0)$, and as is assumed to be strictly positive.

Notice that a smaller Δu^* corresponds to a smaller gain from ensuring that the buyer does not wish to change her mind, and hence to a smaller gain from planning. In particular, if this gain and Δc are sufficiently small then it is efficient to engage in no planning and make no effort into cost reduction. Conversely, for large enough gain from planning, depending on cost savings, it is efficient to invest in planning and cost reduction, d^*, $e^* > 0$, or in planning only $d^* > 0$, $e^* = 0$. These results are summarized in the following proposition, whose proof is in the appendix:

Proposition 1. *Suppose a component is buyer biased* ($\Delta u \geq \Delta c$), then the first order conditions imply:

(1) If $F'(0) < \frac{2}{\triangle u^* + \triangle c}$ then there will be no investment: $d^* = 0$ and $e^* = 0$;

(2) If $\frac{1}{\triangle c} \geq F'(0) > \frac{2}{\triangle u^*}$ there will be strictly positive optimal planning, $d^* > 0$, and no cost reducing effort, $e^* = 0$;

(3) if $F'(0) > max(\frac{2}{\triangle c}, \frac{2}{\triangle u^*})$ both investments: in planning and cost reducing, will be strictly positive, $d^* > 0$ and $e^* > 0$.

When the total gain to planning and cost reduction, as measured by $\triangle u^* + \Delta c$, is small then then it does not pay to plan. In this case there would be no benefit to a long term contract. Conversely, when both gains the gain to planning, $\triangle u^*$, and gain to cost reduction. Δc, are both sufficiently large, then it is efficient for both parties to make relationship specific investments. We consider next the case of a *seller biased component,* defined by the case in which $\Delta c > \Delta u$. In this case, it is always efficient to modify the design in the face of an adverse cost shock.

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

$$
\begin{aligned}
S_S &= (u(0,0) + u(1,1) + \Delta c - \Delta u)/2 - \hat{c} \\
&\quad + F(e)\Delta c/2 + F(d)\left(\Delta u^* + F(e)\Delta u\right)/2 - d - e
\end{aligned}
$$

Hence, the first order conditions for planning and effort when they are positive are given by:

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

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

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

Proposition 2. *In the case of the seller-biased component ($\triangle c > \triangle u$), we have:*

(1) If $F'(0) < \min(\frac{2}{\triangle u^* + \triangle u}, \frac{2}{\triangle c + \triangle u})$ there will be no investment at all, $d^* = 0$, $e^* = 0$;

(2) If $\frac{2}{\triangle c} < F'(0) < \frac{2}{\triangle u^* + \triangle u}$ there will be only cost reducing investment, $e^* > 0$, and no planning, $d^* = 0$;

(3) If $\frac{2}{\triangle u^*} < F'(0) < \frac{2}{\triangle c + \triangle u}$, there will be only planning effort, $d^* > 0$, and no cost reducing effort, $e^* = 0$;

(4) If $F'(0) > \max(\frac{2}{\triangle u^*}, \frac{2}{\triangle c})$ there will investment in both planning and cost reduction, $d^* > 0$ and $e^* > 0$.

As with 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. Moreover, variations in the benefit to planning itself, without an increase in the actual amount of planning, have no effect on cost reducing activities. This illustrates the point that planning is an essential input into cost reduction.

Summary. An efficient project is characterized by an optimal amount of planning into the design that in turn guides the investment into cost reduction by the seller. 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. For complex projects, there are inevitably components that have been left out of the original design, and for which parties have not made relationship specific investments. (see Hart (1990)). These unforeseen components should be added whenever the benefit exceeds the cost.

3. Efficient Contractual Instruments

In this section we discuss the contractual instruments, 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 choosing the contract for the choice of the contractor. The second stage entails the implementation of the project, which includes applying the governance terms provided by the *ex ante* agreement.

Our model builds upon the model of Bajari and Tadelis (2001), but modifies the set of contractual instruments to be more consistent with the AIA form contracts. Bajari and Tadelis suppose that the buyer invests in observable planning that determines the likelihood that the project design is incomplete, and must be renegotiated for the buyer to obtain a value v. After the investment into planning, the seller makes an unobserved cost reducing investment. If the design needs to be changed *ex post,* it is assumed that the cost of this change is not observed by the buyer. It is further assumed that the contract merely specifies the form of compensation, cost plus or fixed price, not the renegotiation protocol. Hence, at the time the contract is renegotiated one has a situation of asymmetric information combined with *ex post* renegotiation. As a consequence the first best cannot be achieved.

In contrast, we have assumed that costs are observable. This is not only consistent with the early work on procurement by Laffont and Tirole (1986), it is also consistent with the requirement that any damages can depend only upon observed costs - the contractor is obliged under the AIA contracts to maintain good accounting records so that the costs of production can be verified. It is also a standard rule in contract law that a contractor has a duty to mitigate any losses - namely they should find the low cost method for achieving performance, and cannot claim for costs when there was an obviously less expensive way to achieve performance.[21]

We do assume that the preferences of the buyer are not observable - an assumption that seems particularly appropriate in construction where it would be very difficult for courts to place monetary value upon aesthetic elements of buildings. If one supposes that both parties share in the surplus from renegotiation, then this still implies inefficient exchange *ex post.* However, if the informed party has all the *ex post* bargaining power, then one can achieve the efficient allocation.[22] This is consistent with the structure of the AIA contracts for which the default rule on question of design is to allocate all *ex post* authority to the buyer.

This does not however ensure that one can achieve efficient *ex ante* investment incentives. In fact, the point of Hart and Moore (1988) and Tirole (1986) is to show that in general one does not achieve efficient investment, even if renegotiation is efficient. In the mechanism design literature, the closest case is the *partially private information* situation considered by Rogerson (1992), who shows that an abstract mechanism can achieve the efficient allocation with *one-sided* relationship specific investment *ex ante* and one-sided asymmetric information *ex post.*[23] When information is asymmetric, *Aghion et al. (1994)* show that one can simultaneously obtain efficient investment by both buyer and seller, and ensure efficient *ex post* trade if parties are able to appropriately allocate bargaining power during the renegotiation phase.

All these mechanisms, including the contracts in Bajari and Tadelis (2001), assume that the courts use the doctrine of specific performance. Moreover, there is a general presumption in the literature that under the rule of expectation damages, when *ex post* renegotiation is possible, parties

[21]See chapter 12 of Farnsworth (1999).

[22]Crémer and McLean (1988) demonstrates this in an abstract mechanism design setting. Kanemoto and MacLeod (1992) show in an employment context that efficiency can be achieved in such a setting with the appropriate allocation of bargaining power to the informed employee.

[23]See proposition 6.

cannot write a contract that achieves an efficient allocation, as formally shown by Rogerson (1984) and Edlin and Reichelstein (1996).

We shall show that it is possible to achieve an efficient allocation even though parties are limited to expectation damages. There are two reasons why we obtain different results from the previous literature. First, the literature typically assumes that the information structure is given. In practice, the amount of information available is a choice variable. For example, construction contracts require sellers to provide detailed information regarding costs in to estmate an appropriate damage award.

Second, the efficiency result of *Aghion et al. (1994)* supposes that *ex post* bargaining power is allocated to one or the other party. In contrast, the AIA form contracts split authority as a function of the nature of the task. Tasks that affect the nature of the final product are under the exclusive control of the buyer, while tasks affecting costs of production, such as the methods used for construction, are under the exclusive control of the seller. These correspond to what we have called buyer biased and seller biased tasks. We shall show that once authority is divided in this way, it is possible to design a contract that provides incentives for efficient planning and cost reduction, while ensuring that renegotiation always results in an *ex post* efficient allocation under the rule of expectations damages.

The AIA forms are not a single contract, but a collection of contractual instruments that are combined as a function of the project needs, to provide a comprehensive agreement. We proceed by describing the appropriate contractual instrument for each stage of the procurement process, and then showing how together they implement the efficient allocation.

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.[24] 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 reveal the seller with the lowest cost of supplying the good (see McAfee and McMillan (1987)). For complex procurement,

[24] *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.

Victor Goldberg (1977) has informally argued that auctions also provide an opportunity to communicate information to the sellers. We formalize this insight, and show that the use of an auction plays an important role in providing the buyer with the appropriate incentives to invest in planning, and thereby solve a significant source of holdup. Under the hypothesis that the quality of the design is observable, investment into planning the design then results in lower bids by prospective sellers. This in turn provides the buyer with first best incentives to invest into the design of the project.

More formally, suppose that the buyer chooses a contract $k \in K$ and investment into the 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. Suppose that there are two potential sellers, $i \in \{1, 2\}$, whose payoffs 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 amount of planning, 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 $\delta = \left|A_1^S - A_2^S\right| > 0$ *is the difference in the bids (there are only two bidders). 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:*

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

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 participating 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 expected payoff to the seller, the buyer will choose the contract $k \in K$ and design d that maximizes the expected 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.[25]

At this point we do not prove that a solution to (8) exists. We demonstrate this by construction - we show that there is a contract that is built up from contractual instruments that correspond 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, the substantial sunk investments may lead the seller to try and holdup the buyer for better terms.

The AIA form contracts have several contractual instruments that explicitly address this issue. Form A701 provides instructions to bidders. 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 when the contractor does not pay them, to avoid subcontractors imposing a mechanic's lien against the building.[26] The second part is a *performance bond*. This bond ensures that should the contractor not complete the

[25]See Myerson (1981).

[26]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 the purchase price before the original owner is paid.

job, there are sufficient funds available to find another contractor who will be able to complete the work.[27]

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 even though the courts 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, with 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.

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 the 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.

Unforeseen Components. Suppose there are additional components that are desired by the buyer that were unforeseen at the time plans were created, and for which the incumbent seller, already

[27]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."

on site, is the most efficient supplier of the new component. In this case, the seller may holdup the buyer and attempt to extract a rent from the buyer in return for providing the new component. Given that the buyer's preferences are not observed, this rent extraction may lead to a social loss.[28]

Given that costs are assumed to be observable, then the first best is achieved if the buyer has the right to make changes as she wishes, with the only obligation being that she compensates the seller for additional costs. This is precisely the solution suggested by article 7 of AIA form A201. Normally, changes 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, it then 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 efficient effort is zero* ($e = 0$.)

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

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 observed by Bajari and Tadelis (2001)). Here we have supposed that the costs are easily observable, and agreed upon by both parties.

Change orders are typically achieved via mutual agreement between the buyer and the seller. Given that the incumbent seller is on site, and thus the low cost supplier, she may attempt to extract a price from the buyer that is greater than cost. If anticipated by the buyer, this would lead to an over investment into design. The question then, is even though the buyer has both the authority and the right to make changes *ex post* at cost, how does one limit opportunistic behavior by the seller?

If the seller does, in the opinion of the buyer, attempt to extort an unreasonable price then the buyer may elect to use a a *change order directive.* This is a contractual instrument provided by the AIA forms under which the seller is ordered or directed to carry out a task before a price has been agreed. 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, which can greatly increase construction costs.[29] The COD reduces the ability of the seller to extract a excessively high price for such changes. He must comply with the directive, 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.[30] 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 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, the

[29] See Atkins and Simpson (2006) for a discussion of the issues.

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

COD ensures that the buyer is able to obtain necessary changes in a timely fashion. This 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.

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 CS:

CS: Changes within the Scope:

(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 CS, 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:

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

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 the level of effort that maximizes social surplus. This result, given 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* in design, 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 to be higher than those with an architect, since they are likely to need more changes *ex post*.

Seller Biased Components. Consider now the case of a seller biased component that has 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. There are other cases there are simply errors in execution. 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, consistent with the principal that the buyer has control, 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 should one 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:

$$F'(e^*) = \frac{2}{\Delta c + l}. \tag{9}$$

Comparing (7) with (9) it follows that the seller will choose efficient investment if $l = F(d^*)\Delta u$. Thus we have the following proposition.

Proposition 6. *For seller biased components ($\Delta c \geq \Delta u$) 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 planning, $F(d^*)$.*

We have assumed throughout that the preferences of the buyer are not observed by the seller, nor by the courts. Hence, to achieve an efficient allocation, the 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 is consistent with several existing common law damage rules.

While proposition 6 provides general conditions under which one obtains the efficient implementation of seller biased components, it suffers from the problem that the courts must measure the harm to the buyer. One can avoid such costly litigation if there were no liability. This is efficient whenever

$$l = F(d^*)\Delta u = 0. \tag{10}$$

This condition is satisfied when design has no effect upon the buyers preferences, or there is no investment into design.

Note that clause 3.3.1 states 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."

Given that these choices affect costs and not the design, control over them are optimally allocated to the seller. Furthermore, under section 5 of A201-1997 the seller has the right to hire subcontractors subject to approval by the buyer. Thus, the AIA form contracts allocate authority to the seller over any decision that affects costs, but has minimal or no impact upon the quality of the project.

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. Together, these contract terms of *contractual instruments* 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, as summarized in the following table:

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, as with the remediation clause (A210-12.3), parties may

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.

not agree regarding whether there has been a 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, if parties have entered into an agreement with clear and verifiable terms this does not imply that the contract is enforceable.[31] This can only be determined by an actual court case. The American Institute of Architects has published a compendium of court cases involving contract disputes (see Stein (2001)). From these, one can learn whether or not a particular contract clause would be enforced as agreed. 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 court 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 several well known legal doctrines. We consider in turn the enforcement of the authority relationship, the choice between specific performance and expectation damages, and finally, rules that limit legal liability.

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

[31]The enforceability problem is not limited to construction contracts. For example, the courts will not enforce a contract in which a patient, prior to receiving medical 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).

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). 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 renegotiation, 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. In practice, supply contracts may have clauses that allow for changes in the quantity. In construction, one cannot always anticipate whether the design will be changed, and hence these contracts implement procedures to regulate the renegotiation process. 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 have shown 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. 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 without 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 the 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 are less deferential to the text of the contract.

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 expectation damages, namely compensating the harmed party for the losses that occurred due to the breach of contract.

A very controversial question is whether or not the courts should use the rule of *specific performance* as a measure of damages.[32] 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 expectation damages. These decisions are very controversial because they are interpreted as undermining the ability of parties to write binding contracts. We show that decisions are consistent with *efficient* procurement in our model.

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

[32]See Schwartz (1979) for example.

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 for 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.[33]

In our model, this 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. The court documents reveal that one reason Kent did not make the final payment was the result of a general dissatisfaction with the work of Jacob & Youngs.[34] 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 used 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 the seller control rights contractual instrument as a solution to opportunistic behavior by 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 *Jacob & 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 courts were to support such behavior then it would lead to higher costs *ex ante,* and less efficient contracts. Hence, the decision in *Jacob & Youngs v. Kent* is consistent with efficient procurement.

[33]The court consisted of seven judges with Hiscock, Hogan and Crance, concurring with Cardozo, while Pound and Andrews concurred with McLaughlin.
[34]See the discussion in Danzig (1978), page 120.

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 into 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 to observe that the Peevyhouses crossed out a term in the agreement that would have allowed Garland not to regrade the land in exchange for damages of \$5,000.[35] 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, the court 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. Thus, 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.[36] 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 might also 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 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.

[35] See Maute (1995).

[36] See Djankov et al. (2003) for some evidence on how courts operate in practice.

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, parties are able to enforce performance with expectation damages using of the various contractual instruments we have discussed above.

In 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 an 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 stipulated damages in the case of non-performance. Given that the courts in the US will not enforce stipulated 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 stipulated damages 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.

Schwartz and Scott (2008) observe that the AIA bonding contract allows the surety to be excused by paying an amount equal to the damages caused by the contractor. This, they argue, implies that even this instrument would not allow parties to ensure performance in US courts, and specifically in *Jacob & Youngs v. Kent.* However, the existence of this clause in the AIA bonding contract does not prevent the courts from enforcing performance in situations in which it appears to the courts that this is efficient, rather than award the buyer damages for diminution of value (i.e., those situations in which authority should be allocated to the buyers, not the sellers). For instance, in Kangas v. Trust [37], the contractor built a house with a basement ceiling that was several inches lower than that called for in the plans. The Trusts sued for damages equal to the cost of lowering the basement floor. In the end, rather than occupy the house, the house was sold. It was established that the

[37] 110 Ill.App.3d 876, 441 N.E.2d 1271, Ill.App. 2 Dist.,1982.

ceiling height did not adversely affect the sale price. Under Schwartz and Scott's interpretation of the law, this would imply that the Trusts would not be awarded any damages for the reduced ceiling height. The courts accepted the evidence that the contract specified that the height of the basement was an important ingredient of the design, and accordingly awarded the Trusts the costs of remediation.[38] This decision is consistent with the view that US courts do enforce the authority that is allocated to the buyers in a construction project.

Unforeseeable Events, Mistakes and Impossibility. There are several legal default rules that deal with events that are unforeseen at the time a contract is agreed. The first of these limit 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, $\Delta u = u(1,1) - u(0,1)$, were large, possibly larger than the cost of taking action to avoid late delivery. However, these losses were unforeseen by Baxendale. Our liability rule explicitly models the degree of foreseeability with $F(d)$. When an event is *unforeseen,* $F(d) = 0$, then the damages due are $l = F(d^*)\Delta u = 0$, a result that is consistent

[38]Specifically the judge ruled: "since damage arose from a willful violation of the building contract and since basement height was of "special value" to homeowners, owners could recover $20,000 from builder for fact that basement was four inches shorter than contracted for rather than diminution in value of the house."

with Hadley v. Baxendale.[39] Moreover, this result generalizes the analysis of Ayres and Gertner (1989) and Bebchuk and Shavell (1991) to the case of partial foreseeability when $F(d^*) > 0$.

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, as in *Mannix v. Tryon* (1907), 152 C 31. The court found that the decolorization of a building arose due to the specifications in the contract about the method used to mix plaster, and as a consequence the contractor was not held liable for the defect. In *McConnell v. Corona City Water Co.* (1906), 149 C 60, the contractor was excused for the collapse of the tunnel because the contractor had followed the design given by defection drawings. In each of these cases, the harm was significant, but the design was inadequate, corresponding to $F(d) = 0$, and 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. This paper contributes to the closing of this gap with an model that is designed to understand the structure of the form construction contracts sold by the American Institute of Architects. These contracts, and contracts quite similar in form, are widely used in the construction industry to allocated billions of dollars of resources. Within the context of our model, we show the optimal contract is a collection of *contractual instruments* - specific clauses that apply at different stages of the project, and for different contingent events. Each of these instruments have analogues in the the American Institute of Architects (AIA) form construction contracts, and hence they are enforceable under the common law rule of expectation damages, as used in the US and UK.

In contrast, the law and economics literature, including Shavell (1980), Rogerson (1984) and Edlin and Reichelstein (1996), claim that in general one cannot achieve the first best using expectation damages. Like much of the literature, these papers follow Grout (1984) and Grossman and Hart (1986), and suppose that the bargaining power of parties is exogenous. In contrast, we find that the AIA contracts have several contractual instruments, such as the bid bond, the change order

[39] 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.

instrument and the change order directive, that are specifically designed to increase the bargaining power of the buyer. There also exist some countervailing instruments that ensure that sellers recover their costs. Together, these observations illustrate how observed contracts that rely only upon the legal rule of expectation damages can use the allocation of authority to efficiently implement complex projects. These results complement the previous efficiency results of Chung (1991), MacLeod and Malcomson (1993) and Aghion et al. (1994) that illustrate how renegotiation design can achieve the efficient outcome under the legal rule of specific performance.

The AIA form contracts themselves are not static. They have evolved over one hundred years in response to industry experience and court rulings. This 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.[40] Specifically, we show that 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.

This analysis is only a starting point for a fuller investigation into how the law can shape the form of observed contracts.[41] As Djankov et al. (2003) show, there is enormous variation across countries in the way courts adjudicate contract disputes. It is likely 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.[42] 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.

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

[41] See for example Schwartz and Scott (2003). In their discussion of this paper they highlight the complexity of the law in practice. Even and how even if parties understand the intent of an agreement, they are always situations where courts do not enforce clearly specified obligations.

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

Appendix A. Proof of Propositions

Lemma. *The functions $S_B(d, e, \Delta c, \Delta u)$ and $S_S(d, e, \Delta c, \Delta u)$ are supermodular in (d, e) on $[0, \infty)^2 \times (0, \infty)^2$.*

Proof. Observe that

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

From Collorary 2.6.3 of Topkis (1998) we have that $F(d)F(e)\Delta c$ and $F(e)\Delta c$ are supermodular. Now S_B is a linear combination of supermodular functions and hence by Lemma 2.6.1 of Topkis (1998) it follows that S_B is supermodular. Similarly, S_S is supermodular. $\square$

This lemma greatly simplifies the proofs of the propositions because it implies that investments are complements and hence increasing or decreasing together when we change the exogenous parameters Δu and Δc from theorem 2.8.1 of Topkis (1998).

Proof of Proposition 1:

Proof. If $F'(0) < \frac{2}{\triangle u^* + \triangle c}$, then using the fact that $F'' < 0$, we get $d^* = 0$ regardless of the level of e^*. Next, $F'(0) < \frac{2}{\triangle u^* + \triangle c} < \frac{2}{\triangle c}$, which implies that $e^* = 0$.

If $\frac{1}{\triangle c} \geq F'(0) > \frac{2}{\triangle u^*}$, then $e^* = 0$ for all values of d^*, meaning that $F(e^*) = 0$. Then $\frac{2}{\triangle u^* + F(e^*)\triangle c} = \frac{2}{\triangle u^*} < F'(0)$, which by concavity of F gives $d^* > 0$.

If $F'(0) > max(\frac{2}{\triangle c}, \frac{2}{\triangle u^*})$, then by concavity of F, $e^* > 0$ regardless of d^* and $d^* > 0$ regardless of e^*. $\square$

Proof of Proposition 2:

Proof. This is similar to proposition 1. $\square$

Proof of Proposition 3:

In the second price auction with independent values it is well know that it is a dominant strategy to bid price that ensures one gets one's reservation value for the project, U_i^S. Given that only the fixed investment varies between sellers, then the low cost seller wins the auction and earns a rent $\delta = |A_1^S - A_2^S|$. Given that the rent is independent of the buyers contracts, then the buyer will choose the contract $k \in K$, and design, d that it maximizes

$$max_{k \in K, d \geq 0, i \in I} E(S_i(\omega, d, e^*(k,d))|k, D).$$

Proof of Proposition 4: For the unforeseen tasks component, the task will be completed only if $u^u \geq c^u$. The seller will complete the job as long as price paid for the task is greater than c^u. With design $d = 0$ for unforeseen components, and, $e = 0$. It is assumed that parties assign probability zero to the unforeseen events in occurring, and hence they do not provide any ex ante incentives.

Proof of Proposition 6: From the seller's pay off the first order condition is given by

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

where l is the penalty paid by the seller for the change of componet produced. If $l = F(d^*)\Delta u$, then $F'(e^*) = (2/(\Delta c + F(d^*)\Delta u))$, and thus BRR implements the efficient allocation.

References

Aghion, P., M. Dewatripont, and P. Rey (1994, March). Renegotiation design with unverifiable information,. *Econometrica 62*(2), 257–282.

Atkins, J. B. and G. A. Simpson (2006, September 15). Ch-ch-changes...managing risk in the change process. *AIArchitect 13*.

Ayres, I. and R. Gertner (1989). Filling gaps in incomplete contracts: An economic theory of default rules. *The Yale Law Journal 99*(87), 87–130.

Bajari, P. and S. Tadelis (2001, Autumn). Incentives versus transaction costs: A theory of procurement contracts. *RAND Journal of Economics 32*(3), 387–407.

Bebchuk, L. A. and S. Shavell (1991). Information and the scope of liability for breach of contract: The rule of Hadley v. Baxendale. *Journal of Law, Economics and Organization 7*(2), 284–312.

Che, Y.-K. and D. B. Hausch (1999, March). Cooperative investments and the value of contracting. *American Economic Review 89*(1), 125–47.

Chung, T.-Y. (1991, October). Incomplete contracts, specific investments, and risk sharing. *Review of Economic Studies 58*(5), 1031–1042.

Crémer, J. and R. P. McLean (1988, November). Full extraction of the surplus in bayesian and dominant strategy auctions. *Econometrica 56*(6), 1247–1257.

Danzig, R. (1978). *The Capability Problem in Contract Law.* Foundation Press.

Djankov, S., R. La Porta, F. Lopez-de Silanes, and A. Shleifer (2003, May). Courts. *Quarterly Journal of Economics 118*(2), 453–517.

Edlin, A. S. and S. Reichelstein (1996). Holdups, standard breach remedies, and optimal investment. *American Economic Review 86*(3), 478–501.

Farnsworth, E. A. (1999). *Contracts, 3nd edition.* Boston: Little, Brown and Company.

Goldberg, V. P. (1977). Competitive bidding and the production of precontract information. *Bell Journal of Economics 8*(1), 250–61.

Goldberg, V. P. and J. R. Erickson (1987). Quantity and price adjustment in long-term contracts: A case study of petroleum coke. *Journal of Law and Economics 30*(2), 369–98.

Grossman, S. J. and O. D. Hart (1986, August). The costs and benefits of ownership: A theory of vertical and lateral integration. *Journal of Political Economy 94*(4), 691–719.

Grout, P. (1984, March). Investment and wages in the absence of binding contracts: A Nash bargaining approach. *Econometrica 52*(2), 449–460.

Hart, O. D. (1990). Is “bounded rationality" an important element of a theory of institutions? *Journal of Institutional and Theoretical Economics 14*, 696–702.

Hart, O. D. (1995). *Firms, Contracts and Financial Structure.* Oxford, UK: Oxford University Press.

Hart, O. D. and J. Moore (1988, July). Incomplete contracts and renegotiation,. *Econometrica, 56*(4), 755–785.

Johnson, S., J. McMillan, and C. Woodruff (2002, April). Courts and relational contracts. *Journal of Law, Economics, and Organization 18*(1), 221–77.

Joskow, P. L. (1988, Apr). Price adjustment in long-term-contracts - the case of coal. *Journal Of Law & Economics 31*(1), 47–83.

Kanemoto, Y. and W. B. MacLeod (1992). The ratchet effect and the market for second hand workers. *Journal of Labor Economics 10*, 85–92.

Klein, B., R. Crawford, and A. Alchian (1978, October). Vertical integration, appropriable rents, and the competitive contracting process. *Journal of Law and Economics 21*, 297–326.

Laffont, J.-J. and J. Tirole (1986). Using cost observation to regulate firms. *Journal of Political Economy 94*, 614–641.

Macaulay, S. (1963). Non-contractual relations in business: A preliminary study. *American Sociological Review 28*(1), 55–67.

MacLeod, W. B. (2002). Complexity and contract. In E. Brousseau and J.-M. Glachant (Eds.), *Economics of Contract in Prospect and Retrospect*, pp. 213–240. Cambridge, UK: Cambridge University Press.

MacLeod, W. B. (2007, September). Reputations, relationships and contract enforcement. *Journal of Economics Literature XLV*, 597–630.

MacLeod, W. B. and J. M. Malcomson (1993, September). Investments, holdup, and the form of market contracts. *American Economic Review 83*(4), 811–837.

Maute, J. L. (1995). Peevyhouse v. Garland coal co. revisited: The Ballad of Willie and Lucill. *Northwestern University Law Review 89*, 1341.

McAfee, R. P. and J. McMillan (1987). Auctions and bidding. *Journal of Economic Literature 25*(2), 699–738.

McKelvey, R. D. and T. Page (2002, December). Status quo bias in bargaining: An extension of the myerson-satterthwaite theorem with an application to the coase theorem. *Journal of Economic Theory 107*(2), 336–355.

Mnookin, R. H. and L. Kornhauser (1979). Bargaining in the shadow of the law - the case of divorce. *Yale Law Journal 88*(5), 950–997.

Myerson, R. B. (1981). Optimal auction design. *Mathematics of Operations Research 6*(1), 58–73.

Myerson, R. B. and M. A. Satterthwaite (1983). Efficient mechanisms for bilateral trading. *Journal of Economic Theory 29*, 265–281.

Odams, A. M. (Ed.) (1995). *Comparative studies in construction law : The Sweet lectures*. London: Construction Law Press.

Posner, R. A. (2003). *Economic Analysis of Law, 6th Edition* (6th Edition ed.). Boston, USA: Little, Brown and Company.

Reny, P. J. (1992, May). Backward induction, normal-form perfection and explicable equilibria. *Econometrica 60*(3), 627–649.

Rogerson, W. P. (1984, Spring). Efficient reliance and damage measures for breach of contract. *RAND Journal of Economics 15*(1), 39–53.

Rogerson, W. P. (1992, October). Contractual solutions to the hold-up problem. *Review of Economic Studies 59*(4), 777–793.

Schwartz, A. (1979). The case for specific performance. *Yale Law Journal 89*, 271.

Schwartz, A. and R. E. Scott (2003, December). Contract theory and the limits of contract law. *The Yale Law Journal 113*(3), 541–619.

Schwartz, A. and R. E. Scott (2008, November). Market damages, efficient contracting and the economic waste fallacy. *Columbia Law Review 108*.

Segal, I. (1999, January). Complexity and renegotiation: A foundation for incomplete contracts. *Reveiw of Economic Studies 66*(1), 57–82.

Shavell, S. (1980, Autmn.). Damage measures for breach of contract. *Bell Journal of Economics 11*(2), 466–90.

Shavell, S. (1984, February). The design of contracts and remedies for breach. *Quarterly Journal of Economics 99*(1), 121–48.

Stein, S. G. M. (Ed.) (2001). *The American Institute of Architects Legal Citator*. New York: Matthew Bender.

Tirole, J. (1986, April). Procurement and renegotiation. *Journal of Political Economy 94*(2), 235–259.

Tirole, J. (1999, July). Incomplete contracts: Where do we stand? *Econometrica 67*(4), 741–782.

White, M. J. (1988). Contract breach and contract discharge due to impossibility: A unified theory. *Journal of Legal Studies 17*(2), 353–76.

Williamson, O. E. (1975). *Markets and Hierarchies: Analysis and Antitrust Implications*. New York: The Free Press.

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