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Surajeet Chakravarty
W. Bentley MacLeod

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ABSTRACT

Economic models of contract typically assume that courts enforce obligations based on verifiable events (corresponding to the legal rule of specific performance). As a matter of law, this is not the case. This leaves open the question of optimal contract design given the available remedies used by the courts. This paper shows that American standard form construction contracts can be viewed as an efficient mechanism for implementing building projects given existing legal rules. It is shown that a central feature of these 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 implies that the legal remedies of mistake, impossibility and the doctrine limiting damages for unforeseen events developed in the case of Hadley vs. Baxendale are efficient solutions to the problem of implementing complex exchange.

Surajeet Chakravarty
University of Exeter
s.chakravarty@exeter.ac.uk

W. Bentley MacLeod
Department of Economics
Columbia University
420 West 118th Street, MC 3308
New York, NY 10027
and NBER
bentley.macleod@columbia.edu

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

There are several ways in which actual contracts vary from those portrayed in economic models. First, economic models of contract typically assume that contracts are enforced as written (a legal rule known as specific performance). In contrast, in the United States the common law rule for breach of contract is that the court award damages for harm arising from the breach (the common law rule of specific expectation damages).[1] Second, economic models of contract are comprehensive in that a contract is modeled as a function that specifies outcomes/actions for every relevant state of the world. However, legally enforceable contracts are typically *modular* - they involve a great deal of "boiler-plate" and only a few terms are modified to deal with special circumstances in the relationship at hand.[2] These differences between theory and practice imply that results obtained from the theoretical economics literature on incomplete contracts may not be directly applicable to many observed contracts.

It is generally recognized that contracts for the exchange of complex goods are necessarily incomplete. Building upon the insights of Williamson (1975), the early literature on contract incompleteness has shown that the need to renegotiate a contract in the face of an unforeseen contingency my lead to inefficient investment into relationship specific investments.[3] However, it is difficult to tell whether a particular observed contract is efficient or not. There is also a general presumption that failure to enforce contracts as written (i.e. lack of specific performance) is likely to lead to inefficient outcomes.[4]

In this paper, we follow Goldberg and Erickson's (1987) suggestion that industry practice is a useful starting point for understanding efficient contract design. We analyze the standard form

[1] See chapter 12 of Farnsworth (1999).
[2] See Kahan and Klausner (1997) for a nice discussion of the law of boilerplate.
[3] See Tirole (1999) for a critical review of this literature.
[4] See Schwartz (1979) for a seminal statement of this view, and Schwartz and Scott (2008) for an up to date account of this argument.

construction contracts developed by the American Institute of Architects (AIA). These forms are used to allocate a large fraction of the resources devoted to construction in the United States, currently about 9% of U.S. GDP.[5]

Our main result is that these contracts are an efficient mechanism for implementing complex building projects in the "shadow" of American Law.[6] A key feature of these contracts is the inclusion of governance covenants that carefully allocate authority between the two parties, and limit the *ex post* bargaining power of the parties. For example, the AIA has a set of forms that are used for implementing an auction for the selection of a contractor. When a contractor wins, he knows that he is the low bidder, and hence has an incentive to try to renegotiate an increase in the contract price. The AIA forms address this problem by requiring bidders to post a bond that makes such renegotiation difficult. Moreover, in addition to ensuring that the low cost seller is awarded the contract, the auction also ensures that the buyer is the residual claimant to any future gains from trade. This in turn ensures that the buyer makes efficient investments into planning and design. AIA forms have many additional contractual instruments that allocate authority to either the buyer or the seller as a function of the events that occur during of the construction project. Together the various contractual instruments provided by the AIA forms use the law, as enforced in American courts, to ensure the construction of complex projects at the lowest cost.

Our model also provides a rule for contract damages that is a function of the extent to which an event is "foreseeable" or not. An implication of this rule is that it is optimal to excuse performance in situations when an event is not foreseen. This result implies that the current excuses from performance under American law are efficient damage rules. This includes the legal rule of "mistake," which can occur when one party did not understand an obligation, "impossibility", an unforeseen event occurs that makes performance impossible, and the doctrine limiting damages for unforeseen events developed in the case of Hadley vs. Baxendale .

The agenda of the paper is as follows. In the next section, we briefly discuss the relationship of this work to the literature. Section 3 outlines the procurement model we study and characterizes the optimal allocation. Section 4 discusses several contractual instruments that are found in the AIA form contracts, and show how together they implement the efficient allocation. In section 5, we

[5]Very similar contracts are used in other parts of the world. See Odams (1995).

[6]Mnookin and Kornhauser (1979) introduced the idea that contract renegotiation (divorce agreements in their case) typically occur outside the courtroom, but in the "shadow of the law". In our case, the AIA contract shapes *ex post* renegotiation taking into account the limits of legal enforceability.

show that our model provides a rule for contract damages that can explain several of the of excuses from performance of a contract as *efficient* default rules. The final section of the paper contains a concluding discussion.

2. Relationship to the Literature.

The early 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 that leads to *ex post* efficient allocations at the cost of providing inadequate incentives to make relationship specific investments.[7] 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. Bajari and Tadelis (2001) introduce a clever way to endogenize contract incompleteness based upon the idea that planning for the future is a relationship specific investment that affects the probability that a contract has a clear performance obligation for any realized state of the world. Taking the renegotiation game as given, and assuming the legal rule of specific performance, they show that the choice between a fixed price and cost plus contract depends upon the trade-off best the *ex ante* cost of planning and the *ex post* benefit in reduced costs of renegotiation. Tirole (2009) uses this idea to build an elegant and comprehensive model of incomplete contracts that provides predictions regarding contract duration, and the extent to which relational contracts are optimally incomplete.

Another line of the literature explores the conditions under which one has *efficient* contracting. Chung (1991) and Aghion, Dewatripont, and Rey (1994), building upon the general results of Moore and Repullo (1988), show that if one has the rule of specific performance available, then one can achieve the first best with a contract regulates the *ex post* bargaining power of parties through the appropriate manipulation of the default terms. Maskin and Tirole (1999) show that renegotiation design can ensure efficient even though goods are complex in that they cannot be described *ex ante.* Recently, Evans (2008) has shown that one can achieve efficient investment and trade in a model with simple contracts and an infinite horizon bargaining model.

There is also a literature on legal defaults that asks the question - how should the law set damages when a contract terms are missing or incomplete? The early work by Shavell (1984) and Rogerson

[7]See Che and Hausch (1999) for a rather general model illustrating the point that contract incompleteness leads to inefficient allocations. Similarly, Segal (1999) shows that contract complexity implies that parties choose a simple, but inefficient, fixed price contract.

(1984) considers the 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). They find that in general none of these rules achieve the first best, though specific performance is generally preferred to the other rules. Edlin and Reichelstein (1996) show that specific performance can ensure efficient trade, but expectation damages cannot achieve an efficiency allocation in their model.

The paper most related to our work is MacLeod and Malcomson (1993) who provide an early result on efficient contracting in the shadow of the law. The goal of that paper is explore how the holdup model can explain many features of observed contracts, such as wage and price rigidity. The model provides a explanation for Joskow (1988)'s puzzling observations regarding long term coal contracts. Joskow found that these contracts often have complex indexing provisions that ensure that contract price tracks the market price for coal. The puzzle then is why have a contract at all rather than simply use the market price? MacLeod and Malcomson (1993) show that the combination of the US law limiting the use of specific performance and the need to provide incentives to both parties to make relationship specific investments yields a contract with exactly this form that implements the first best.[8] Thus, even though the law constrains the set of feasible contracts, parties are still able to find contractual instruments that implement the efficient allocation.

This paper extends these results to the case of complex exchange exemplified by large construction projects. In this case, simple indexed contracts are not sufficient to implement an efficient allocation. Rather, efficiency is achieved with a complex combination of contractual instruments. Our results also illustrate that in contract design one must be cautious before concluding that expectation damages necessarily lead to an inefficient allocation, as the literature had thus far concluded.

3. 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.[9] The key ingredients of the procurement process are as follows:

[8]See proposition 6 or MacLeod and Malcomson (1993).

[9]See Klein, Crawford, and Alchian (1978) for a discussion of why contracts are needed in the presence of relationship specific investment. See also Hart and Moore (1988).

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

(2) Investment into planning by the buyer is assumed to be observable by the potential sellers, but not contractible. Bajari and Tadelis (2001) observe that project design provides a 'concrete' example of a relationship specific investment that is observable by both parties *ex post,* but cannot be explicitly contracted upon (Grossman and Hart (1986)). It is well known in the construction industry that contractors use information on the quality of project design when setting their bids.[10]

(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, etc. This complexity implies that 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 to 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 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

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

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 the execution of the project.

The next subsection 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. The next subsection 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:

(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.
   (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 resolved (in court if necessary).

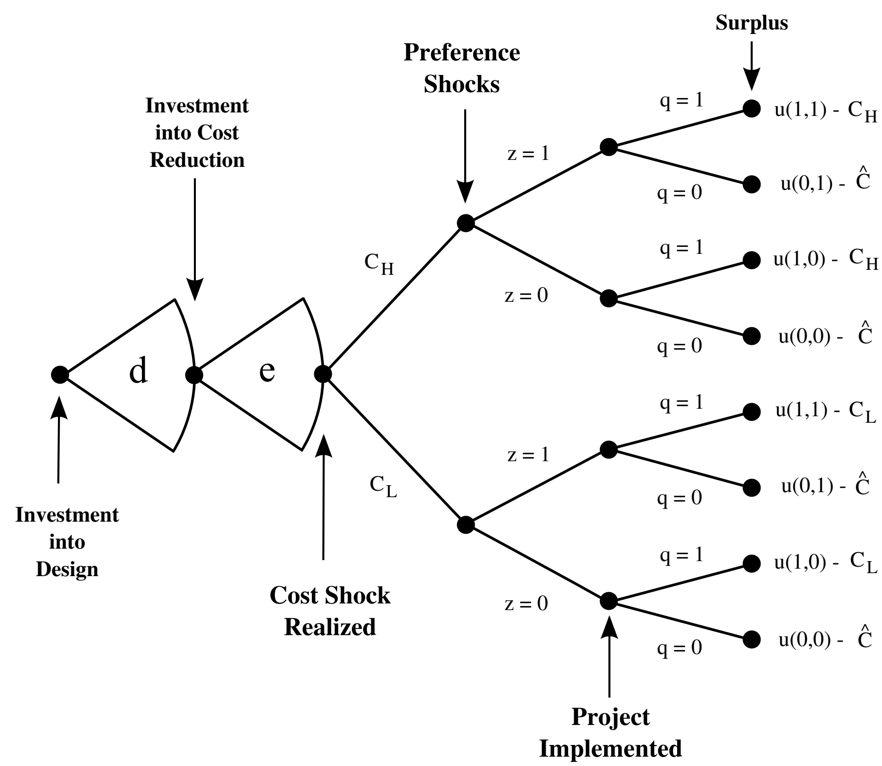

FIGURE 3.1. Time Line of Decisions and Events

Ex Ante Stage.

At step 1 (a) the buyer invests into 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.[11] The uncertainty due to design leads to two ways in which the

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

existing contract may have to be changed later. First, an existing component specification may be changed. Second, 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 that 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 without 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*.[12] 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 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

[12]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.

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.[13] 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, we use the same function, $\rho(.)$, 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, as 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. Without pecuniary transfers, the payoffs to the buyer and seller given the state, ω, and the realized project, $Q(\omega)$, are:

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

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

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

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 $\pi \in \Pi$ and Π 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 statics 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 whether 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 of whether or not to change the foreseen component. Given the preference shock z, it is efficient to keep the original design if and only if :

$$u(1, z) - u(0, z) \geq c - \hat{c}. \tag{3.1}$$

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:[14]

$$S_B(d,e) = u(0,0) - \hat{c} + (F(d)+1)\left(u(1,1) - u(0,0) + F(e)\Delta c\right)/2 - d - e, \tag{3.2}$$

where

$$F(x) = 2\rho(x) - 1 \tag{3.3}$$

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

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

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 characterized by:

$$F'(d^*) = \frac{2}{\Delta u^* + F(e^*)\Delta c}, \tag{3.4}$$

$$F'(e^*) = \frac{2}{(F(d^*) + 1)\Delta c}, \tag{3.5}$$

where $\Delta u^* = u(1,1) - u(0,0) \geq 0$ is the difference 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-verso. The marginal impact of planning upon foreseeability at zero investment is $F'(0)$, and 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 is no investment:* $d^* = 0$ *and* $e^* = 0$*;*
(2) *If* $\frac{1}{\triangle c} \geq F'(0) > \frac{2}{\triangle u^*}$ *there is strictly positive optimal planning,* $d^* > 0$*, and no cost reducing effort,* $e^* = 0$*;*
(3) *If* $F'(0) > max(\frac{2}{\triangle c}, \frac{2}{\triangle u^*})$ *then investment into planning and cost reduction is 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 it does not pay to plan. In this case, there would be no benefit to a long term contract. Conversely, when 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 $\Delta c > \Delta u$, where 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:

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

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

$$F'(d^*) = \frac{2}{\Delta u^* + F(e^*)\Delta u}, \tag{3.6}$$

$$F'(e^*) = \frac{2}{\Delta c + F(d^*)\Delta u}. \tag{3.7}$$

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 is no investment at all, $d^* = 0$, $e^* = 0$;*

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

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

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

As with buyer biased components, investments into planning and cost reduction are complementary. Case 1 also illustrates that if the gain from planning is sufficiently small, then there is no investment in planning nor cost reduction. 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 by the buyer that in turn guides the investment into cost reduction by the seller. The amount of investment into planning by the seller and cost reduction by 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[15]. These unforeseen components should be added whenever the benefit exceeds the cost.

4. 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

[15]Hart (1990) makes the point that if an event is not foreseen, then this cannot affect the level of relationship specific investment.

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.[16]

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 the 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.[17] 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.*[18] When information is symmetric, Aghion, Dewatripont, and Rey (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 cannot write a contract that achieves an efficient allocation, as formally shown by Rogerson (1984) and Edlin and Reichelstein (1996).

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

[17] Crémer and McLean (1988) demonstrate 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.

[18] See proposition 6 of Rogerson 1992.

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 to estimate an appropriate damage award.

Second, the efficiency result of Aghion, Dewatripont, and Rey (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 expectation 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: Choice of Seller. Contractors are typically selected by some form of sealed-bid auction. Normally, the owner chooses the lowest bid, although they have the legal right to choose any bidder they wish, and often they do not choose the lowest bid.[19] The reason is that some sellers may be either technically or financially incapable of executing the project, and hence may make unrealistically low bids. This 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, 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

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

thereby solves 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:*

$$max_{k \in K, d \geq 0, i \in I} E\left\{S_i(\omega, d, e(k, d))\,|k, d\right\}. \tag{4.1}$$

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 (4.1). Note that from the revenue equivalence theorem, as long as the fixed costs A_i^S are independently distributed across sellers, then a first price auction would also yield the same expected price and payoff.[20]

At this point we do not prove that a solution to (4.1) 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.[21] The second part is a *performance bond*. This bond ensures that should the contractor not complete the job, there are sufficient funds available to find another contractor who will be able to complete the work.[22]

Under form A312 the courts would never be asked to enforce performance per se. If a dispute arises and there is stoppage of work by the contractor, the buyer would ask the bonding company to

[20] See Myerson (1981).

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

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

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 contractor 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 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 on site, is the most efficient supplier (least cost) 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.[23]

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

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 on the price for the the change. 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 must produce 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* ($e = 0$.)

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 *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 an agreement on price has been reached. 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.[24] The COD reduces the ability of the seller to extract an 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.[25] 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 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.

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

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

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 CS 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:

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

If one compares this expression with the social surplus in (3.2), one can see that $\frac{\partial U^S}{\partial e} = \frac{\partial S_B}{\partial e}$, and hence under CS 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 CS 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 expectation 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 contracts' 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 for projects 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 that 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 principle 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 one should determine the anticipated use value. Suppose that when the seller decides to set $q = 0$, a penalty of l is paid to the buyer. In that case the expected utility of the seller is:

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

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

$$F'(e^*) = \frac{2}{\Delta c + l}. \tag{4.2}$$

Comparing (3.7) with (4.2) 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 ($\Delta c > \Delta u$) 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 the paper that the preferences of the buyer are neither 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 the case when:

$$l = F(d^*)\Delta u = 0. \tag{4.3}$$

This condition is satisfied when design has no effect upon the buyer's preferences, or when there is no investment into design. For example, the methods that the seller uses to implement the design should be of no concern to the buyer. In fact, if a seller has a superior construction method, the buyer would obtain a lower bid if she allows the seller to use such a method. This is reflected in clause 3.3.1 of the AIA form A201-1997:

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

Thus, the buyer does *not* have the right to directly control the employees of the contractor, and hence the construction relationship is not a form of employment relationship. Furthermore, under section 5 of A201-1997 the seller has the right to hire subcontractors subject to approval by the owner. We denote this contractual instrument by:

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

This instrument, combined with the buyer's right to make changes to the design clearly illustrates that the AIA form contracts *split control rights.*

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 table 1.

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 - Change Order Directive	*interim*	Obliges seller to make change.
A210-7.4 - Minor Changes	*interim*	Minor modifications create no change in price.
A210-3.3.1 - Seller Control	*interim*	Seller has right to organize production.
A210-12.3 - Remediation	*ex post*	Buyer can accept price reduction for non-conforming design.

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

5. 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.[26] 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.

[26]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).

Authority. The authority provided by change orders and change directives in AIA form contracts is very different from the standard assumption one makes in contract theory. To see this, suppose that a buyer and seller have agreed upon a contract to exchange q^0 units of a good at a price P^0. Further suppose that this requires significant relationship specific investment by the buyer (for example, the buyer might be a utility, who has built a train line to the mine supplying coal). Suppose that the buyer would like to increase the amount purchased. Models that allow for renegotiation, such as Hart and Moore (1988) or Aghion, Dewatripont, and Rey (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. However, 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.[27] 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, Dewatripont, and Rey (1994), that the courts use specific performance. In this section, we discuss two famous cases in which it would seem that specific performance is the natural remedy, but in which the courts awarded much smaller expectation damages. These decisions are very controversial because they are interpreted as undermining

[27] See Schwartz (1979) for example.

the ability of parties to write binding contracts. However, one can show that these 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). 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 in the contract. The contract also specified that the final payment of \$3,483.46 to Jacob & Youngs be conditional upon the successful 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.

Jacob and Youngs refused to make the changes because the pipes that were installed were of a quality that was equivalent to those manufactured by Reading Co and hence it made no economic sense to tear up the walls to replace the pipes. As a consequence, Jacob & Youngs felt justified in suing Kent for the final payment. At trial Jacob & Youngs were barred from submitting evidence regarding the quality of the replacement pipes, and the judge ruled for Kent.

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 very controversial, with three judges dissenting. The dissenting judges felt that since this ruling would have the force of law, it would undermine the ability of parties to write enforceable (and hence efficient) contracts.[28]

In our model, we show that 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 a result of a general dissatisfaction with the work of Jacob & Youngs.[29]

[28]The court consisted of seven judges with Hiscock, Hogan and Crance, concurring with Cardozo, while Pound and Andrews concurred with McLaughlin, the judge who wrote the dissenting opinion.

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

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 was motivated to use the technical requirement that the pipes be of the Reading brand to justify the non-payment. Given that Kent was not substantially harmed by the change of pipe brands, and did not plan to change the pipes, the non-payment could be viewed as *opportunistic* behavior in the sense of Williamson (1975).

One can view the SCR, or the seller control rights contractual instrument as a solution to opportunistic behavior by the buyer. During production a seller may take shortcuts, either inadvertent or consciously, that lower costs in a ways 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.

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). 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. This amount was less than the estimated cost of remediation of 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.[30] 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. This case has

[30]See Maute (1995).

generated a great deal of legal scholarship on the question of what the courts should have done. For parties who write contracts, this question is moot. Their concern is with writing a contract that is enforceable given the way the courts behave in practice. This is one goal of the AIA forms.

The AIA forms, specifically form A312, provide a solution via the *performance bond.* These bonds ensure 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. They price bonds as a function of the past performance of the seller purchasing the bond.

Should the surety not perform, given that the financial liability is clearly specified, the application of expectation damages is straightforward, and would in general equal the cost of completion or the limit on the bond, what ever is smaller. 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. In this case, the bond itself provides a measure of expectation damages since it would clearly specify that the buyer should be compensated for the cost of project completion up to some well defined limit. In contrast, Garland Coal breached a duty to returns good in a certain condition, for which the standard award is set equal to expectation damages when there are no liquidated damages.

If Kent, in *Jacob & Youngs v. Kent,* had wished to have Reading pipe for reasons other than the transport of water, then the contract should have included an explicit penalty class for 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 expectation damages, where the damages are measured by the stipulated penalty for non-performance.

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 would not do so in *Jacob & Youngs v. Kent.* However, this rule is not as general as one might think. For instance, in Kangas v. Trust [31], 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 ceiling height did not adversely affect the sale price. Under Schwartz and Scott's interpretation of *Jacob & Youngs v. Kent* 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. This result is consistent with the BRR (buyer remediation rights) rights clause found in the AIA forms.[32]

Unforeseeable Events, Mistakes and Impossibility. There are several legal default rules that deal with events that are unforeseen at the time an agreement regarding a contract is reached. The first of these limit liability to damages that are *foreseen,* as established in 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

[31] 110 Ill.App.3d 876, 441 N.E.2d 1271, Ill.App. 2 Dist.,1982.

[32] 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."

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 with Hadley v. Baxendale.[33] 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 the mistake doctrine. 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 Cal. 31. Here 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 Cal. 60 the contractor was excused for the collapse of the tunnel because the contractor had followed the design given by defective drawings. In each of these cases, the harm was significant, but the design was inadequate. This corresponds to $F(d) = 0$, and thus according to our rule no liability for the seller.

6. 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 a model that is designed to explain the structure of the form construction contracts sold by the American Institute of Architects. These contracts, and contracts quite similar to them in form, are widely used in the construction industry to allocated billions of dollars of resources. Within the context of our model, we show that the optimal contract is a collection of *contractual instruments or modules* - clauses that are tailored to specific events that may occur at different stages of the project.

Moreover, these clauses not only specify the obligations for each party, they also regulate the renegotiation of contract terms in the face of new information, including the allocation of decision making authority to the party who has the information most relevant to the decision at hand. Each of these instruments have analogues in the American Institute of Architects (AIA) form construction contracts. For example, the bid bond, the change order instrument and the change order directive

[33] 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.

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 upon the legal rule of expectation damages can use the allocation of authority to efficiently implement complex projects.

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.[34] 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. Our results show that the rule of expectation damages does not necessary contrain the efficiency of observed agreement. However, we do not provide a general theory of why the rule has its current form. Such as theory should explain the enormous variation across countries in the way courts adjudicate contract disputes (see Djankov, La Porta, Lopez-de Silanes, and Shleifer (2003)). 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. Though 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, McMillan, and Woodruff (2002), parties have increased reliance upon informal enforcement. We need a great deal of further work to understand the complex interplay between contract form, transactions costs, and the limits of legal enforcement.

Appendix A. Proof of Propositions

First, a preliminary lemma.

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

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 Corollary 2.6.3 of Topkis (1998), we have that $F(d)F(e)\Delta c$ and $F(e)\Delta c$ are supermodular. Since S_B is a linear combination of supermodular functions, then, by Lemma 2.6.1 of Topkis (1998), it follows that S_B is supermodular. Similarly, S_S is supermodular. □

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 $F'' < 0$, 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^*, implying 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^*. □

Proof of Proposition 2:

Proof. This is similar to proposition 1. □

Proof of Proposition 3: In the second price auction with independent values it is well know that it is a dominant strategy to bid a price that ensures that 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 buyer's contracts, then the buyer will choose the contract $k \in K$, and design, d, that solves

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

Proof of Proposition 4: For unforeseen components the price of completion is set equal to the observable cost, c^u, and thus under COI the buyer will add the task if and only $u^u \geq c^u$. If $e = 0$ is efficient, this implies by the complementarity of design and cost reduction that it is efficient to set $d = 0$. Hence, there is no *ex ante* gain from a contract, and it follows that COI efficiently implements this component.

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 component produced. If $l = F(d^*)\Delta u$, then $F'(e^*) = (2/(\Delta c + F(d^*)\Delta u))$, and thus BRR implements the efficient allocation.

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

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

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

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