Standard Breach Remedies, Quality Thresholds, and Cooperative Investments

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Abstract

When investments are non-verifiable, inducing cooperative investments with simple contracts may not be as difficult as previously thought. Indeed, modeling "expectation damages" close to legal practice, we show that the default remedy of contract law induces the first best. Hence, there is no need for privately stipulated remedies. Yet, in order to lower informational requirements of courts, parties may opt for a "specific performance" regime which grants the breached-against buyer an option to choose "restitution" if the tender's value falls below some (exogenously given) quality threshold.

Keywords: breach remedies, incomplete contracts, cooperative investments.

JEL-Classification: K12, L22, J41, C70

1 Introduction

When parties in bilateral trade make relationship-specific investments which have little value to third parties, markets do not protect them against opportunistic expropriation by their trading partner. This is when contracts are potentially useful. Yet, if we assume that contracts are inherently incomplete, they might not offer enough protection. As a result, the danger of hold-up would lead parties to invest less than the socially optimal level (Williamson 1979, 1985; Grout, 1984; Grossman and Hart, 1986; Hart and Moore, 1988).

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In response to this result of underinvestment, a large body of literature on contractual solutions to the hold-up problem has developed. By showing that simple (incomplete) contracts can achieve the first best in many situations, the literature argues that the incompleteness of contracts might not pose too serious a problem. There are two strands of this literature.

One strand considers the special informational environment of Hart and Moore (1988), who assume that it is impossible to contract on *any* investment-related information including quality of output. It shows that simple contracts can solve the hold-up problem if specific investments are selfish in nature. This is the case where, for example, a seller invests in order to reduce her cost or a buyer invests in order to increase his benefit from the procured good or service (Chung, 1991; Aghion, Dewatripont, and Rey, 1994; Nöldeke and Schmidt, 1995; Edlin and Reichelstein, 1996). Yet, these results do not carry over to the case of a supplier investing to adapt products to the buyer's special needs. Indeed, Che and Hausch (1999) show that contracts are completely useless in protecting such purely cooperative investments, if it is impossible to rule out ex-post renegotiation.[1]

The other strand of the literature is less explicit about informational assumptions and mainly concerned with the impact of the standard breach remedies of contract law on the efficiency of specific investments. Starting with the seminal papers of Shavell (1980, 1984) and Rogerson (1984), this literature asks how these breach remedies interact with simple contracts specifying little more than the good to be exchanged and the price to be paid (essentialia negotii). It often concludes that achieving the first best is possible.

Two such efficiency results exist for cooperative investments. Che and Chung (1999) show that, with costless renegotiation, a simple contract, which does not condition on investment, achieves the first best if the contract is governed by a regime of "reliance damages". This is a standard remedy of contract law under which the court orders the breaching buyer to reimburse the seller all his investments. Schweizer (2006) shows that a regime of "bilateral expectation damages" also achieves the first best even in bilateral investment problems, seemingly contradicting Che and Chung (1999) who argue that

[1] We borrow the term "cooperative investments" from Che and Hausch (1999). They were first studied in an incomplete contract setting by MacLeod and Malcomson (1995) and are also referred to as "cross investments" (e.g. Guriev, 2003) or "investments with externalities" (e.g. Nöldeke and Schmidt, 1995).

"expectation damages" do not induce any cooperative investments. Under this remedy, the court orders the breaching party to compensate the victim such that the latter is in as good a position as if the contract had been performed. The difference in results stems from Schweizer's assumption that parties can also claim damages if the counterparty underinvested relative to the level specified in the contract.

The puzzling coexistence of the "irrelevance of contracting" result in Che and Hausch (1999) and the "first-best" results in Che and Chung (1999) and Schweizer (2006) can be explained by the latter papers' (implicit) relaxing of informational assumptions. In order to enforce "reliance damages", investments have to be verifiable in court. Yet then, it is not very surprising from the perspective of contract theory that the first best should be feasible. Indeed, parties could also directly condition on investments in their original contract. For "bilateral expectation damages", also the buyer's valuation would have to be verifiable. Then, however, it follows from principal-agency theory that risk neutral parties will always be able to achieve the first best (e.g. Holmström, 1979).[2]

Still, the point is that efficiency is induced by real-world institutions of contract law, rather than by some fancy mechanism. Yet, the fact that different contract remedies with very different informational requirements necessary for enforcement are compared on equal footing reveals a rather cavalier attitude towards informational problems. In fact, this strand of literature simply *assumes* that courts possess all relevant information.

In our paper, we shall not stick to the *explicit* informational environment of Hart and Moore (1988) and Che and Hausch (1999) for two reasons. First, while certainly a very interesting polar case, it would imply that none of the *standard* breach remedies could be applied, except for "specific performance" (which only requires the court to enforce performance).[3] This, however, seems very restrictive for many purposes.[4] Second, we will show in Section 5 that it is sufficient to assume that courts are able to verify whether the

[2]Indeed, principal-agent literature has long been concerned with what Che and Hausch (1999) have called "cooperative investments" in the bilateral trade literature.

[3]In this sense Edlin and Reichelstein (1996) provide a result which is interesting for both strands of literature as long as they only speak of "specific performance". Yet they also provide results for "expectation damages".

[4]On the other hand, given that courts will not always be equally able to apply different breach remedies, we shall be precise regarding the informational requirements of the institutional solutions we propose.

good in question exceeds a certain minimal quality threshold in order to achieve first-best levels of cooperative investments. This is still much less than assuming that courts can observe the gains of trade for every possible realization of the good's quality level. Yet, it is enough for the "irrelevance of contracting result" of Che and Hausch (1999) to no longer apply.

We proceed by first revisiting "expectation damages", which is the default remedy of common law within the same framework as Che and Chung (1999). Expectation damages compensate the victim of breach in the amount of profit that he would have received had the contract been duly performed. Che and Chung (1999) show that it performs very badly inducing *zero* cooperative investments. This result, however, follows from their implicit assumption that the contract stays silent in terms of *required quality*. Yet, such contracts are virtually impossible to write. Even if the parties do not stipulate anything explicit as to quality in their contract, the court will do it for them by default, e.g. requiring the good to serve its purpose (implied quality). Taking this feature of real world contracting into account, we can show that expectation damages will always induce positive levels of cooperative investments. Indeed, it is possible to achieve the first best by writing so-called Cadillac contracts (Edlin, 1996) which define the highest possible quality level as the quality required under the contract. This result holds, even if, because of *non-verifiability of investments*, both "bilateral expectation damages" as proposed by Schweizer (2006) and "reliance damages" as advocated by Che and Chung (1999) are not available. Hence, as the default regime already induces the first best, there is generally no need for privately stipulated reliance damages, as proposed by Che and Chung (1999).

Still, reliance damages could be preferable for informational reasons. Expectation damages require the gains of trade to be verifiable. This imposes a considerable informational burden on courts. It will, however, depend on the circumstances whether reliance damages fare any better. Although accounting data is available, verifying investment is notoriously difficult. Contractors will always have the incentive to mischarge and misallocate costs. Karpoff and Vendrzyk (1999) report that "a total of seven different agencies monitor defense contractors to assure compliance with DOD [Department of Defense] regulations". Moreover, many "fraud investigations are triggered by audits of contractor's cost accounting records by the DOD's Defense Contract Audit Agency". Hence, even if there is evidence of the use of reliance damages as reported by Che and Chung (1999), the evidence also reveals the practice of costly monitoring by the Department of Defense.

Furthermore, reliance damages are not the only alternative, if parties doubt whether courts possess enough information to enforce expectation damages. Consider a regime, which allows the buyer to choose between "specific performance" and "restitution" if the tender's value is below some threshold and lets parties enforce the contract otherwise (SPR-regime). Under restitution, the parties are discharged of their duties under the contract, and the buyer recovers any progress payments that he might have made to the seller. As we will show, this regime also achieves the first best but, compared to expectation damages, lowers informational requirements considerably. Instead of observing the gains of trade for every possible realization of the tender's quality level, the court merely has to observe whether the tender's value is higher or lower than some *arbitrarily* chosen threshold. As we have argued before, this regime requires no more information to be verifiable than is *implicitly* assumed by Hart and Moore (1988). While it is difficult, even for an expert, to assess the absolute gains of trade in any possible instance, it should be relatively easy for him to testify whether the good is better or worse than some well-chosen benchmark. Whenever this poses fewer problems than verifying the absolute value of the seller's investment, we argue that parties who contemplate privately stipulated remedies, should use SPR instead of reliance damages.

Finally, we look at a regime applying to situations in which the seller is excused for not honouring the contract. In fact, while it is common in the literature to treat expectation damages as the default remedy, the real-world default regime is often more complex and part of a regime which gives the aggrieved party the option to choose between several remedies (Priest, 1978; Stremitzer, 2007a). It turns out that such a regime can also induce first-best cooperative investments without having to write Cadillac contracts, which seems to be more appealing as a *positive* theory of how parties induce cooperative investments.

The paper is organized as follows: Section 2 describes the model. In Section 3, we work out two benchmarks: the socially optimal level of investment and the investment level absent of institutional arrangements. In Section 4, we show that expectation damages induce first-best levels of cooperative investments. Our results pertaining to the SPR regime and the optional remedy regime which applies if non-performance is excused are derived in sections 5 and 6 respectively. Section 7 concludes.

2 The model

A buyer and a seller potentially trade a good. Both parties are risk neutral. In the first period, the seller makes a relationship-specific cooperative investment, $e \in \mathbb{R}_0^+$. The buyer's benefit from trade, v, is a random variable stochastically determined by the amount of the seller's investment, e, measured in money terms. The scrap or resale value of the good to the seller is 0.[5] The cost of the seller's performance is deterministic and equal to a known constant, $c > 0$. That is, the seller's investment is cooperative, and there are no selfish investments. This setting is identical to the setting studied in Che and Chung (1999).

The timing of the model, depicted in Figure 1, is as follows: At date 0, the buyer and the seller sign a contract. The contract specifies a fixed price p to be paid by the buyer upon performance as stipulated in the contract. It also specifies a quality level $\bar{v}$ and a lump sum payment t made by the seller to the buyer.[6] At date 1, the seller makes a cooperative investment: $e \geq 0$. At date 2, the buyer's benefit from the seller's performance, v, is drawn from $[0, v_h]$ by the distribution function $F(\cdot\,|e)$. The seller's cost of performance is deterministic and equal to c, where $0 \leq c < v_h$. At date 3, the parties play a breach game, in which they announce their willingness to deliver or accept the good and choose among the available breach remedies. This game will be explained in more detail below.

We assume that renegotiation has no associated costs and can occur at any time after date 3 and before the seller actually performs at date 4. The parties split the surplus

[5] Consequently there cannot be a threat point effect like in Edlin and Hermalin (2000).

[6] It is difficult to imagine a contract that does not stipulate required quality. Even if the parties do not write anything explicit about quality in their contract, the court will do it for them by default. In our example of the car manufacturer, the court would at least require the motor to work or to match the performance criteria of a benchmark product.

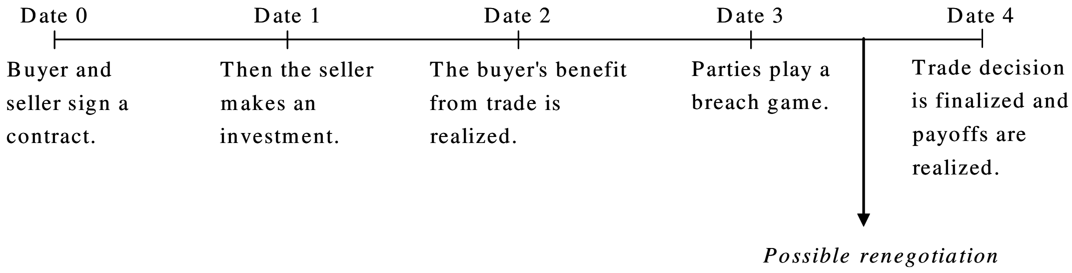

Figure 1: Timeline.

from renegotiation at an exogenously given fixed ratio, with the seller receiving a share $\alpha \in [0,1]$.[7] Under this assumption, the buyer's choice of legal remedy can be reversed whenever reversing it is mutually beneficial for both parties.

As a leading example, consider car manufacturer who contracts with an engineering firm to develop the motor for a new car. Assume that the development of the motor roughly consists of two stages: A design stage, where a prototype is developed; and an engineering stage, which prepares for production. If the parties sign a contract, the engineering firm will first invest into R&D to come up with a prototype. The quality of the prototype will tend to rise as investment into the design process increases. After the quality of the prototype becomes apparent, the parties decide whether to proceed to the engineering stage. This decision will be made in the shadow of the available legal remedies that define the threat points in negotiations.

Different legal remedies require different information to be verifiable. In the case of expectation damages (ED) the court must observe the buyer's valuation and the seller's variable cost. For restitution (R),whether the buyer's benefit from performance lies below or above a certain threshold level $\bar{v}$ must be observable. In the case of specific performance (SP), the court must only observe whether delivery has occurred. We assume that the court cannot verify the seller's investment. The seller's choice of investment may be private information. Everything else, however, is observable by the parties. The following technical assumptions are made throughout:

Assumption 1 $F(\cdot|\cdot)$ is twice continuously differentiable.

[7] The same ex-post bargaining setup was used by Edlin and Reichelstein (1996).

Assumption 2 $F_e(\cdot\,|e) < 0$ and $F_{ee}(\cdot\,|e) > 0$ for all v in $(0, v_h)$ and for all $e \geq 0$.

Assumption 3 $F_e(v\,|0) = -\infty$ and $F_e(v\,|\infty) = 0$ for all v in $(0, v_h)$.

Assumption 2 means that an increase in e moves the distribution in the sense of the first-order stochastic dominance at a decreasing rate, while Assumption 3 ensures an interior solution.

3 Benchmark

As a benchmark, we consider first-best outcome. It has two components: (i) the efficient trade decision has trade occur if and only if $v \geq c$, and (ii) the efficient investment level e_0, maximizes the net expected gains from trade, conditional on the efficient trade decision:

$$e_0 \in \arg\max W(e) \equiv \int_c^{v_h} (v - c)\ F_v(v\,|e)\ dv - e. \tag{1}$$

Integrating (1) by parts, the efficient investment level, e_0, is characterized by the following first-order condition:

$$W'(e_0) = -\int_c^{v_h} F_e(v\,|e_0)\ dv - 1 = 0. \tag{2}$$

If parties do not contract but simply bargain at date 3, they will split the gains of trade according to their respective bargaining power. The seller's expected payoff will then be:

$$U_n(e) \equiv \alpha \int_c^{v_h} (v - c)\ F_v(v\,|e)\ dv - e. \tag{3}$$

Integrating by parts and differentiating, we can write the first-order condition for the seller's optimal investment decision e_n:

$$U_n'(e_n) \equiv -\alpha \int_c^{v_h} F_e(v\,|e_n)\ dv - 1 = 0 \tag{4}$$

As $F_e(v\,|\cdot) < 0$ and $F_{ee}(v\,|\cdot) > 0$, it can be seen that the seller underinvests: $e_n < e_0$. By Assumptions 2 and 3, both e_0 and e_n are unique, finite, and strictly positive.

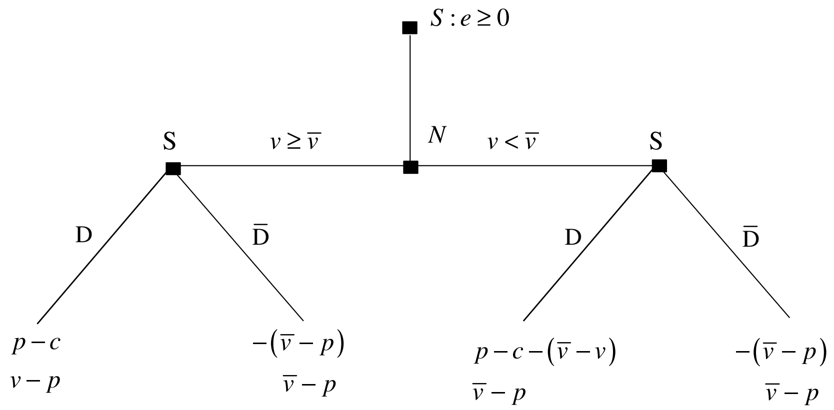

Figure 2: Subgame induced by ED starting with the seller's investment decision.

4 Expectation damages

4.1 Renegotiation impossible

First consider the game that is induced by the expectation damages remedy which is widely held to be the default remedy in the US.[8] Under this rule, the breaching party has to compensate his counterparty such that the latter is in as good a position as if the former party had fully performed.

Therefore, after quality v of the prototype is realized, the supplier faces the following decision: If he chooses to deliver the good, he receives the trade price, incurs production or supply costs, and has to compensate the buyer for having breached the contract if quality is below the required quality level $\bar{v}$. Hence the supplier's payoff is $p - c - [\bar{v} - v]^+$, where we shall frequently use the notation $[\cdot]^+ = \max[\cdot, 0]$. If he chooses not to deliver, and assuming $c < p < \bar{v}$, he merely has to pay the buyer damages of $\bar{v} - p$ (Figure 2). Note, that the court will calculate damages with respect to $\bar{v}$ because this is the quality that the supplier was required to deliver under the contract.[9]

It is easy to see that in subgame perfect equilibrium, the seller will take the efficient delivery decision, choosing to deliver whenever the value of the good is higher than

[8] Section 6 offers some qualifactions on this point.

[9] We have implicitly made the simplifying assumption that the buyer always accepts delivery. In Appendix A, we show that the analysis of this and the following subsection does not change if we allow both the seller *and* the buyer to breach.

variable cost of production, $v > c$. The seller's expected payoff is therefore:

$$U_{ED}(e) \equiv -(\bar{v}-p)\ F(c\,|e) + \int_c^{\bar{v}} [p-c-(\bar{v}-v)]\ F_v(v\,|e)\ dv + \int_{\bar{v}}^{v_h} (p-c)\ F_v(v\,|e)\ dv - e. \tag{5}$$

Rearranging and differentiating, we get the following first-order condition:

$$U'_{ED}(e) = -\int_c^{\bar{v}} F_e(v\,|e)\ dv - 1 = 0. \tag{6}$$

Comparing this expression with the benchmark condition (2) and observing that $U''_{ED}(e) < 0$ by Assumption 2, Proposition (1) immediately follows:

Proposition 1 *If renegotiation is not possible, expectation damages induce positive levels of cooperative investments. Underinvestment is generally the norm, yet investment incentives rise in required quality $\bar{v}$. If parties set required quality such that it cannot be met with positive probability, $\bar{v} \geq v_h$ (Cadillac contract, see Edlin, 1996), expectation damages can even implement the first best.*

This result stands in contrast to Proposition 1 of Che and Chung (1999), who claim that expectation damages induce *zero* cooperative investments if renegotiation is not possible. This follows from their implicit assumption that the contract says nothing about required quality. Yet, in practice, such contracts are virtually impossible to write. Even if the parties do not stipulate anything explicit regarding quality in their contract, the court will, by default, do it for them. In our example of the car manufacturer, the court would at least require the motor to work or to match the performance criteria of a reference product. As we will show in the next subsection, we can get a similar result when we allow for renegotiation.

4.2 Renegotiation possible

If renegotiation is possible, adjustments to the payoffs in Figure 2 need to be made.[10] If $v < \bar{v}$, it is still optimal for the seller to announce delivery for $v \geq c$ and to breach

[10] We follow Che and Chung (1999) and Che and Hausch (1999) in assuming that the possibility of renegotiation influences the parties' breach decision. This implies that the parties anticipate being able to renegotiate court decisions. In Rogerson (1984) parties can only renegotiate prior to going to court. In this case, the analysis of the previous subsection would remain unchanged.

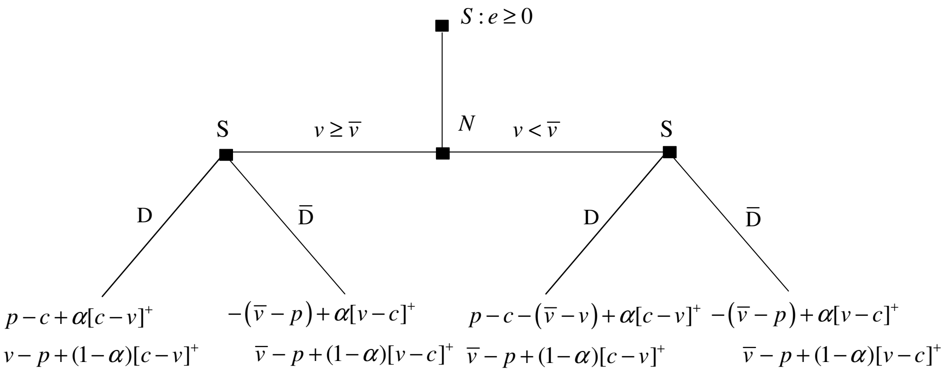

Figure 3: Subgame induced by expectation damages with renegotiation.

the contract for $v < c$. Hence, the seller's equilibrium payoffs will be $p - c - (\bar{v} - v)$ and $-(\bar{v} - p)$ respectively, just as in the case without renegotiation. If $v \geq \bar{v}$, however, equilibrium payoffs may change. Making the natural assumption that $c < p < \bar{v}$, the seller will breach the contract if:

$$v > \frac{\bar{v} - c}{\alpha} + c \equiv x(\bar{v}). \tag{7}$$

Intuitively imagine that an engineering firm develops a motor which is much better than required under the contract, $v >> \bar{v}$. By breaching the contract, it only has to pay damages of $\bar{v} - p$. This may be less than the seller's share in the renegotiation surplus of $\alpha(v - c)$. Hence, the seller will have an incentive to strategically breach the contract for sufficiently high realizations of v.[11]. Consequently, the seller's equilibrium payoffs will be $p - c$ for $v \leq x(\bar{v})$ and $-(\bar{v} - p) + \alpha(v - c)$ for $v > x(\bar{v})$.

The seller's expected payoff is therefore:

$$\begin{aligned} U_{ED}^{R}(e) \equiv & -(\bar{v} - p)\ F(c|e) + \int_{c}^{\bar{v}} [p - c - (\bar{v} - v)]\ F_v(v|e)\ dv \qquad (8) \\ & + \int_{\bar{v}}^{x(\bar{v})} (p - c)\ F_v(v|e)\ dv + \int_{x(\bar{v})}^{v_h} [-(\bar{v} - p) + \alpha(v - c)]\ F_v(v|e)\ dv - e. \end{aligned}$$

Rearranging and differentiating, we get the following first-order condition:

$$-\int_{c}^{\bar{v}} F_e(v|e)\ dv - a\int_{x(\bar{v})}^{v_h} F_e(v|e)\ dv - 1 = 0. \tag{9}$$

Comparing expression (9) with (6) and (2) respectively and observing that $x(\bar{v}) > \bar{v}$ for all $\bar{v}$ we can write the following proposition:[12]

[11]Courts may be reluctant to support such strategic breaches. We shall discuss this issue below in section 6.

[12]This result stands in contrast to Proposition 4 of Che and Chung (1999).

Proposition 2 *When required quality is low, $x(\bar{v}) < v_h$, expectation damages induce higher levels of cooperative investments if renegotiation is possible than if it is not. As required quality rises above a certain threshold, $x(\bar{v}) \geq v_h$, incentives under either assumption coincide. Cadillac contracts implement the first best. For $x(\bar{v}) < v_h$, incentives do not necessarily increase in required quality.*

4.3 Discussion

Although Edlin (1996) gives some examples of such contracts, we do not *generally* observe Cadillac contracts in reality. In our example of the car manufacturer, parties would not normally agree on a motor that cannot be built at the current state of technology. This makes the results of Propositions 1 and 2 unappealing as a positive theory of how parties induce first-best cooperative investments. Still, it is reassuring that expectation damages as the default common law remedy at least induce positive levels of such investments. Moreover, the first-best result could still qualify as a normative theory on how parties should write contracts. Then, however, one would have to argue why parties should prefer such a contract over a simple contingent contract where $p = v$ for $v > c$, and $p = 0$ otherwise.[13] Indeed, there are good reasons for relying on common breach remedies. Unusual contracting practices may raise suspicion if at least one of the parties is unsophisticated. Even if both are sophisticated, the parties might want to choose a mechanism that courts are familiar with. As courts are specialized in ruling on standard breach remedies, enforcing them will probably be reliable and relatively cheap (Che and Chung, 1999).

5 SPR with renegotiation

Expectation damages require that the gains of trade be verifiable. This imposes a considerable informational burden on courts. If parties doubt whether courts possess the necessary information to enforce expectation damages, we show that they can use a remedy regime which considerably lowers informational requirements while still achieving

[13] It is a standard result in the principal agency literature that such a scheme achieves first best for risk neutral agents (e.g. Holmström (1979)).

the first best. It combines the restitution remedy (R) with specific performance (SP). Under the regime (SPR), both the seller and the buyer can have the contract enforced if the tender is conforming to the contract, $v \geq \bar{v}$. In this case, the seller incurs costs of c, delivers the good of quality v to the buyer, and receives the agreed upon price p in return. Whenever the court's order to perform would result in inefficient trade, the parties renegotiate and split the renegotiation surplus $[c - v]^+$ according to their respective bargaining power.[14] In the case where quality is non-conforming, $v < \bar{v}$, the buyer can either insist on performance - such that the payoffs are as just described - or terminate the contract and ask for restitution.[15] Termination discharges all remaining obligations under the contract and restitution allows the buyer to recover any progress payment he might have made to the seller. As we assumed that the good does not have any value for the seller, the parties would both end up with 0 payoffs. Yet, once again, they will renegotiate whenever there is a positive renegotiation surplus, $[v - c]^+$.

In our example, this means that if the prototype is satisfactory, both the engineering firm and the car manufacturer can have the contract enforced, i.e., the second stage of the project will be realized, unless parties renegotiate. However, if the prototype is unsatisfactory, the manufacturer has the option to either terminate the contract or to continue to insist on performance. Figure 4 represents the subgame starting from the seller's investment decision. We go on to prove the following proposition:

Proposition 3 *Under a regime which lets the buyer choose between specific performance and restitution if the tender's value is below a certain threshold value $\bar{v}$ and otherwise grants the parties specific performance, there exists a price which induces first-best cooperative investments for all threshold values $\bar{v} \in [c, v_h)$. Under an additional assumption, the result extends to threshold values $\bar{v} \in (0, c)$.*

[14] As both the specific performance and restitution remedy do not automatically lead to ex-post efficient trade, there is no hope to achieve first-best unless renegotiation is possible.

[15] Strictly speaking, under the perfect tender rule, the court will examine if the tender corresponds to the quality features stipulated in the contract. Therefore, in theory, a buyer could terminate and ask for termination even if the non-conforming tender is better than a conforming one. Yet, courts are likely to deny termination in such a case, especially if parties have not defined in detail the product's quality features. In this case, the court has to decide ex post whether the tender is conforming, i.e., whether it corresponds to the quality features that the parties hypothetically would have written into the contract. It is inconceivable that this decision would not be strongly influenced by whether the product delivers good value to the client or not.

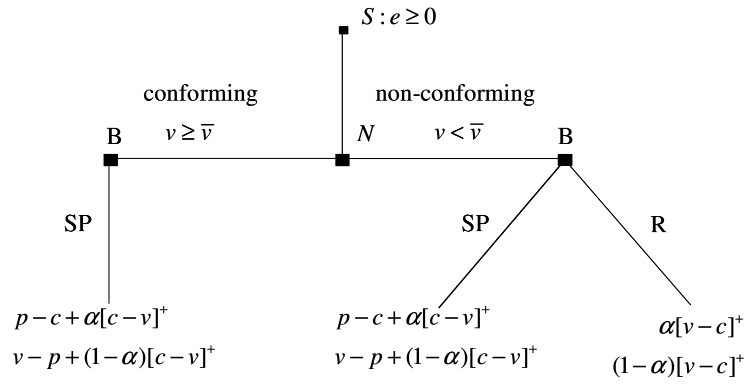

Figure 4: Subgame induced by SPR.

Proof. Assume that the quality threshold is set above or equal to variable cost, $\bar{v} \geq c$. For conforming quality, $v \geq \bar{v}$, this implies that no renegotiation surplus arises under specific performance. Payoffs are simply $p - c$ and $v - p$ for the seller and the buyer, respectively. For non-conforming quality, $v < \bar{v}$, termination will be optimal for the buyer if:

$$(1-\alpha)[v-c]^{+} > v - p + (1-\alpha)[c-v]^{+} \iff v < \frac{p-(1-\alpha)c}{\alpha} \equiv \check{v}(p). \tag{10}$$

Let p_{SPR1} be the optimal price and assume that it will be high enough such that:

$$\bar{v} < \check{v}(p_{SPR1}) \iff p_{SPR1} \geq p_L \equiv \alpha\bar{v} + (1-\alpha)c \geq c. \tag{11}$$

Then, whenever quality is non-conforming, we have $v < \bar{v} < \check{v}(p_{SPT})$ implying that the buyer will choose termination. Hence, the seller's expected payoff is:

$$U_{SPR1}(e,p) \equiv \alpha \int_c^{\bar{v}} (v-c)\ F_v(v\,|e)\ dv + \int_{\bar{v}}^{v_h} (p-c)\ F_v(v\,|e)\ dv - e. \tag{12}$$

Integrating by parts and partially differentiating with respect to e, gives us:

$$U'_{SPR1}(e,p) = \left[-\alpha \int_c^{\bar{v}} F_e(v\,|e)\ dv - 1\right] + [p_L - p]\, F_e(\bar{v}\,|e). \tag{13}$$

Given that e_0 is the first-best investment decision, it follows from expression (13), Assumption 2 and the benchmark condition (2) that $U'_{SPR1}(e_0, p_L) < 0$. As $U'_{SPR1}(e_0,p) \to \infty > 0$ for $p \to \infty$ and observing that $U'_{SPR1}(e_0,p)$ is continuous in p, we can argue by the intermediate value theorem that there exists a price $p_{SPR1} \in (p_L, \infty)$ such that $U'_{SPR1}(e_0, p_{SPR1}) = 0$. As it follows from $p_{SPR1} > p_L$ and Assumption 2 that

$U''_{SPR1}(e, p_{SPR1}) < 0$ for all $e \geq 0$, investment decision e_0 must be a global maximum of the seller's expected payoff function $U_{SPR1}(e, p_{SPR1})$. Hence, price p_{SPR1} induces the first-best investment decision for $\bar{v} \geq c$. (Note that assumption (11) is satisfied as $p_{SPR1} > p_L$). We relegate the proof for the case where the quality threshold is set below variable cost to Appendix B. ■

Remark 1 *Extending the result to threshold levels below variable cost will always be possible if the seller's bargaining power is sufficiently low or if the quality threshold is set only slightly lower than variable cost. Interestingly, it will also hold for sufficiently low(!) quality thresholds. A general sufficient condition is that* $F_e(v|e_0)/F_{ee}(v|\cdot)$ *is non-increasing in* $v \in [\bar{v}, c)$. *This will, for example, hold true for the class of separable distribution functions:* $F(v|e) = k(v)g(e) + h(v)$ *(see Appendix B for an explicit example).*

The intuition of the proof is as follows: If it were possible to always terminate and ask for restitution, the seller would underinvest due to buyer hold-up. Indeed, his payoff would be $a(v - c)$ just as in the no-contract case. Yet, under SPR, termination is only available if the tender's value is below the threshold. If, however, the seller produces high quality, the contract is enforced, and the seller derives a payoff of $p - c$. Hence, $p - c$ acts as a *quality premium* for the seller. The higher this premium, the higher the seller's investment will be, as, by investing, he can increase the probability of exceeding the quality threshold. Therefore, by choosing an appropriate price p, it is possible to counterbalance the underinvestment effect due to the hold-up effect.[16] In fact, the regime induces an incentive contract stipulating two different payoffs for the agent, depending on whether the output is above or below some threshold level.

In order to enforce this regime, the court has to observe 1) the contract price, 2) whether delivery took place, and 3) whether the value of the good exceeds the quality threshold. Obviously, the third requirement is the most problematic. It should be clear, however, that less information is needed than under expectation damages where the whole range of possible realizations of the tender's value has to be verifiable. In our example, the court would have to observe the exact value that the proposed motor design will

[16]Note, however, that price will have to become extremly high for $F_e(\bar{v}|\cdot) \to 0$. This will often be the case for $\bar{v} \to v_h$ and $\bar{v} \to 0$.

have to the manufacturer. Under SPR, it suffices that the court can observe whether the prototype is better or worse than some *arbitrarily* chosen threshold.

A natural benchmark could be the quality of a reference product. Suppose that a competitor already has his car on the market. Then it is clear that a prototype that does not at least match this existing product should be deemed unsatisfactory. While it is difficult, even for an expert, to assess the absolute value of some new design, it should be relatively easy to assess whether it is better or worse than some well chosen benchmark.

This has an interesting implication for contracting: Parties can privately stipulate breach remedies - and frequently do so for important projects. Yet, even then, they will not normally design a mechanism from scratch but rather use basic legal remedies which courts are familiar with. Our analysis suggests that the SPR regime might be an attractive choice: It achieves the first best but, compared to the default expectation damages regime, it lowers informational requirements.[17]

6 EDR with renegotiation

In this section, we will analyze the default regime which broadly applies in both common and civil law for situations where the seller is excused for non-performance. It is based on expectation damages for partial breach.[18] As a matter of fact, the first best can be achieved without having to write Cadillac contracts.

Under the regime, the buyer has the option to choose between expectation damages for partial breach (ED) and restitution (R) whenever quality is non-conforming, $v < \bar{v}$.[19]

[17] Common law courts have traditionally limited the parties' power to privately stipulate specific performance (Farnsworth (2004), §12.7, p. 751). The same restrictions generally apply for stipulating very high damage payments in the event of breach (liquidated damages) on the ground that they indirectly achieve the same as specific performance. The reason is the "fundamental principle that the law's goal on breach of contract is not to deter breach by compelling the promisor to perform, but rather to redress breach by compensating the promissee" (id, § 12.18 p. 811). The modern trend, however, is in favor of the extension of specific performance (id, §12.4 p. 743). Revised article 2 of the Uniform Commercial Code gives effect to such agreements. California amended §1671 of its Civil Code as early as 1977, to make liquidated damages provisions valid.

[18] As the seller's non-performance is excused, the buyer cannot demand damages for total breach. As a matter of legal doctrine, he cannot ask for "damages" at all but only for a reduction of the price. There is even a distinct remedy of this name in civil law countries. Yet, it is recognized that, in practice, price reduction leads to roughly the same result as expectation damages for partial breach (Kropholler (2006) §281 Rz 5; RegBegr BT-Drucks 14/6040, 226).

[19] Unlike previously agued, we assume that the buyer can terminate the contract and demand restitution, even if the non-conformity is not "material". This would be true under the "perfect tender rule" of

Otherwise, if $v \geq \bar{v}$, the victim of breach is granted expectation damages. However, in a modification of the standard regime, we follow Che and Chung (1999) in assuming that the seller cannot unilaterally breach the contract by refusing to deliver. Although they treat this as a purely technical assumption, this may be a fairly accurate description of reality. Indeed, §649 of the German BGB gives specific performance to the buyer against a breaching seller but only expectation damages to the seller against a breaching buyer.[20]

We will now describe the breach game induced by this regime (hereafter referred to as "EDR"). After realization of the tender's value at date 2, the seller can either announce his intention to deliver or not (Figure 5). If the seller refuses to deliver ($\bar{D}$), the buyer can choose between specific performance (SP) and expectation damages (ED). If he chooses specific performance, payoffs are:

$$\begin{aligned} \Pi_S\left(\bar{D},\ SP\right) &= p - c + \alpha[c-v]^+ \text{ and} \\ \Pi_B\left(\bar{D},\ SP\right) &= v - p + (1-\alpha)\left[c-v\right]^+. \end{aligned} \tag{14}$$

Note that we assume throughout that parties will negotiate towards the efficient ex-post trade decision. As, under specific performance, the court orders the good to be traded, parties only need to renegotiate if $c > v$. When the buyer chooses expectation damages, renegotiations will only occur for $v > c$ and payoffs are:

$$\begin{aligned} \Pi_S\left(\bar{D},\ ED\right) &= -[\bar{v}-p]^+ + \alpha\left[v-c\right]^+ \text{ and} \\ \Pi_B\left(\bar{D},\ ED\right) &= [\bar{v}-p]^+ + (1-\alpha)\left[v-c\right]^+. \end{aligned} \tag{15}$$

In the case where the seller announces delivery (D), the buyer declares whether he intends to accept the good or not. If he accepts (A), the good is traded. The seller incurs production cost c and receives price p but has to compensate the buyer for the

§2-601 Uniform Commercial Code. Also in Roman law, the buyer was allowed to choose freely between actio quanti minoris and actio redhibitoria.

[20] In this particular case, common law courts are also likely to grant specific performance to the buyer, despite their general reluctance to do so: Imagine that an engineering firm develops a motor which is much better than required under the contract, $v >> \bar{v}$. By breaching the contract, it only has to pay damages of $\bar{v} - p$. This may be less than the seller's share in the renegotiation surplus which is $\alpha\,(v-c)$. Given that the good is relationship specific, it is obvious that the seller does not breach the contract, because he has found another buyer with higher valuation. His only objective can be to extract additional surplus from the buyer in renegotiation. Courts are, however, reluctant to lend their hand to a party which breaches strategically in order to increase its bargaining leverage (Nothern Ind. Pub. Serv. Co. v. Carbon County Coal Co., 799 F.2d 265, 279-80 (7th Cir. 1986) cit. in: Lyon and Rasmusen (2004)).

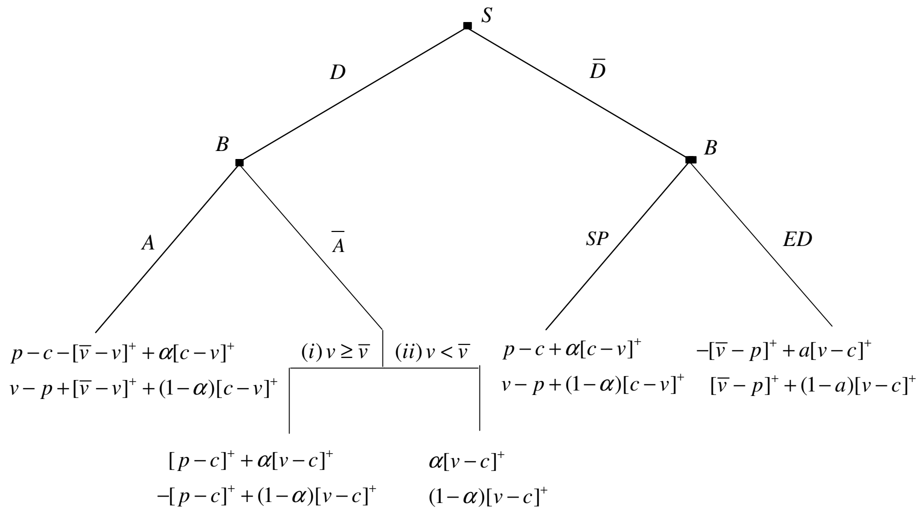

Figure 5: Subgame induced by EDR.

non-conformity, $\bar{v}-v$. Payoffs will be:

$$\begin{aligned} \Pi_S(D,\ A) &= p-c-[\bar{v}-v]^{+}+\alpha\,[c-v]^{+} \text{ and} \\ \Pi_B(D,\ A) &= v-p+[\bar{v}-v]^{+}+(1-\alpha)\,[c-v]^{+}. \end{aligned} \tag{16}$$

If the buyer chooses to reject the seller's tender $\left(\bar{A}\right)$, legal consequences differ depending on whether the tendered good was conforming to the contract (i) or not (ii).

(i) Conforming tender $\mathbf{v} \geq \bar{\mathbf{v}}$. If the buyer rejects a conforming tender, the seller can recover damages of $[p-c]^{+}$. Payoffs will be:

$$\begin{aligned} \Pi_S\left(D,\ \bar{A}\right) &= [p-c]^{+}+\alpha[v-c]^{+} \text{ and} \\ \Pi_B\left(D,\ \bar{A}\right) &= -[p-c]^{+}+(1-\alpha)\,[v-c]^{+}. \end{aligned} \tag{17}$$

We can proof the following lemma:

Lemma 1 *If the good is conforming to the contract, $v \geq \bar{v}$, and, ruling out that both the threshold and the price are set below variable cost, $\bar{v} < c \wedge p < c$, the seller will realize equilibrium payoff $p-c$.*

Proof. Appendix C1. ■

(ii) Non-conforming tender $v < \bar{v}$. If the tender is non-conforming to the contract, the buyer does not become liable for rejecting delivery. On the contrary, the buyer has the legal right to terminate the contract and to ask for restitution. He can recover any progress payment that he might have made to the seller. Therefore, the parties' payoffs are confined to their share in the renegotiation surplus:

$$\begin{aligned}\Pi_S\left(D,\ \bar{A}\right) &= \alpha[v-c]^+ \text{ and} \\ \Pi_B\left(D,\ \bar{A}\right) &= (1-\alpha)\left[v-c\right]^+.\end{aligned} \tag{18}$$

Solving the subgame, given that the seller has announced not to deliver $(\bar{D})$, we can prove the following lemma:

Lemma 2 *If the good is non-conforming, $v < \bar{v}$, and ruling out $\bar{v} < c \wedge p < c$, it will never be optimal for the buyer to choose specific performance.*

Proof. Appendix C2. ■

We now look at the subgame, given that the seller announces delivery (D), and find that it can only be optimal for the buyer to choose acceptance (A) if:

$$\bar{v} - p + (1-\alpha)\left[c-v\right]^+ \geq (1-\alpha)\left[v-c\right]^+. \tag{19}$$

Rearranging this condition, it can be written as:

$$v \leq \frac{\bar{v}-p}{1-\alpha} + c \equiv \hat{v} \tag{20}$$

which is very intuitive, as the buyer is more likely to terminate the contract and renegotiate if the renegotiation surplus is high (high v), and he can expect a big share in the renegotiation surplus (low α). We can now prove the following lemma:

Lemma 3 *Ruling out parameter constellations where $\bar{v} < c \wedge p < c$, the following holds for the seller's equilibrium payoff if the good is non-conforming to the contract: 1) If $p < \bar{v}$, the seller's payoff will be $-(\bar{v}-p)$ for $0 \leq v \leq c$, $p - c - (\bar{v} - v)$ for $c < v < \hat{v}$ and $\alpha(v-c)$ for $v > \hat{v}$. 2) If $p \geq \bar{v}$, payoffs will be 0 for $0 \leq v \leq c$, and $\alpha(v-c)$ for $v > c$.*

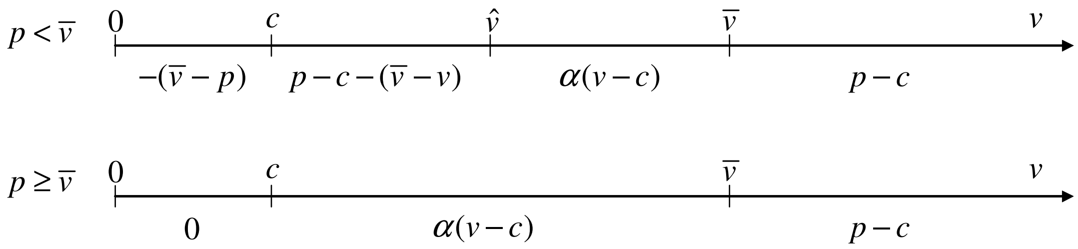

Figure 6: Seller's equilibrium payoffs under EDR.

Proof. Appendix C3. ∎

Figure 6 summarizes Lemmas 1-3.[21] We will prove the following proposition:

Proposition 4 *Under a regime which allows the buyer to choose between expectation damages for partial breach and restitution if the tender is non-conforming and grants expectation damages otherwise, there exists a price which induces first-best cooperative investments for every possible threshold value* $\bar{v} \in (0, \infty)$.

Proof. The proof comes in two parts. (i) First, we show that the first best can be achieved if the threshold is set below or at variable cost, $\bar{v} \leq c$. (ii) Then, we show that this is also true for $\bar{v} > c$.[22] (i) Suppose that $\bar{v} \leq c$. Further assume that the optimal price will exceed variable cost:

$$p_{EDR1} > c. \tag{21}$$

Then, by $\bar{v} \leq c$ it follows that $p_{EDR} > \bar{v}$, such that the seller's payoff will be 0 for all $v \in (0,\ \bar{v})$ and $p - c$ for $v \geq \bar{v}$. Therefore, the seller's expected payoff is:

$$U_{EDR}(e, p) \equiv (p - c)\left(1 - F\left(\bar{v}\,|e\right)\right) - e. \tag{22}$$

Taking partial derivatives with respect to e we get:

$$U'_{EDR}(e, p) \equiv -\left(p - c\right) F_e\left(\bar{v}\,|e\right) - 1. \tag{23}$$

It follows from Assumption 2 that $U'_{EDR}(e_0, p = c) = -1 < 0.$ and $U'_{EDR}(e_0, p) \to \infty > 0$ for $p \to \infty$, where e_0 is the first-best investment decision. As $U'_{EDR}(e_0, p)$ is continuous

[21] Note that we do not wish to imply by Figure 6 that intervals are non-empty.

[22] Note that we will not assume $\bar{v} < c \wedge p \leq c$ in any part of the proof, so that the equilibrium payoffs represented in Figure 6 apply throughout. Also note that the results do not change if we assume that the buyer moves first to announce his intention to reject the good.

in p, it follows by the intermediate value theorem that there exists a $p_{EDR1} \in (c, \infty)$ such that $U'_{EDR}(e_0, p_{EDR1}) = 0$. It follows from $p_{EDR1} > c$ and Assumption 2 that

$$U''_{EDR}(e, p_{EDR1}) \equiv -(p_{EDR1} - c) F_{ee}(\bar{v}|e) < 0. \quad (24)$$

Hence, e_0 is a global maximum of the seller's expected payoff function $U_{EDR}(e, p_{EDR1})$. (Note that assumption (21) is satisfied for $p = p_{EDR1}$). We relegate the proof of part (ii) to Appendix D. ■

The intuition for the result is the following: (i) For low-quality thresholds, $\bar{v} \leq c$, the seller's payoff is $p - c$ if the value exceeds the threshold and 0 otherwise. Hence, the attractiveness of producing high quality increases in the price. As the seller can increase the probability of high quality by increasing investments, it is possible to use the price to adjust the seller's investment incentives to the efficient level. A similar balancing argument is behind the result for high quality thresholds, $\bar{v} > c$ (ii).[23] Finally, it is possible to make EDT degenerate into ED so that we can derive a Cadillac contract result analogous to Proposition 1

We have already argued that the result of Section 4 showing that the first best can be achieved under ED by writing Cadillac contracts is not very appealing as a positive theory of how parties induce first-best cooperative investments. Indeed, we do not generally seem to observe Cadillac contracts in reality. Proposition 4 might fill this gap. It is based on expectation damages but modelled more closely to the more complex optional structure of real-world legal regimes. As we gain additional degrees of freedom, we can derive a first-best result for *arbitrarily* chosen quality thresholds. Hence, the first best can also be achieved for more natural contracts stipulating intermediate levels of quality.

7 Conclusion

Our paper makes the following three points: 1) The existing default legal regime already induces first-best cooperative investments. Hence, there is no urgent need for privately

[23] Yet, as an additional complication, we have to take into account that the seller's payoff depends on the buyer's choice of breach remedies, which in turn depends on the contract price. If price is set above a certain threshold, the buyer will always terminate. However, for such prices, we can show that the balancing argument does not always work: Overinvestment will occur for some parameter constellations. Still, for exactly these parameter constellations, parties will achieve the first best by setting a lower price for which expectation damages will also be chosen in equilibrium.

stipulated remedies in order to induce cooperative investments. 2) If the parties doubt whether the court possesses enough information to apply expectation damages, they can create legal remedies of their own. Che and Chung (1999) suggest that they use reliance damages. We argue that, in some cases, it is easier for courts to verify whether the buyer's valuation exceeds some well-chosen quality threshold than to verify the absolute value of the seller's investment. Then, parties should prefer a regime combining specific performance and restitution (SPR) over reliance damages. 3) In order to apply the SPR regime, only little more information needs to be verifiable than is assumed by Che and Hausch (1999). Moreover, our analysis lends support to the broader trend for expanding the use of specific performance in common law. Specifically, it should be in the power of the parties to enlarge the availability of specific performance by dispensing with the adequacy test and other criteria for such relief. Finally, it could be a promising avenue for future research to devise incentive schemes by using common breach remedies of contract law as basic building blocks in optional remedy regimes.

8 Appendix

8.1 Appendix A: Allowing for buyer's breach

8.1.1 ED without renegotiation

Rather than assuming ad hoc that the buyer never breaches the contract we will now show that legal remedies of contract law *induce* the buyer to accept delivery.[24]

Conforming quality, $\mathbf{v \geq \bar{v}}$. If quality is conforming non-acceptance $\left(\bar{A}\right)$ of the supplier's tender constitutes breach. Hence, the supplier can recover damages of $[p - c]^+$(Figure 7). Under the natural assumption that the price is set such that $p \in (c, \bar{v})$, we see that $v - p > -[p - c]^+$ for all $v \geq \bar{v}$. Hence, the buyer will accept delivery in equilibrium. Under the substantial performance doctrine, different remedies will be available

[24] Although Che and Chung (1999) make the opposite simplifying assumption, namely, that the *seller* never refuses to deliver, the underlying sequence of decisions is the same as in our paper. Obviously, trade can only occur if the seller decides to deliver and the buyer decides to accept. Their analysis, like ours, does not change by taking account of this extensive version of the game. Also note, that it is straightforward to show that the timing of delivery and acceptance decisions does not matter.

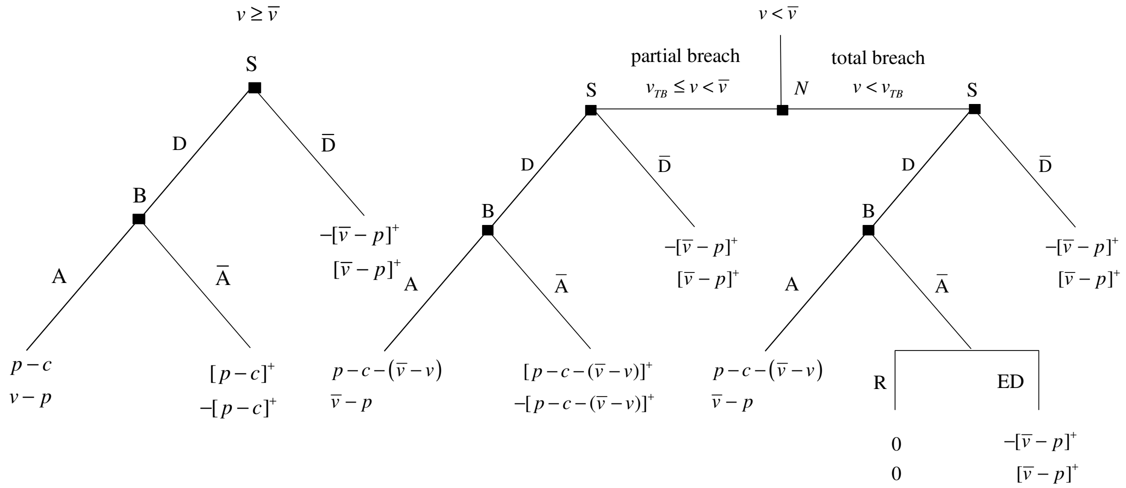

Figure 7: ED without renegotiation if the buyer is allowed to breach.

depending on whether the non-conformity amounts to total breach or not.[25]

Non-conformity constitutes partial breach, $\mathbf{v}_{TB} \leq \mathbf{v} < \bar{\mathbf{v}}$. If quality is non-conforming it is less clear why the buyer should be obliged to accept delivery. Yet, if breach due to non-conforming quality is non-material, $v_{TB} \leq v \leq \bar{v}$, the buyer is indeed only allowed to demand damages for partial breach. Therefore, if the buyer rejects delivery, the supplier can recover the full price, minus cost saved, minus damages to which the buyer would have been entitled: $[p-c-(\bar{v}-v)]^+$. For $p \in (c, \bar{v})$, we see that $\bar{v}-p > 0 \geq -[p-c-(\bar{v}-v)]^+$. Hence, the buyer will accept delivery in equilibrium.

Non-conformity constitutes total breach, $\mathbf{v} < \mathbf{v}_{TB}$. If, however, the non-conformity is material, $v < v_{TB}$, the buyer can terminate the contract. In this case he can ask for restitution (R) under which he can recover any progress payment that he might have made to the seller. Both parties end up with 0 payoff as the good has no value to the seller. Alternatively, the buyer can recover damages for total breach, $[\bar{v}-p]^+$. Assuming that the parties will coordinate on the Pareto efficient equilibrium and $p \in (c, \bar{v})$, the buyer will accept for $v - c > 0$ and reject for $v - c \leq 0$. It is optimal for the seller to refuse to deliver if $v - c \leq 0$. Hence, an equilibrium exists where the buyer will choose

[25]We analyse a regime where every non-conformity can be treated as total breach ("perfect tender rule") in Section 6.

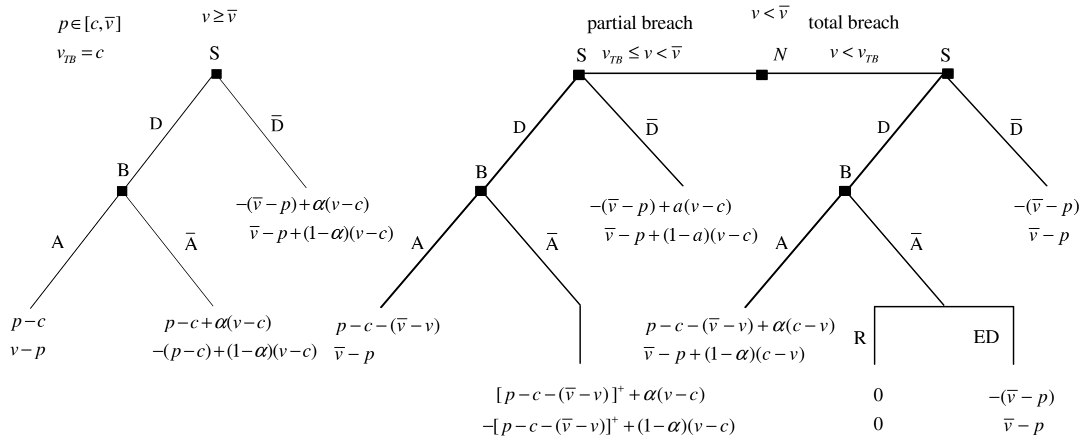

Figure 8: ED with renegotiation if the buyer is allowed to breach.

acceptance on the equilibrium path.[26]

8.1.2 ED with renegotiation

If we assume that parties renegotiate towards the ex-post efficient trade decision, adjustments to the payoffs in Figure 7 need to be made: If e.g. the buyer rejects the seller's tender, although trade is efficient $v > c$, parties will renegotiate splitting the resulting surplus of $v - c$ according to their respective bargaining power. Similarly the parties will renegotiate if the buyer accepts the tender, although $c \leq v$ (Figure 8, note that we continue to assume $p \in (c, \bar{v})$).If the tender is conforming, $v \geq \bar{v}$, the buyer will accept in equilibrium as $-(p-c)+(1-\alpha)(v-c) = v-p-\alpha(v-c) < v-p$ is true for all $p \in (c, p)$ and $\bar{v} \leq v$. We make one additional assumption which is crucial: Under the substantial performance doctrine of common law the buyer may only treat the non-conformity as total breach if $v < v_{TB}$. In civil law countries a similar provision requires non-conformity to be "fundamental". One test for concluding that non-conformity cannot be treated as total breach is whether the buyer still has an "interest" in the good despite non-conformity. We will assume that the court will conclude that such an interest exists whenever the parties would freely renegotiate to trade: $v > c$. This implying setting $v_{TB} = c$. We distinguish two cases:

[26]There is of course another payoff equivalent equilibrium where the seller announces delivery and the buyer rejects. Hence, strictly speaking, we have only established that we can model the game "as if" the buyer always chooses acceptance.

Non-conformity constitutes partial breach: $c = v_{TB} \leq v < \bar{v}$. As $-[p - c - (\bar{v} - v)]^+ + \alpha(v - c) < \bar{v} - p + (1 - \alpha)(v - c) < \bar{v} - p$ for all $v \geq c$, it is always optimal for the buyer to accept delivery.

Non-conformity constitutes total breach: $\mathbf{v} < \mathbf{v}_{TB} = \mathbf{c}$. As $\bar{v} - p + (1 - \alpha)(c - v) > (\bar{v} - p) > 0$ for $v < c$ the buyer will always choose acceptance if given the choice. Anticipating this decision by the buyer, the seller will choose to breach the contract.

8.2 Appendix B: Extension to $\bar{\mathbf{v}} \in (\mathbf{0}, \mathbf{c})$.

Proof. Consider the case where the quality threshold is set below variable cost, $\bar{v} < c$. Again, we assume that the optimal price is high enough such that

$$\bar{v} < \check{v}(p_{SPR2}) \implies p_{SPR2} > p \geq c. \tag{25}$$

This implies that the buyer will always choose termination if quality is non-conforming, $v < \bar{v}$. The seller's payoff will then be 0. If quality is conforming but the buyer's valuation is below variable cost, $\bar{v} \leq v < c$, the buyer will initially ask for specific performance but then agrees to renegotiate towards the ex-post efficient trade decision. The seller's payoff is $p - c + \alpha(c - v)$. If valuation is above variable cost, trade takes place as stipulated in the contract and the seller's payoff will be $p - c$. Hence, the seller's expected payoff will be:

$$U_{SPR2}(e, p) \equiv \int_{\bar{v}}^{c} (p - c) + \alpha(c - v) \;\; F_v(v|e) \;\; dv + \int_{c}^{v_h} (p - c) \;\; F_v(v|e) \;\; dv - e. \tag{26}$$

Integrating by parts and taking partial derivatives with respect to e, gives us:

$$U'_{SPR2}(e, p) = \alpha \int_{\bar{v}}^{c} F_e(v|e) \;\; dv - 1 + [p_L - p] F_e(\bar{v}|e). \tag{27}$$

It follows from the benchmark condition (2) and Assumption 2 that $U'_{SPR2}(e_0, p_L) < 0$. As $U'_{SPR2}(e_0, p) \to \infty > 0$ for $p \to \infty$ and observing that $U'_{SPR2}(e_0, p)$ is continuous in p, it follows by the intermediate value theorem that there must exist a $p_{SPR2} \in (p_L, \infty)$ such that $U'_{SPR2}(e_0, p_{SPR2}) = 0$. In order for e_0 to be a global maximum of the seller's expected payoff function, the following second order condition must hold for all $e \geq 0$:

$$U''_{SPR2}(e, p_{SPR2}) = \alpha \int_{\bar{v}}^{c} F_{ee}(v|e) \;\; dv + [p_L - p_{SPR2}] F_{ee}(\bar{v}|e) < 0. \tag{28}$$

Solving $U'_{SPR2}(e_0, p_{SPR2}) = 0$ for p_{SPR2} and inserting into (28) gives us:

$$\alpha \int_{\bar{v}}^{c} F_{ee}(v|e)\ dv - \frac{\alpha \int_{\bar{v}}^{c} F_e(v|e_0)\ dv - 1}{F_e(\bar{v}|e_0)} F_{ee}(\bar{v}|e) < 0. \tag{29}$$

Multiplying with $F_e(\bar{v}|e_0)$ and dividing by $F_{ee}(\bar{v}|e)$ and rearranging we get:

$$\int_{\bar{v}}^{c} \frac{F_e(\bar{v}|e_0)}{F_{ee}(\bar{v}|e)} F_{ee}(v|e) - F_e(v|e_0)\ dv > -\frac{1}{\alpha}. \tag{30}$$

which we assume to hold true. ■

Remark 2 *The assumption will always be fulfilled if the seller's bargaining power a is sufficiently low or if the quality threshold $\bar{v}$ is only slightly lower than variable cost. Interestingly, it will also hold for sufficiently low(!) threshold levels, as $F_e(\bar{v}|\cdot) \to 0$ for $\bar{v} \to 0$. A sufficient condition for the assumption to hold true is that $F_e(v|e_0)/F_{ee}(v|\cdot)$ is non-increasing in $v \in [\bar{v}, c)$. Then the integrand will be non-negative. This will e.g. be the case for the class of separable distribution functions: $F(v|e) = k(v)g(e) + h(v)$. An explicit example would be the function $F(v|e)$: $[0,10] \times [0,\infty] \to [0,1]$:*

$$F(v|e) = v(10-v)\left(\frac{10^{-3}}{e+0,1}\right) + \left(\frac{v}{10}\right)^3. \tag{31}$$

8.3 Appendix C1: Proof of Lemma 1

In order to proof Lemma 1 which states the seller's equilibrium payoffs for the case that $v \geq \bar{v}$, we distinguish seven different cases, which cover all possible parameter constellations except for $\bar{v} < c \wedge p < c$.

(1) If $\mathbf{v > c \wedge p \geq c}$. In the subgame where the seller has chosen D, the buyer accepts in equilibrium if $\Pi_B(D, A) > \Pi_B(D, \bar{A})$ which holds for $v - p \geq -(p-c) + (1-\alpha)(v-c)$. This can be rearranged to: $v - c \geq (1-\alpha)(v-c)$ which is true for all $v > c$. In the subgame where the seller has chosen $\bar{D}$, the buyer chooses ED, if $\Pi_B(\bar{D}, ED) > \Pi_B(\bar{D}, SP)$ which is true because $v - p < [v-p]^+ + (1-\alpha)(v-c)$ for all $v > c$. Let W denote joint payoff which is constant independent of the history of the game. Using what we have just proven and $\Pi_B(D, A) = \Pi_B(\bar{D}, SP)$ we get:

$$\Pi_S(D, A) = W - \Pi_B(D, A) = W - \Pi_B(\bar{D}, SP) > W - \Pi_B(\bar{D}, ED) = \Pi_S(\bar{D}, ED) \tag{32}$$

Hence, in equilibrium the seller offers delivery and the buyer accepts. The seller's equilibrium payoff will be $p - c$.

(2) If: $\mathbf{v > c \wedge p < c}$. In the subgame where the seller has chosen D, the buyer accepts in equilibrium if $\Pi_B(D, A) > \Pi_B(D, \bar{A})$ which is true because $v - p > v - c \geq (1-\alpha)(v-c)$ for all $v > c \wedge p < c$. In the subgame where the seller has chosen $\bar{D}$, the buyer chooses ED if $\Pi_B(\bar{D}, ED) > \Pi_B(\bar{D}, SP)$. Given that this condition holds and using $\Pi_B(D, A) = \Pi_B(\bar{D}, SP)$ we get:

$$\Pi_S(D, A) = W - \Pi_B(D, A) = W - \Pi_B(\bar{D}, SP) > W - \Pi_B(\bar{D}, ED) = \Pi_S(\bar{D}, ED) \quad (33)$$

Hence, given that $\Pi_B(\bar{D}, ED) > \Pi_B(\bar{D}, SP)$, the seller offers delivery and the buyer accepts. The seller's equilibrium payoff will be $p - c$. If $\Pi_B(\bar{D}, ED) < \Pi_B(\bar{D}, SP)$, it is optimal for the buyer to choose SP. But then, the seller is indifferent between choosing to deliver or not, as $\Pi_S(D, A) = \Pi_S(D, SP)$ and the payoff in equilibrium will be $p - c$. It is easy to see that the same holds true for $\Pi_B(\bar{D}, ED) = \Pi_B(\bar{D}, SP)$.

(3) If $\mathbf{v < c \wedge p \geq c}$. In the subgame where the seller has chosen D, we can see that $\Pi_S(D, A) = p - c + \alpha(c - v) > p - c = \Pi_S(D, \bar{A})$ for all $v < c$. It follows that $\Pi_B(D, A) < \Pi_B(D, \bar{A})$. Hence, it is optimal for the buyer to reject. In the subgame where the seller has chosen $\bar{D}$, we can see that $\Pi_S(\bar{D}, SP) = p - c + \alpha(c - v) > 0 = \Pi_S(\bar{D}, ED)$ as $\bar{v} \leq v < c \leq p$. If follows that $\Pi_B(\bar{D}, SP) < \Pi_B(\bar{D}, ED)$ implying that the buyer chooses ED. As $\Pi_S(D, A) = p - c + \alpha(c - v) > 0 = \Pi_S(\bar{D}, ED)$, the seller offers delivery and the buyer rejects in equilibrium. The seller's equilibrium payoff will be $p - c$.

(4) If $\mathbf{v = c \wedge p > c}$. If the seller chooses D, his payoff will be $p - c$ irrespective of what the buyer does. If the seller chooses $\bar{D}$, it is optimal for the buyer to choose ED if $\Pi_B(\bar{D}, ED) > \Pi_B(\bar{D}, SP) \iff 0 > v - p$ which is true as we assumed $v = c < p$. Yet, this implies $\Pi_S(\bar{D}, ED) < \Pi_S(\bar{D}, SP) = p - c = \Pi_S(D, \cdot)$. Hence, the seller chooses D in equilibrium and gets an equilibrium payoff of $p - c$.

(5) If $\mathbf{v = c \wedge p = c}$. If $v = c \wedge p = c$ it is easy to see that the seller's payoff will be $0 = p - c$, irrespective of what either party does.

(6) If $\mathbf{v = c \wedge p < c}$. Given that the seller has chosen D, it is optimal for the buyer to choose A if $\Pi_B(D, A) > \Pi_B\left(D, \bar{A}\right) \iff v - p > 0$ which is always true as we assumed $v = c > p$. If the seller has chosen $\bar{D}$, it is optimal for the buyer to choose SP if $\Pi_B\left(\bar{D}, SP\right) > \Pi_B\left(\bar{D}, ED\right) \iff v - p > [\bar{v} - p]^+$ which is true as $v - p > 0$ and $v - p \geq \bar{v} - p$. The seller's equilibrium payoff will therefore be $\Pi_S(D, A) = \Pi_S\left(\bar{D}, SP\right) = p - c$ irrespective of what he does.

(7) If $\mathbf{v < c \wedge p < c}$. As $v < c \wedge p < c$ implies $\bar{v} < c \wedge p < c$ for $v \geq \bar{v}$, this case is beyond the scope of the lemma and does not have to be further considered.

8.4 Appendix C2: Proof of Lemma 2.

Given that the seller has chosen $\bar{D}$, the seller will only choose SP if

$$v - p + (1-\alpha)[c - v]^+ \geq [\bar{v} - p]^+ + (1-\alpha)[v - c]^+. \tag{34}$$

Rearranging gives us:

$$v - p \geq [\bar{v} - p]^+ + (1-\alpha)(v - c). \tag{35}$$

a) As $v < \bar{v}$ this will never be satisfied for $v > c$. b1) If $v \leq c \wedge p \geq \bar{v}$, the buyer will choose SP if $v - p \geq (1-\alpha)(v - c)$. Rearranging and using $v \leq c$ gives us: $p < \alpha v + (1-\alpha)c \leq c$. Yet, $p < c$ can only hold for $\bar{v} < c$. Suppose the opposite: $\bar{v} \geq c$. As $p \geq \bar{v}$ this implies $p \geq c$ which contradicts the condition. Therefore, SP will never be chosen by the buyer if we rule out $\bar{v} < c \wedge p < c$. b2) If $v \leq c \wedge$ $p < \bar{v}$, condition (35) can be rewritten as: $v - p > \bar{v} - p + (1-\alpha)(v - c)$. Rearranging and using $v \leq c$ gives us: $\bar{v} < \alpha v + (1-\alpha)c \leq c$. This inequality can only hold for $\bar{v} < c$. Hence, SP will never be chosen by the buyer if we rule out $\bar{v} < c \wedge p < c$.

8.5 Appendix C3: Proof of Lemma 3.

1) If $p < \bar{v}$ it can be seen that $c < \hat{v}$. a) If $v \in [0, c]$and given that the seller has chosen D, the buyer will choose A as $v \leq c < \hat{v}$. Making use of the result of Lemma 2 that we

do not have to bother about the possibility of the buyer choosing specific performance, it is then optimal for the seller to choose $\bar{D}$, whenever $\Pi_S(D,A) < \Pi_S(\bar{D},ED)$. This is true as

$$p - c - (\bar{v} - v) + \alpha(c - v) = -(\bar{v} - p) - (1-\alpha)(c - v) < -(\bar{v} - p) \qquad (36)$$

for all $v < c$. For $v = c$, he his indifferent between choosing D and $\bar{D}$. In either case, the seller's equilibrium payoff will be $-(\bar{v} - p)$. bi) If $v > c$, and given that the seller has chosen D, it is optimal for the buyer to choose A if $v \in (c,\ \hat{v}]$. Then, it is optimal for the seller to choose D, whenever $\Pi_S(D,A) > \Pi_S(\bar{D},ED)$. This is true as

$$p - c - (\bar{v} - v) = -(\bar{v} - p) + v - c > -(\bar{v} - p) + \alpha(v - c) \qquad (37)$$

for all $v > c$. bii) If $v \in (\hat{v}, \infty]$ it is optimal for the buyer to choose $\bar{A}$. The seller then chooses D, whenever $\Pi_S(D,\bar{A}) > \Pi_S(\bar{D},ED)$ which is true for all $p < \bar{v}$. Hence, in equilibrium the seller always announces delivery and the buyer accepts for $v \in [c, \hat{v}]$ and rejects for $v \in (\hat{v}, \infty]$. The seller's equilibrium payoff will be $p - c - (\bar{v} - v)$ and $\alpha(v - c)$ respectively.

(2) If $p \geq \bar{v}$ it can be seen that $\hat{v} < c$. ai) If $v \in [0, \hat{v}]$ and given that the seller has chosen D, the buyer will choose A. Using $\Pi_B(D,A) > \Pi_B(D,\bar{A})$ and observing that $p \geq \bar{v}$ and $v < c$ we can write:

$$\Pi_S(D,A) = W - \Pi_B(D,A) < W - \Pi_B(D,\bar{A}) = 0 = \Pi_S(\bar{D},ED). \qquad (38)$$

Hence, it is optimal for the seller to choose $\bar{D}$ and his equilibrium payoff will be 0. aii) If $v \in (\hat{v}, c)$ and given that the seller has chosen D, the buyer will choose $\bar{A}$. Then, the seller will be indifferent between choosing D and $\bar{D}$ as $\Pi_S(D,\bar{A}) = \Pi_S(\bar{D},ED) = 0$. The seller's equilibrium payoff will be 0. b) If $v \in [c, \infty)$ and given that the seller has chosen D, the buyer will always choose $\bar{A}$ in equilibrium. As $\Pi_S(D,\bar{A}) = \Pi_S(\bar{D},ED)$ the seller is indifferent between choosing D and $\bar{D}$. Either way his equilibrium payoff will be $\alpha(v - c)$.

8.6 Appendix D

Suppose that the quality threshold is above variable cost, $\bar{v} > c$. Then, for $c < v < \bar{v}$ we know from expression (20) that the buyer will choose termination followed by restitution if:

$$v > \hat{v}(p) \equiv \frac{\bar{v} - p}{1 - \alpha} + c. \tag{39}$$

We distinguish three cases: a) $\hat{v}(p) < c$, b) $c \leq \hat{v}(p) \leq \bar{v}$ and c) $\hat{v}(p) > \bar{v}$. (see Figure 9). We can derive the following lemma:

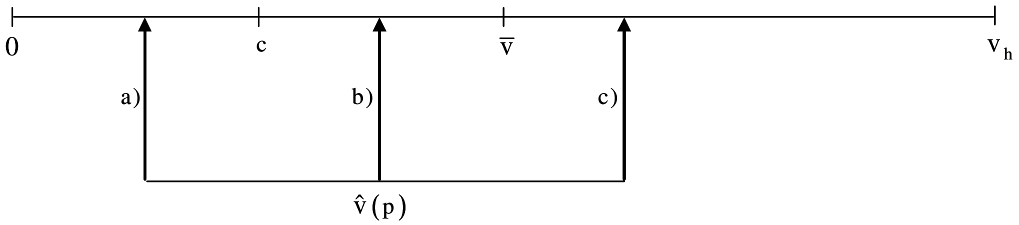

Figure 9: Termination cut-offs for different prices.

Lemma 4 *For all $\bar{v} > c$, it is possible to find a price such that EDR induces first-best cooperative investments.*

Proof. The proof comes in two parts. (i) First, we show for which parameter constellations the first best can be achieved by setting a price consistent with case (a). (ii) Then, we will show that for all parameter constellations, for which the first best cannot be achieved under case (a), it is possible to induce the first best by setting a price consistent with case (b).

i) Case (a) is characterized by $\hat{v}(p) < c \iff p > \bar{v}$. Hence, it follows from Lemmas 3 and 1 that the seller's expected payoff is:

$$U_a(e,p) \equiv \alpha \int_c^{\bar{v}} (v - c)\ F_v(v\,|e)\ dv + \int_{\bar{v}}^{v_h} (p - c)\ F_v(v\,|e)\ dv - e. \tag{40}$$

Integrating by parts and differentiating with respect to e gives us:

$$U_a'(e,p) = -\alpha \int_c^{\bar{v}} F_e(v\,|e)\ dv - 1 + [p_L - p]\, F_e(\bar{v}\,|e). \tag{41}$$

with $p_L \equiv \alpha\bar{v} + (1-\alpha)c$ (see supra (11)). It follows from the first-order condition for the social optimum (2) that $U_a'(e_0, p_L) < 0$. As $U_a'(e_0, p) \to \infty$ for $p \to \infty$, and $U_a'(e_0, p)$ is continuous in p, it follows by the intermediate value theorem that there exists a $\bar{p} \in (p_L, \infty)$ such that $U_a'(e_0, \bar{p}) = 0$. It is easy to see that $U_a''(\cdot, p) < 0$ for all

$\bar{p} \in (p_L, \infty)$, such that e_0 is a global maximum of the seller's expected payoff function $U_a(e, \bar{p})$. Yet, it follows from the characterization of case (a) that $\bar{p} > \bar{v}$. Therefore, if $\bar{p} \in (p_L,\ \bar{v}]$ the lowest possible price under case (a) will lead to overinvestment. (Note that $\bar{v} > c$ implies that the interval is non-empty).

ii) We will now show that for all parameter constellations for which $\bar{p} \in (p_L,\ \bar{v}]$, there exists a p' such that it is possible to induce the first best under case (b). Case (b) is characterized by:

$$p \in [p_L,\ \bar{v}] \iff \hat{v}(p) \in [\hat{v}(\bar{v}) = c,\ \hat{v}(p_L) = \bar{v}]. \tag{42}$$

As $p < \bar{v}$ it follows from Lemmas 3 and 1 that the seller's expected payoff can be written as:

$$\begin{aligned} U_b(e,p) \quad \equiv \quad & -\int_0^c (\bar{v}-p)\ F_v(v\,|e)\ dv + \int_c^{\hat{v}} p - c - (\bar{v}-v)\ F_v(v\,|e)\ dv \\ & +\alpha \int_{\hat{v}}^{\bar{v}} (v-c)\ F_v(v\,|e)\ dv + \int_{\bar{v}}^{v_h} (p-c)\ F_v(v\,|e)\ dv - e. \end{aligned} \tag{43}$$

Integrating by parts, differentiating with respect to e and inserting $e = e_0$ gives us:

$$U_b'(e_0,p) \equiv [p_L - p]\, F_e(\bar{v}\,|e_0) - \int_c^{\hat{v}} F_e(v\,|e_0)\ dv - \alpha \int_{\hat{v}}^{\bar{v}} F_e(v\,|e_0)\ dv - 1. \tag{44}$$

As we defined $\bar{p}$ as the price such that $U_a'(e_0,\bar{p}) = 0$, it follows from expression (41) that we can write:

$$[p_L - p]\, F_e(\bar{v}\,|e_0) = \alpha \int_c^{\bar{v}} F_e(v\,|e_0)\ dv + 1 - (p - \bar{p})\, F_e(\bar{v}\,|e_0). \tag{45}$$

Inserting (45) into (44) we get:

$$U_b'(e_0,p) = -(p-\bar{p})\, F_e(\bar{v}\,|e_0) - (1-\alpha) \int_c^{\hat{v}} F_e(v\,|e_0)\ dv. \tag{46}$$

We will now show that there exists a $p' \in [p_L,\ \bar{v}]$ such that $U_b'(e_0,p') = 0$. Observing that $p = p_L$ implies $\hat{v} = \bar{v}$ (see 42) and inserting into (44) gives us:

$$U_b'(e_0,p_L) = -\int_c^{\bar{v}} F_e(v\,|e_0)\ dv - 1 \tag{47}$$

which is *negative* by the benchmark condition (2). Observing that $p = \bar{v}$ implies $\hat{v} = c$ (see 42) and inserting into (46) gives us:

$$U_b'(e_0,p = \bar{v}) = -F_e(\bar{v}\,|e_0)\,(\bar{v} - \bar{p}) \tag{48}$$

which is *positive* as $\bar{p} \in (p_L, \bar{v})$. Then, as $U_b' (e_0, p)$ is continuous in p, it follows by the intermediate value theorem, that there must exist a $p' \in (p_L, \bar{v})$ for which $U_b' (e_0, p') = 0$. The investment decision e_0 is a global maximum of the seller's expected payoff function if $U_b'' (\cdot, p') < 0$:

$$U_b'' (e, p') = [p_L - p'] F_{ee} (\bar{v} \,|e) - \int_c^{\hat{v}(p')} F_{ee} (v \,|e) \ dv - \alpha \int_{\hat{v}(p')}^{\bar{v}} F_{ee} (v \,|e) \ dv < 0. \tag{49}$$

As $\hat{v} (p') \in (c, \bar{v})$ for all $p' \in (p_L, \bar{v})$, the last two terms are negative. As $p' > p_L$ also the first term must be negative. Hence, the function is concave for the relevant values of p'. ■

Case (c) is characterized by

$$\hat{v} (p) > \bar{v} \iff p < p_L \tag{50}$$

We can derive the following lemma:

Lemma 5 *It is possible to induce the first best by setting a price $p < p_L$ (case c) and a threshold $\bar{v} \geq v_h$ (Cadillac contract).*

Proof. If $\hat{v} (p) > \bar{v}$, it follows from Lemmas 3 and 1 that the seller's expected payoff can be written as:

$$\begin{aligned} U_c (e) \ \equiv \ & - \int_0^c (\bar{v} - p) \ F_v (v \,|e) \ dv + \int_c^{\bar{v}} p - c - (\bar{v} - v) \ F_v (v \,|e) \ dv \\ & + \int_{\bar{v}}^{v_h} (p - c) \ F_v (v \,|e) \ dv - e. \end{aligned} \tag{51}$$

Integrating by parts and differentiating, we can write the first-order condition for the seller's optimal investment decision, e_c:

$$U_c' (e_c) = \int_c^{\bar{v}} F_e (v \,|e_c) \ dv - 1 = 0. \tag{52}$$

It can easily be seen that, by setting $\bar{v} \geq v_h$, the first best, $e_c = e_0$, is achieved in equilibrium. ■

The intuition of the proof is as under the ED regime: The seller is made a residual claimant. In fact, it can be seen that, in order to obtain it, parameters are set such that EDT degenerates into ED.

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