Before Death Do Us Part: On Premature Contract Breakup and Partial Property Rights*

Bernhard Ganglmair†

University of Zurich and *IZA, Bonn*

March 30, 2008

Abstract

In the presence of specific investment, sophisticated contracts or vertical integration have been proposed as solutions to a holdup problem that arises when parties cannot commit not to renegotiate an agreement ex-post. In a repeat transaction framework, I argue that if parties are assigned a property rights bundle with ex-post decision rights on (1) the terms of trade and (2) the durability of trade, a first-best outcome is implementable even with a simple contract. This is because the durability decision, motivated by actual legal practice, gives rise to an exit option that allows the otherwise underinvesting buyer to appropriate breakup rents that restore her investment incentives at the cost of seller's moral hazard from trying to avoid the buyer's breakup threat. For three cases of renegotiation rigidity, I present conditions under which a simple contract allows for an efficient outcome. The results imply that a strict compliance standard in (2) with high quality requirements for the seller may be necessary to induce efficient investment if buyer's weight in (1) is sufficiently low. This implication competes with the legal literature on compliance standards in U.S. and international contract law that promotes a restriction of buyer's exit options.

JEL classification: D23, D86, K12.

Keywords: repeat transaction trade, specific investment, decision rights, contract breakup, holdup, moral hazard; installment contracts, compliance standards

*This paper has substantially benefitted from discussions with Victor Goldberg, Avery Katz, and Alan Schwartz. I also thank Christian Ewerhart, Thomas Gall, Wolfgang Köhler, María Sàez-Martí, Patrick Schmitz, Urs Schweizer, Alexander Stremitzer, seminar participants at Bonn, Innsbruck, NYU, and Zurich for helpful comments. Special thanks to the Center of Legal and Economic Studies at Columbia University where part of this research was undertaken. Financial support from the Deutsche Forschungsgemeinschaft (GRK 629) and the Swiss ESKAS is gratefully acknowledged. An earlier version of this paper was circulated under the title "Breakup of Repeat Transaction Contracts, Specific Investment, and Efficient Rent Seeking."

†University of Zurich, Institute for Empirical Research in Economics, Blümlisalpstrasse 10, 8006 Zürich, Switzerland. Phone: +41 44 634-5158; Fax: +41 44 634-4907; ganglmair@iew.uzh.ch, http://www.iew.uzh.ch/home/ganglmair.

1 Introduction

A quite robust result from contract theory states that contractual incompleteness and a lack of ability to prevent ex-post opportunism through renegotiation of an agreement give rise to a holdup problem as demonstrated by Klein, Crawford, and Alchian (1978), Williamson (1979, 1985), or Hart and Moore (1988), to name a few.[1] Once a party has invested, she is "locked-in" by the specificity of this investment (Farrell and Shapiro, 1989) and thus vulnerable to opportunistic holdup by the other party, particularly if she does not bear exclusive bargaining power (or, alternatively, full property rights) and is therefore not able to recoup the full returns of her investment. Anticipating this susceptibility to such quasi-rent seeking, her ex-ante incentives are diluted, inducing her to underinvest. Economists and lawyers alike have proposed a wide array of possible solutions to this holdup problem. With respect to the degree of simplicity of a contract, MacLeod and Malcomson (1993) for instance show that with a higher degree of contract sophistication, i.e. with less incomplete agreements, holdup can be alleviated and efficient investment restored. Moreover, accounting for the ex-ante costs of contract design, Crocker and Reynolds (1993) argue that parties trade off these ex-ante transaction costs and the costs of ex-post opportunism and establish a result of optimal contractual incompleteness. One conclusion from this economic literature is that simple (non-arbitrarily complex) contracts may indeed implement quite complex final outcomes.[2]

While the contract theory literature often relies on the mere enforceability of contracts, studies on the economics of contract law explicitly account also for the nature of contract enforcement. Such analyses are particularly concerned with the design of default breach remedies and their impact on *ex-ante* investment and *ex-post* trade decisions.[3] Referring to this strand of the literature, the aim of this paper is to find an answer to the question of whether a more involved decision rights structure can restore a first-best outcome when simple contracts with the usually employed bargaining power assumption will be subject to holdup. In particular, I will account for an *ex-post* decision right on the durability of a trade relationship. Hence, I am not interested in contract design and efficient specifications of the terms of trade *per se*, but rather in rules and regulations governing contract *breakup* other than by breach of contract. According to Goldberg (1976:433), who asserts that "the very essence of contract is the restriction of future options," this is one of the prime functions of contracting. For instance, although vowing before the altar to hang in *until* death do us part, often enough we do not hesitate to plan ahead for the day when one of the two of us decides to surrender *before* then. Such prenuptial agreements are an illuminating example for a restriction of a future options (i.e. commitment

[1] Comprehensive reviews of this ever-growing literature can be found in Schmitz (2001), Bolton and Dewatripont (2005), or Shavell (2007). See also Corbin (1963:105) for legal reference or Anderhub, Königstein, and Kübler (2003) for experimental evidence.

[2] See Rogerson (1992) for a discussion of the *simple* and *complex* contract approach to the holdup problem.

[3] There exists a vast literature on the properties of (default) breach remedies with respect to *ex-ante* investment incentives and *ex-post* allocative efficiency. See for instance Shavell (1980), Rogerson (1984), Spier and Whinston (1995), Edlin (1996), Edlin and Reichelstein (1996), Che and Chung (1999), Che and Hausch (1999), or Schweizer (2006) among others.

to abide by a particular breakup procedure upon the materialization of a trigger event) in a bilateral relationship. For this paper, I assume the "procedure" to be given by legal default rules and concentrate on the "trigger," that means the nature of events that give one party the right to exercise the breakup option. The following example defines the nature of the considered contract framework:

Repeat transaction trade: *Suppose that Hart and Moore's (1990) chef and skipper still carry on their "gourmet seafare" service, and the chef has assumed ownership of the yacht.*[4] *Their business is thriving, as over the years the chef has established a reputation of serving the best clam chowder in the region. Each year she presents an even finer recipe, and each year she approaches a local fisherman to bargain over a contract that, throughout the season, ensures her a steady weekly supply of clams over, say, T weeks. Let this contract be such that the chef orders a fixed amount of clams at a specified quality for a constant price. Whether or not the actual clam harvest is of high or low quality depends on a number of factors, and the fisherman as well as the chef will not learn their exact realization until the first cutter casts off. In case of a bad season, the fisherman will have to exert higher costs than in a good season to find enough clams that meet the chef's contracted expectations (suppose higher marginal returns for better average seafood quality). They both understand that writing a complete contract, accounting for all these exogenous factors, is not viable, but rather anticipate renegotiation of their agreement to modify the specifics upon observation of the season's quality type.*

As illustrated, I will consider a long-term contract framework and focus on repeat transaction trade (e.g. weekly supply) as key feature. I assume that the buyer is given decision rights on the further proceeding of the agreement after each of these transactions. The chef, having received the first, second, or nth weekly delivery of clams, can decide whether to prematurely suspend the sequence of the fisherman's weekly performances and thus break up the contract before it has been fully executed and repudiate deliveries $n+1$ to T. Alternatively, she can continue and wait for the second, third or $(n+1)$th delivery. Restricting the parties' choice set to simple contracts, I investigate the effects on *ex-ante* (the chef's human capital investment to think of a recipe that will earn her a Gault Millau toque) and *ex-post* incentives (the fisherman's search effort for good, i.e. complying, clams in a bad season) of widely or narrowly defined *decision rights* that eventually facilitate or impede contract breakup.

The focus and question of this paper allows to touch upon a number of key issues. First, the problem of efficiently putting an (early) end to formal agreements has been approached from various angles. Cramton, Gibbons, and Klemperer (1987), among others, consider the question of how to efficiently design the dissolution of a quite generally defined partnership. In this context, Comino, Nicolò, and Tedeschi (2006) demonstrate that the absence of an explicit termination clause in a partnership agreement serves as "discipline device," alleviating the holdup problem within the partnership and mitigating the otherwise dominating underinvestment result. Moreover, Aghion, Dewatripont, and Rey (1994) discuss a number of contractual

[4]Hence, incentive issues in the relationship between the chef and the skipper do not need to be accounted for.

conventions for joint-venture or professional sports contracts that illustrate how specific renegotiation rules affect the process of premature contract termination. Yet another means of administering contract dissolution is by explicitly disallowing it. The vice and virtue of such exclusive dealing contracts have been analyzed, among others, by Rasmusen, Ramseyer, and Wiley (1991), Bernheim and Whinston (1998), or Segal and Whinston (2000). These agreements rule out contract termination (e.g. trade with third parties) and have been object of interest in the antitrust literature for their anticompetitive and entry-distorting nature. The opposite extreme, not restricting contract termination at all, gives rise to agreements referred to as termination-at-will or employment-at-will contracts and object of investigation for instance in MacLeod and Nakavachara (2007). Also, restricting his attention to these two discrete contract designs, Klein (1980) tries to explain parties' contract choice through the prevalence of holdup caused by incomplete contracting.

By implicitly assuming that parties will fully comply with the stipulated breakup rules, these studies account for tailored rules, yet abstract from possible violations. A different strand of the existing literature explicitly accounts for legal enforcement of contracts and refers to contract breakup as breach of contract. It aims, inter alia, at studying the strategic role of contract in deterring entry. Aghion and Bolton (1987) show in a model without specifc investment that parties will agree to enter an explicit (written) agreement in order to deter market entry of an alternative supplier, results that imply that entry will occur with inefficiently low probability. This is because contract parties will specify liquidated damage clauses that allow only the highest productivity entrants to bail out the buyer from the initial contract. Their results, however, do not hold and market entry will be efficient if the initial contract can be renegotiated or if the entrant is competitive and earns zero profits (Spier and Whinston, 1995). In the latter case, the contract setting does not give rise to external effects and the individually optimal level of stipulated damages is equal to the level of efficient expectation damages (cf. Cooter and Eisenberg, 1985). In the context of employment contracts, Muehlheusser (2007) more generally demonstrates that by imposing an upper bound on such privately stipulated damages, a regulator can induce a Pareto-improvement over unregulated contract choice.

Third, contract (dis)continuation has played a central role in the yet limited literature on long-term trade relationships that contract over frequent transactions rather than a single exchange. Goldberg (1976) notes that for long-term agreements, reaching into the distant future, issues other than a precise specification of the physical terms of trade become important. As writing fully contingent contracts is taken to be infeasible over such a long time horizon, contract duration and termination become key features in contracting. In line with this, Williamson (1971) and Klein (1980) argue that long-term contracts have some advantages over spot-contract arrangements in protecting the incentives to invest in long-lived relationship-specific investment.[5] Joskow (1985, 1987) or Crocker and Masten (1988) analyze the markets for coal and natural gas, respectively, and find that parties indeed enter contracts with longer duration the

[5]Kenney and Klein (1983) or more recently Masten (2007) analyze the virtues of "bundling" purchases when transaction costs are nontrivial.

more important relationship-specific investment becomes. This is in order to ensure an extended return horizon for the investing party. Long-term commitment, however, does not necessarily solve the holdup problem in such settings. If, due to changing environmental conditions in a non-static market, trade on rather than off the Pareto-frontier requires periodic modifications of the terms of trade, or if the market price of the good has changed in a way such that the buyer (seller) can trade outside the contract at a lower (higher) market than contract price, then the investing party is vulnerable to opportunistic renegotiation. More complex contracts account for this problem by specifying clauses that design or restrict possible renegotiation. Goldberg and Erickson (1987) or Crocker and Masten (1991) present respective empirical evidence for the use of quantity and price-adjustment clauses to account for this.

Unfortunately, this literature on the effects of contract breakup in the context of specific investment remains silent on a number of issues. In this paper, I will tackle two: First, the literature accounts little for discriminative treatment of premature termination with respect to the restrictions that are imposed on contract parties. Both exclusive dealing or termination-at-will contracts just represent two polar cases. Moreover, treating contract breakup as breach of contract and penalizing it by the payment of privately stipulated damages (as for instance in Aghion and Bolton (1987)) bears a strong flavor of exclusive dealing. While this means that the analysis in the economics literature is based extensively on corner solutions, the legal literature, in particular on compliance standards in the context of multi-delivery contracts, is indeed concerned with intermediate cases. In such a legal context, a *strict compliance standard* (e.g. a "perfect tender rule") implies that a buyer who receives a defective good from a seller is entitled to repudiation of the remaining part of the contract. The seller thus forfeits his contractual right to serve in future periods if past deliveries do not fully comply with contract terms of trade, allowing the buyer to treat the *entire* contract as breached.[6] Since a truly *perfect tender* is difficult to accomplish (cf. Whaley, 1974), especially with regard to customized and more complex commodities, a strict compliance standard effectively resembles a conditional termination-at-will contract (i.e. conditional on the event of delivery). In his treatise on warranties of quality of performance, Llewellyn (1937:378) already posits that a less restrictive "commercial (substantial) standard of performance" needs to substitute for the strict compliance rule. Then, under such a *substantial compliance standard*, a defective delivery in a repeat transaction contract may only be treated as breach of contract if it is beyond a certain threshold.[7] Rather than constituting a termination-at-will contract, such a substantial compliance standard introduces

[6]See, for instance, the U.S. common law case of *Norrington v. Wright (1885) 115 U.S. 188.* It concludes that if a seller makes a nonconforming delivery with respect to one installment, the buyer is given the right to treat the whole contract as breached and to terminate the entire contract. In *Fullam v. Wright & Colton Wire Cloth Co. (1907) 196 Mass. 474,82 N.E. 711* the court stipulates that "[w]here there is a contract to sell goods to be delivered in installments and the seller in violation of the contract tenders as a first installment goods inferior to the requirements thereof, the buyer may not only refuse to accept the installment, but he may also rescind the contract *in toto*."

[7]See, for instance, *Helgar Corp. v. Warner's Features, Inc. (1918) 58 N.Y.L.J. 1780, 119 N.E. 113.* The decision states that an aggrieved party has *no* right to refuse further delivers (i.e. terminate the contract) unless a "seriousness of the damage suffered by him" can be shown.

a buyer's conditional *exit option*, i.e. the right to breakup or terminate the contract, for a particular subset of the underlying state or action space. Goldberg and Erickson (1987) note in the context of long-term contracts that thus constraining the buyer's options will eventually restrict her *ex-post* opportunism and protect the seller's investment incentives.[8]

Second, the discussion of breakup restrictions in long-horizon contracts predominantly focuses on the role of such regulation as means to protect the investment incentives of the victim of termination (e.g., Goldberg and Erickson, 1987). It is usually assumed that the noninvesting party chooses discontinuation of the contract as a renegotiation threat to appropriate some or all of the investing party's quasi-rents. In the example given above, the chef (buyer) invests in a cooking recipe to enhance the value of the asset, i.e. the seafood. The seller's (fisherman's) payoffs will be subject to the realization of the state of nature (average quality of clams). Furthermore, suppose the chef is monetarily compensated for low quality deliveries such that she is just as well off as if the seller had delivered in full compliance with the contract. Then her payoffs are constant and determined by the contract; not paying for a delivery can therefore not be an optimal response. This implies that unless the parties' agreement specifies an exit clause for the seller in case of a bad quality realization or buyer's full payment, the seller will not have a credible exit option as any such move of breakup will constitute breach of contract on his part. This, however, need not necessarily hold for the buyer. To see this, note that, since in the given example the quality of the delivered commodity depends on the seller's input of effort, time, or production capital, his contract performance will likely be defective depending on the costs of these inputs. If a breakup rule allows for the buyer's premature termination, then she will be able to exercise a respective bargaining threat since such contract breakup does *not* constitute contract breach.

For this paper, I consider a trade technology with sequential delivery of nondurable goods. In the given example, the fisherman may be able to supply the chef's accumulated season demand, the chef's preferences (or cooking technology), however, require a weekly supply of *fresh* seafood.[9] I shall refer to such a contract as *repeat transaction contract*.[10] It is *non-divisible* in the sense of Edlin and Reichelstein (1996:487) who assert that *divisible* contracts are "legally equivalent to a large number of independent contracts in which the seller supplies one individual unit of the good and the buyer pays the unit price." The independence of such a sequence of single-shot contracts, however, does not allow for a breakup rule to be conditional on earlier performances;[11] or analogously, the *bundling* of a number of sequential deliveries

[8] A similar wastefulness result for strict compliance rules (in simple one-shot contracts over highly customized goods, particularly in construction contracts) can be found in the work by Goetz and Scott (1981), Baird, Gertner, and Picker (1994:232) or Schwartz and Scott (2003) on "mandatory acceptance of substantial performance."

[9] Alternatively, suppose the chef has the necessary conservation technology to make use of a one-time delivery of the full season demand, yet instantaneous (i.e. within one period) production of this season demand is technologically not feasible (abstracting from capacity adjustments or supply from third parties).

[10] A sequence of single-delivery deals is more likely to give rise to holdup problem than such a multi-delivery long-term contract. Vertical integration through buying the fishery business and employing the fisherman is not considered, as I am not interested in the integration of firms but the role contracts play in coordinating their activities. Moreover, if the chef already owns the yacht, what is he supposed to do with yet another cutter?

[11] This relates to Fellingham, Newman, and Suh (1985) who conclude that if a contract does not exhibit any

and the conditionality of the buyer's exit option renders the repeat transaction contract not fully divisible. The contract gives the buyer the right to be served as specified by the terms of trade; any noncompliance by the seller will be compensated through damages for breach of contract. In the tradition of the law and economics literature, I assume that parties do not privately stipulate these damages but rely on a default breach remedy (see, e.g., Ayres and Gertner, 1989) that puts an aggrieved party in as good a position as if the other party had fully conformed but limits damages to what they are under efficient investment, i.e. *efficient expectation damages* (Cooter and Eisenberg, 1985).[12]

Furthermore, I assume a particular decision structure. A contract, once it is entered, can be thought of as an *asset*,[13] and the contract parties are assigned certain *property rights* on this asset. Tirole (1999:742–743) defines property rights as a "bundle of decision rights" where such a single *decision right* is referred to as a "right for the party to pick a decision in an allowed set of decisions."[14] I will define such a bundle, denoted by ϕ, as a vector of two distinct element: (1) the right to change the contract's quality and price terms (*material* decision rights), and (2) the right to dispose of the further proceeding of the contract (*procedural* decision rights):

$$\phi = \begin{pmatrix} \text{the right to modify the } \textit{terms} \text{ of trade} \\ \text{the right to set the } \textit{durability} \text{ of trade} \end{pmatrix}$$

With respect to the former, I assume that neither party has the right to *uni*laterally modify the terms under which the goods are traded. Changes of quality or price clauses require mutual consent and neither party can by force impose on the other party deviations from the original agreement once they are locked in. This implies that if modifications of the contract are necessary in order for trade to take place on the Pareto-frontier, parties will have to enter bilateral renegotiations. They will be able to obtain a particular fraction of the renegotiation surplus, depending on their respective relative bargaining power which I assume to be exogenously given. Second, the decision right on the further proceeding of the contract introduces a conditional breakup rule as discussed above. Once the first good is delivered, the continuation of trade, and as such the durability of the contract, is at the discretion of the buyer. She may thus rightfully walk away and repudiate the contract with respect to the second delivery if the quality of the first is below a certain threshold. Note that this *exit option* approach is somewhat related to the models by Aghion, Dewatripont, and Rey (1994) or Nöldeke and Schmidt (1995), differs, however, in a crucial detail: The buyer's right to terminate in t is conditional on the seller's delivery in $t-1$, whereas in Aghion, Dewatripont, and Rey (1994) trade is assumed to be

memory, i.e. if for instance a later payment or action does not depend on an earlier action, then in a model with full commitment a repeat transaction contract and a series of sequential single-shot contracts both implement the first best outcome. There are therefore no gains to a long-term contract and the repeated game can be played myopically (see also Strausz, 2006). Renegotiation, however, will render this no-memory requirement violated.

[12]Cooter and Eisenberg (1985) refer to Fuller and Perdue (1936) for legal underpinnings; see also Craswell (1989), Leitzel (1989), or Spier and Whinston (1995) for applications.

[13]I owe this characterization of contract to Victor Goldberg.

[14]See also Simon (1951) or Hart (1989).

exogenously probabilistic, and the option contract in Nöldeke and Schmidt (1995) is such that the seller gets to decide unconditionally whether or not to trade.

The analysis of this proposed framework with a finite repeat transaction contract, partial property rights and conditional breakup allows for a number of conclusions. First, the results are based on a clear distinction of (Nash)-bargaining *power* as opposed to bargaining *position*. The former relates to the bargaining shares (characterized by a parameter β) and the latter to disagreement point payoffs. The parties' bargaining shares reflect their relative say and as such their weight of material decision rights, whereas the bargaining position is determined by the buyer's exit option. I show that at the renegotiation stage, this exit option—the conditional right to choose the outside options in the bargaining game—allows for buyer's opportunistic rent-seeking that mitigates the holdup problem from less-than-perfect bargaining *power* (labeled β-holdup). This is because holding up the seller in *ex-post* renegotiations yields additional breakup rents that increase the buyer's returns on investment and, under frictionless renegotiation and certain parameter restrictions, induce efficient incentives where she would otherwise (if this exit option were not granted) underinvest. The buyer's opportunism thus generates social value; put differently, without her opportunistic behavior a first-best outcome cannot be implemented under the contract framework of interest. The exit option (procedural decision rights) thus complements incomplete material decision rights to prevent a holdup problem and may serve as contractual solution, based on simple contracts, where otherwise vertical integration has been proposed.

Second, I consider different degrees of rigidity and study the contract setup under no renegotiation, restricted renegotiation, and frictionless or full renegotiation. For a sufficiently rich contract choice set (no upper bounds on the contractible quality), I show that a non-renegotiated repeat transaction contract under a Kleinian (1980) exclusive dealing assumption (with termination not an issue) can implement a first-best outcome. In that case, material decision rights are obsolete as neither party has the right to make modifications without mutual consent. The procedural decision right, on the other hand, allows for such unilateral changes, and the formal analysis shows that a first-best outcome can be implemented only if the buyer is never granted the right to terminate. For a fully renegotiated contract, under given parameter restrictions, there exists a nonempty set of property rights bundles such that an efficient outcome is implementable. If renegotiations are restricted, i.e. the contract can only be modified after the first trade round, a first-best efficient outcome is possible only under restrictive parameterization. This is because the buyer's exit option gives a low quality seller the incentive to exert excessive costs and effort in the first period in order not to deliver a good of a quality below the prespecified threshold (characterized by a parameter μ) that triggers the exit option. By doing so, he improves his bargaining *position* and thus his payoffs from contract renegotiation. The model's results imply that a particular level of this so called μ-holdup (of seller's performance incentives as result of moral hazard) needs to be allowed for in order to alleviate the β-holdup problem (of buyer's investment incentives). An optimal, second-best breakup rule is such that both effects are balanced.

Third, the results then allow for implications with respect to the legal literature on compliance standards. In particular, I show that if the buyer's bargaining power (i.e. her say in bilateral renegotiations) is sufficiently low, a strict compliance standard may indeed be necessary to induce efficient investment. This is in clear contradiction to parts of the vigorous legal literature on this matter, for instance Llewellyn (1937:375ff). Insisting on a *substantial* rather than a *strict* compliance standard of performance, although promoting less distortion of the seller's activities by alleviating μ-holdup and moral hazard, may in the end lead to insufficient investment by the buyer.

The structure of the paper is as follows: In Section 2, I introduce the basic setup of the repeat trade technology with specific investment. In Section 3, the institutional framework, in particular the legal means of contract enforcement, is discussed. In Section 4, I translate the assumed decision rights structure ϕ into bargaining *power* and *position* of the (restricted) renegotiation routines. In Section 5, I derive the parties' equilibrium strategies for the semi-renegotiated contract. Section 6 holds the main results of the paper as discussed above. In Section 7, I conclude and discuss some implications for the legal literature on compliance standards. The formal proofs for the nature of the bargaining structure and the buyer's investment incentives are relegated to Appendix A and B, respectively.

2 Setup

Two risk neutral expected utility maximizers without any wealth constraints engage in finitely repeated trade. For tractability, I restrict the analysis to two trading periods. Let the seller "S" (*he*) produce and deliver an indivisible and nondurable commodity of nonnegative quality q_1 at date 1 and of quality q_2 at date 2, and let this commodity vector be denoted by $\vec{q} = (q_1, q_2)$ where $q_i \in \Sigma \subseteq \mathbb{R}_+$. The goods are referred to by their time of delivery. The costs of production of good i with quality q_i are given by a convex, twice-differentiable cost function $c(q_i, \theta)$.[15] Technological restrictions prevent advanced production of good 2 at date 1. Upon the start of production of good 1, the seller observes his productivity type θ that prevails over the lifetime of the business relationship. A higher productivity denotes lower production costs, $c_\theta(q_i, \theta) < 0$, in particular, lower marginal costs, $c_{q_i\theta}(q_i, \theta) <$ for all q_i and θ. Type θ is randomly drawn from the unit interval Θ with *pdf* $f(\theta)$ and a strictly increasing *cdf* $F(\theta)$. It is observable to the buyer and seller yet nonverifiable by third parties. The seller does not incur any fixed costs, hence $c(0, \theta) = 0$ for all θ. Moreover, the Inada conditions are satisfied for cost function $c(q_i, \theta)$ with respect to q_i.

The buyer "B" (*she*) can increase her valuation of q_i by investing $r \geq 0$ at convex cost $z(r)$. Such investment may be in the business's physical or human capital and is relationship-specific with zero value outside the respective buyer-seller match. Let the buyer's valuation of q_i for both $i = 1, 2$ be denoted by a quasi-concave, twice-differentiable valuation function $v(r, q_i)$

[15] For the remainder of this paper I will refer to the seller's activity as "production," "delivery," or "performance" and use these terms interchangeably.

that satisfies the Inada conditions for both arguments. The buyer's valuation is nonnegative for any q_i and r. A higher level of investment r implies a higher valuation for any given q_i, i.e. $v_r(r, q_i) > 0$ and $v_{rr}(r, q_i) \leq 0$, where $v(0, q_i) > 0$ for any positive q_i. Moreover, r has a positive effect on the marginal valuation of q_i, $v_{q_i r}(r, q_i) > 0$. Perfect relationship-specificity implies $v(r, 0) = 0$ and $v_r(r, 0) = 0$.

Whether or not the parties indeed trade in performance periods $t = 1, 2$ is at the discretion of the buyer. For simplicity, I assume that if the parties do not trade in $t = 1$, they will not trade in $t = 2$.[16] Once good 1 is exchanged, the buyer can decide not to trade good 2 with the seller but instead put an end to the trade relationship and exit the game. Let this decision $\tau \in \{E, C\}$ be equal to E if the buyer *exits* and no good is exchanged in $t = 2$, or C if she decides to *continue*.

Let the time-invariant and unverifiable state (r, θ) be denoted by $\lambda \in \mathbb{R}_+ \times \Theta$. The surplus from trade of commodity i with quality q_i is denoted by $w(\lambda, q_i) = v(r, q_i) - c(q_i, \theta)$. The two-period trade surplus from repeat transactions (net of investment costs $z(r)$) is simply the sum of $w(\cdot)$ over i, given $\tau = C$, hence $W(\lambda, \tau, \vec{q}) = w(\lambda, q_1) + 1_{(\tau=C)} w(\lambda, q_2)$. Moreover, let the social surplus be equal to these gains of trade $W(\cdot)$ minus the costs of investment $z(r)$ and denoted by $\widehat{W}(\lambda, \tau, \vec{q})$. From the above assumptions it follows that $\widehat{W}(\lambda, \tau, \vec{q})$ is concave in q_i and r; moreover, let it be nonconvex in type θ.

The sequence of decisions in this buyer-seller model is the following: The buyer invests r before the productivity type θ is realized. The seller then observes state λ and chooses quality levels q_i for $i = 1, 2$ where q_2 is conditional on buyer's decision τ. Since termination implies a loss of second period gains of trade, $\tau = E$ is Pareto-inferior to continuation $\tau = C$ for all positive productivity types $\theta > 0$. The first-best investment and activity levels are such that the social surplus $\widehat{W}(\lambda, \tau, \vec{q})$ is maximized. Let the optimal activity level for $i = 1, 2$ as best response to buyer's investment be a function of the time-invariant state λ and denoted by

$$\sigma^o(\lambda) \in \arg\max_{q_i \in \Sigma} \widehat{W}(\lambda, C, \vec{q}); \tag{1}$$

the optimal quality strategy vector is $\vec{\sigma}^o(\lambda) = \big(\sigma^o(\lambda), \sigma^o(\lambda)\big)$. By time-separability of $w(\cdot)$, the quality function $\sigma^o(\lambda)$ is time-invariant. Similarly, the optimal level of investment is a best response to the quality strategy and maximizes the expected social surplus such that

$$\rho^o(\vec{\sigma}^o) \in \arg\max_{r \in \mathbb{R}_+} \int_\Theta \widehat{W}(\lambda, C, \vec{\sigma}^o(\lambda)) f(\theta) d\theta. \tag{2}$$

The first-best levels are then $\sigma^*(\theta) = \sigma^o(\rho^*, \theta)$ and $\rho^* = \rho^o(\vec{\sigma}^*(\theta))$. The benchmark outcome of this model is defined as follows:

Definition 1 (First-best benchmark)**.** *The first-best benchmark outcome $\langle \vec{\rho}^*, \vec{\sigma}^*(\theta) \rangle$ is such that parties trade in the second period, $\tau = C$, and the* ex-ante *efficient investment level ρ^* and*

[16] For durable trade opportunities, e.g. a particular good may be traded in $t = 2$ if parties cannot agree on a contract in $t = 1$, see for instance Che and Sakovics (2004) or Watson and Wignall (2007).

the ex-post *efficient activity vector* $\vec{\sigma}^*(\theta)$ *are mutual best responses and characterized by the following first-order conditions:*

$$\frac{\partial \widehat{W}(\vec{\rho}^*, \theta, C, \vec{q})}{\partial q_i} \stackrel{!}{=} 0 \quad \textit{for } i = 1, 2, \tag{3}$$

$$\int_{\Theta} \frac{\partial \widehat{W}(\lambda, C, \vec{\sigma}^*(\theta))}{\partial r} f(\theta)\, d\theta \stackrel{!}{=} 0. \tag{4}$$

The assumptions for $v(r, q_i)$ and $c(q_i, \theta)$ ensure that there exists a unique $\sigma^*(\theta) > 0$ for any $\theta > 0$. Recall that the seller does not incur any fixed costs of production, then for any positive productivity type θ there is always a positive value of q_i such that $w(\lambda, q_i) > 0$. Hence, trade is always efficient. Moreover, by the properties of $v(r, q_i)$ and $z(r)$ the first-best investment level is positive, $\rho^* > 0$.

3 Contract choice and breach remedies

The parties' trading opportunities are subject to the underlying institutional framework. This section introduces the peculiarities of legal enforcement of a simple supply contract, in the next section I discuss the assignment of decision rights.

Before the buyer invests and the seller produces and delivers goods $i = 1, 2$, parties enter an *incomplete* and *simple* supply contract. Enforceability of such a contract before a court of law is restricted to terms that are verifiable, i.e. are observable to third parties, or can be proven without reasonable doubt or at less than prohibitively high cost. As is the standard approach in the law and economics literature, the seller's productivity type θ and the buyer's investment level r are taken to be nonverifiable, while quality and price levels as well as the parties' communication are contractible. Similarly, contract clauses that condition on this state λ are assumed to be not enforceable and contracts *incomplete*. Moreover, the class of contracts under consideration is *simple* with regard to the unconditionality of quality and price provisions. This means that a supply contract specifies a constant quality level $\bar{q}$ to be delivered in exchange for a price $\bar{p}$ where $\bar{q}$ and $\bar{p}$ are fixed both within and between trade periods. The overall payment $2\bar{p}$ for both goods is such that the expected joint surplus $\widehat{\Pi}$ is equally shared between the buyer and seller[17] and the per-unit price $\bar{p}$ equally apportioned across deliveries.

Definition 2 (Repeat transaction contract)**.** *Let $Q \subseteq \Sigma$ the parties' contract quality choice set. A repeat transaction contract Z specifies $\bar{q} \in Q$ as quality of good i to be delivered in $t = i$ in exchange for a price $\bar{p} \in \mathbb{R}$.*

I will refer to the contract quality choice set as "rich," denoted by $Q = \overline{Q}$, if it is constrained only by what cannot be the result of efficient production, hence $\overline{Q} = \{\bar{q} : \sigma^*(\theta), \theta \in \Theta\}$. Analogously, a "poor" choice set, denoted by $Q = \underline{Q} \subset \overline{Q}$, constrains the parties at the contracting

[17]This pricing rule corresponds to a non-cooperative bargaining solution with zero outside options (see, e.g., Rubinstein, 1982; Sutton, 1986) or a cooperative, symmetric Nash-bargaining solution with zero disagreement points (Nash, 1950).

stage. In particular, I assume for $\underline{Q}$ that a *Cadillac* contract over "as large a quantity or quality as is generally efficient" (Edlin, 1996:106), $q^{\max} = \sigma^*(1)$, is not available. Hence, $\underline{Q} = \{\bar{q} : \sigma^*(\theta), \theta \leq \underline{\theta} < 1\}$ where $\sigma^*(\underline{\theta})$ is the highest quality level the parties can agree on.

Contract Z binds the parties to trade in periods $t = 1, 2$ and defines their obligations as follows: The buyer is granted a right to be served, i.e. has a claim over delivery of goods $i = 1, 2$ of predetermined quality $\bar{q}$ in periods 1 and 2, while the contract grants the seller the right to deliver and see his delivery accepted and paid for by the buyer. Unless these rights are forfeited by action or deliberately waived by proper communication, failure to comply with the respective contractual obligations results in "breach" of contract. In that case, the contractual performance claims (delivery and acceptance) are replaced by claims for monetary compensation compelled by a court of law.

For the respective breach remedies I loosely follow the notation in Edlin (1996:106). Suppose the seller delivers a good of quality $q_i < \bar{q}$. The buyer can claim monetary compensation that puts her in as good a position as if the seller had fully conformed to his obligations. The seller is thus liable for any losses the buyer incurs from a defect in commodity i. In particular, the buyer can recover her *efficient expectation damages* (Cooter and Eisenberg, 1985) that restrict compensation to her damages for any q_i under an efficient investment level ρ^*. They are denoted by $d(q_i, \bar{q})$ and defined as

$$d(q_i, \bar{q}) = \max\left\{v(\rho^*, \bar{q}) - v(\rho^*, q_i), 0\right\}. \tag{5}$$

They are equal to zero for any $q_i \geq \bar{q}$ and equal to $v(\rho^*, \bar{q})$ if $q_i = 0$, i.e. if the seller delivers zero quality or does not perform at all. Note that equation (5) implies a no-windfall-gains assumption. This means that the seller may not recover from the buyer any compensation for a supraconforming quality $q_i > \bar{q}$, neither does he have to pay damages for the nonconformity of such a $q_i > \bar{q}$.

Alternatively to default damage function (5), parties could agree on privately stipulated damages that translate into a general price function, specifying an enforceable price $p(q_i)$ for any delivered quality level $q_i \in \Sigma$. Aghion and Bolton (1987) or Nöldeke and Schmidt (1995), for instance, model the buyer-seller trade relationship in such a way. Considering a binary rather than a continuous decision variable, as it is the case in this paper, however, their price function takes on only two values, a price for trade and (a possibly negative) one for no trade. Note that contract Z, with fixed-price, fixed-quality terms of trade and governed by efficient expectation damages as default breach remedies, is strategically identical to a contract specifying a constant quality level $\bar{q}$ and a price function

$$p(q_i) = \min\left\{\bar{p} - \big(v(\rho^*, \bar{q}) - v(\rho^*, q_i)\big), \bar{p}\right\}. \tag{6}$$

I have argued earlier that since the given setup does not exhibit any externalities and information asymmetries between the contract parties, privately stipulated damages (through an appropriately characterized $p(q_i)$) and optimal default breach remedies will yield identical equilibrium outcomes.[18]

The damage function in equation (5) (or its transformation in equation (6)) implies that efficient expectation damages introduce a *compensation bias* for inefficient investment levels. To see this, note that the buyer's effective, compensated payoffs as function of her investment level and the delivered quality q_i are given as

$$\bar{b}(r, q_i) = v(r, q_i) - \bar{p} + d(q_i, \bar{q}); \tag{7}$$

her true expectation interest, given the actual level of investment, is equal to $v(r, \bar{q}) - \bar{p}$. It is straightforward to check that the buyer is overcompensated for a defective quality level $q_i < \bar{q}$ if $r < \rho^*$. This is due to the value-enhancing nature of her investment, $v_{q_i r}(r, q_i) > 0$, that induces damages $d(q_i, \bar{q})$ under efficient investment ρ^* to be higher than under the actual level $r < \rho^*$. The reverse case holds true for $r > \rho^*$. Lemma 1 provides a useful characterization of the degree of over- and undercompensation.

Lemma 1 (Compensation bias)**.** *Let $q_i < \bar{q}$ and $h(r, q_i) = v(\rho^*, q_i) - v(r, q_i)$. Efficient expectation damages yield a compensation bias $h(r, \bar{q}) - h(r, q_i)$. This term is positive ("overcompensation") for $r < \rho^*$ and negative ("undercompensation") for $r > \rho^*$.*

Proof. The buyer's true expectation interest given r is equal to $v(r, \bar{q}) - \bar{p}$. For $q_i < \bar{q}$ her compensated, i.e. effective, payoffs in equation (7) can be rewritten as $\bar{b}(r, q_i) = v(r, q_i) - \bar{p} + v(\rho^*, \bar{q}) - v(\rho^*, q_i)$. Rearranging this yields $\bar{b}(r, q_i) = v(\rho^*, \bar{q}) - \bar{p} - h(r, q_i)$. The difference between the compensated payoffs and the true expectation interest is thus given as

$$\begin{aligned} \bar{b}(r, q_i) - (v(r, \bar{q}) - \bar{p}) &= v(\rho^*, \bar{q}) - \bar{p} - h(r, q_i) - v(r, \bar{q}) + \bar{p} \\ &= v(\rho^*, \bar{q}) - v(r, \bar{q}) - h(r, q_i) \quad = \quad h(r, \bar{q}) - h(r, q_i). \end{aligned}$$

This expression is equal to zero for $r = \rho^*$. By the assumption of positive cross-derivatives $v_{q_i r} > 0$ it is straightforward that the compensation bias is positive for underinvestment $r < \rho^*$ and negative if $r > \rho^*$, given $q_i < \bar{q}$. Note that for a fully (or supraconforming) $q_i \geq \bar{q}$ the buyer is not compensated and the bias equal to zero. Q.E.D.

A central result of the law and economics literature on the economics of breach remedies is that expectation damages induce efficient activity incentives for the seller (e.g., Shavell, 1980).[19] This is because they allow him to fully internalize the buyer's losses for a nonconforming q_i. With nonverifiability of investment r and the compensation bias in Lemma 1, this alignment of seller's incentives, however, ceases to hold. A negative bias, implying buyer's undercompensation, results in less-than-full internalization, whereas a positive bias induces the seller to internalize losses the buyer does in fact not incur. Efficient expectation damages indeed induce optimal *ex-post* performance by the seller if the buyer has efficiently invested. Otherwise, i.e. if they do not suffice in inducing efficient *ex-ante* investment, the seller's incentives are diluted. The

[18] See Spier and Whinston (1995) for a related argument.

[19] For a survey and discussion of the *efficient breach* paradigm see for instance Hermalin, Katz, and Craswell (2007).

following restriction on this effect will prove to be useful. It states that, given $\bar{q}$, the valuation effect of $r = \rho^*$ relative to $r = 0$ must be strictly smaller than the expected per-period trade surplus given efficient investment. Let σ_i be the seller's choice of q_i, given λ. The value of the compensation bias is maximized for $r = 0$ and $\sigma_i = 0$ such that $h(0, \bar{q}) - h(0, 0)$, where $h(0, 0) = 0$. The restriction on $v_r(r, q_i)$ thus reads as follows:

Assumption 1. *$h(0, \bar{q}) < \int_\Theta w(\rho^*, \theta, \sigma_i) f(\theta) d\theta$.*

Moreover, let the seller's realized and expected per-period payoffs be denoted by $\bar{s}(\sigma_i, \theta)$ and $\bar{s}_i^e$, respectively,

$$\bar{s}(\sigma_i, \theta) = \bar{p} - c(\sigma_i, \theta) - d(\sigma_i, \bar{q}) \tag{8}$$

$$\bar{s}_i^e = \bar{p} - \int_\Theta \left[c(\sigma_i, \theta) + d(\sigma_i, \bar{q}) \right] f(\theta) d\theta. \tag{9}$$

I assume the buyer's payoffs in equation (7), given efficient investment (or damages for a zero-quality delivery $\sigma_i = 0$), to be nonnegative; analogously for the seller's expected per-period payoffs in equation (9).

Assumption 2. *$\bar{b}(\rho^*, \bar{q}) \geq 0$ and $\bar{s}_i^e \geq 0$ for $i = 1, 2$.*

We can now quantify the buyer's liability for breach of contract: The contract binds the parties to their promises; unless he forfeits, the seller has the right to deliver. His true expectation interest with respect to delivery of good $i = 1, 2$ is equal to $\bar{s}(\sigma_i, \theta)$ in equation (8), yet since remedies may not condition on a state variable, his compensated damages amount to $\max\{\bar{s}_i^e, 0\} = \bar{s}_i^e$ as given in equation (9).

4 Renegotiation and partial property rights

A means of governing a multi-period trade setup other than by contract is by vertical integration: The chef may simply buy the cutter and employ the fisherman. Such a structure implies full property rights for the upstream buyer who seizes control over the downstream seller. As a result, the holdup problem ceases to be an issue. In this paper, however, I am interested in a contractual solution involving revocability of a contract and a more colorful picture with explicitly spelt out *decision rights.* I refer to such rights as *complete* if a party can unilaterally decide without the other party's consent; or *partial* if both parties have a (weighted) say and actual decisions can only be made by mutual consent. Moreover, decision rights can be *absolute* or *conditional.* The former are predetermined and not modified as the trade proceeds. The latter implies that the right to pick a decision depends on factors that are inherent to precisely the situation these rights are in place to govern. The combined set of all these rights constitutes a party's *property rights* (also cf. Simon, 1951; Hart, 1989). Within this framework, an ownership structure arising from vertical integration (cf. Grossman and Hart, 1986) in its most basic sense, for instance, consists of absolute and complete decision rights. The same holds true for the right to decide whether or not to trade in an option contract as studied, e.g., by Nöldeke and Schmidt (1995).

A contract, once it is entered, can be easily thought of as an asset with certain characteristics such as attributes (terms of trade) and life span (trade durability bounded by the initially specified contract duration). The property rights on such an asset allow a party to change some or all of these characteristics. Note that if these rights are complete, then the respective owner can impose on the other party any changes or modifications; if they are partial, however, both parties will have to enter bilateral renegotiations over some of the asset's characteristics. As discussed in the introductory section, I will assume this *property rights bundle* $\phi = (\beta, \mu) \in \mathcal{B} \times \mathcal{M}$ to consist of two elements. First, neither party has the right to unilaterally change the contract terms under which the goods are traded. This *material* decision right, characterized by $\beta \in \mathcal{B}$, is straightforward for many commercial contracts other than output or requirement contracts. It is by assumption absolute and partial.[20] Second, the buyer is granted the conditional and complete right to decide on the further proceeding of the contract once good 1 at quality q_1 has been delivered. That way, the durability of the contract, and as such the seller's right to serve in the second period and generate payoffs $\bar{s}(\sigma_2, \theta)$, is at the buyer's discretion.[21] Moreover, it is assumed to be contingent on the seller's production level in $t = 1$. The buyer is granted an *exit option*, the right to discontinue trade with the seller and thus to terminate the contract, for a particular subset of the underlying action space Σ. Again, any such assignment of this *procedural* decision right, characterized by $\mu \in \mathcal{M}$, needs to be enforceable, the buyer's exit option can therefore not be conditioned on the underlying state space but only on the verifiable history of the contract. In particular, I assume a monotonic *breakup rule* that partitions Σ into two convex subsets, $\Sigma = \Sigma^E \cup \Sigma^C$. The breakup rule is then a function $\mu : \Sigma \times Q \to \{\text{rightful}, \text{wrongful}\}$ where an exit option is granted and termination "rightful" if $q_i \in \Sigma^E$ and "wrongful" otherwise. For simplicity, I assume the partition along parameter μ and the rule to be linear. The functional form is given as follows:

Definition 3 (Breakup rule). *Let $\mu \in [0, 1]$. Premature contract breakup $\tau = E$ is rightful if and only if $q_1 < \mu\bar{q}$.*

This breakup rule, giving rise to a restricted buyer-option contract, implies that for a delivered quality below the threshold $\mu\bar{q}$, the seller is in *total* breach of contract and forfeits his right to deliver in $t = 2$ and see his delivery accepted and paid for. Hence, the buyer may not only collect damages as in equation (5) for a nonconforming quality q_1, but she is granted the right to breakup and recover the losses associated with no delivery, $q_2 = 0$, in $t = 2$. If, however, $q_1 \geq \mu\bar{q}$, then breaking up the trade relationship constitutes breach of contract on the buyer's

[20] See, e.g., Aghion, Dewatripont, and Rey (1994), Spier and Whinston (1995), Che and Chung (1999), or Watson (2007) for such renegotiation surplus sharing. Edlin and Reichelstein (1996) allow for the (conditional) sharing rule to be contingent on the realized state and the terms of trade.

[21] The question of interest here is *Who* is in the position of deciding whether or not trade takes place? See, e.g., Grossman and Hart (1986) for the literate on ownership structure, or, e.g., Nöldeke and Schmidt (1995) and Lyon and Rasmusen (2004) on option contracts.

side. In that case, she will be liable for the seller's expected payoffs in equation (9). Legal enforcement of contract Z is through the remedy regime (a *legal mechanism*) characterized by the damage function $D : \Sigma^2 \times \{E, C\} \to \mathbb{R}$ that maps parties' verifiable actions $\vec{q}$ and τ into monetary flows from the seller to the buyer,

$$D(\vec{q}, \tau) = \begin{cases} \sum_{i=1}^{2} d(q_i, \bar{q}) & \text{if } \tau = C \\ d(q_1, \bar{q}) + d(0, \bar{q}) & \text{if } \tau = E \text{ and } q_1 < \mu\bar{q} \\ d(q_1, \bar{q}) - \int_{\Theta} \left[c(\sigma_i, \theta) + d(\sigma_i, \bar{q}) \right] f(\theta)\, d\theta & \text{if } \tau = E \text{ and } q_1 \geq \mu\bar{q}. \end{cases} \tag{10}$$

This enforcement mechanism specifies the parties' legal claims. Note that, given that price $2\bar{p}$ has been paid, the exact timing of the transfers is irrelevant for this paper's analysis. Alternatively, a privately stipulated price system $P(\vec{q}, \tau) = 2\bar{p} - D(\vec{q}, \tau)$ is strategically identical to default breach remedies.

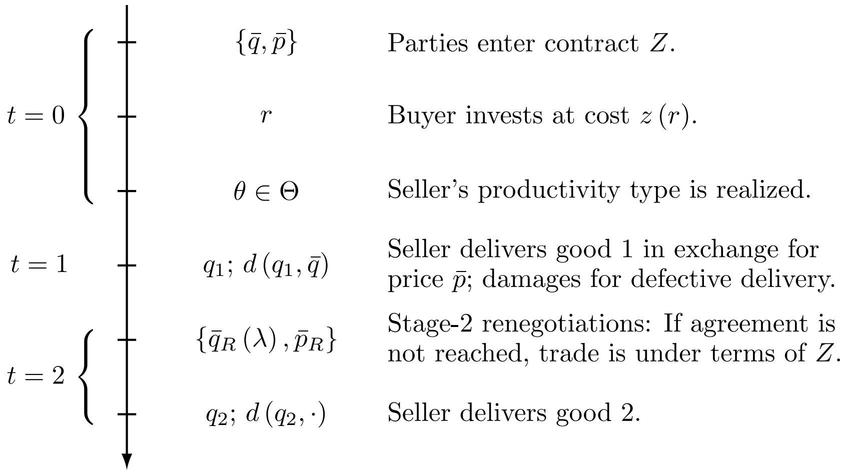
Three features of the procedural decision right are worth mentioning. First, a sequence of single-shot contracts with buyer's relationship-specific investment gives the seller a bargaining leverage through opportunistic holdup, whereas in a repeat transaction contract with a conditional breakup rule this threat potential is reversed since holdup is now put into the hands of the buyer. Second, although Aghion, Dewatripont, and Rey (1994), designing a contract that relies on randomization of trade, do not account for breakup τ as a decision variable, the approach in this paper is somewhat related to theirs as the monotonic partition of Σ yields a probabilistic exit option. Yet, while in their paper the probability of a trade default is predetermined, this model yields an endogenous probability as the seller eventually decides on whether or not to produce below the breakup threshold $\mu\bar{q}$. Thus, the institutional setup is closer to actual legal practice in cases where the contract does not specify any particular termination clause.[22] The option contract studied in Nöldeke and Schmidt (1995), on the other hand, grants the seller with certainty the *absolute* decision on whether or not to trade. The conditionality on contractible factors in this papers requires the action space to be richer than the binary choice set in, e.g., Aghion and Bolton (1987), implying also a more sophisticated price function to replace efficient expectation damages (cf. Spier and Whinston, 1995). Third, renegotiation of the contract renders the second period trade dependent on the first period. This intertemporal effect gives rise to the nondivisibility of the contract as discussed in the introductory section.

Renegotiation Parties may renegotiate the contract after state λ has been realized in order to modify the terms of exchange and trade on the Pareto-frontier. I consider three different degrees of renegotiation depth[23]: *(1)* the contract is not renegotiable; *(2)* the contract is *rigid*, that means the terms of trade for the first round cannot be modified (the timeline of this *semi-renegotiation* trade scenario is depicted in Figure 1); and *(3)* the contract is fully flexible

[22] See the concluding section for a discussion of U.S. and international contract law.

[23] For a specific treatment of renegotiation technology, in particular with respect to timing, see Watson (2007).

Figure 1: Timing of the model with contract rigidity



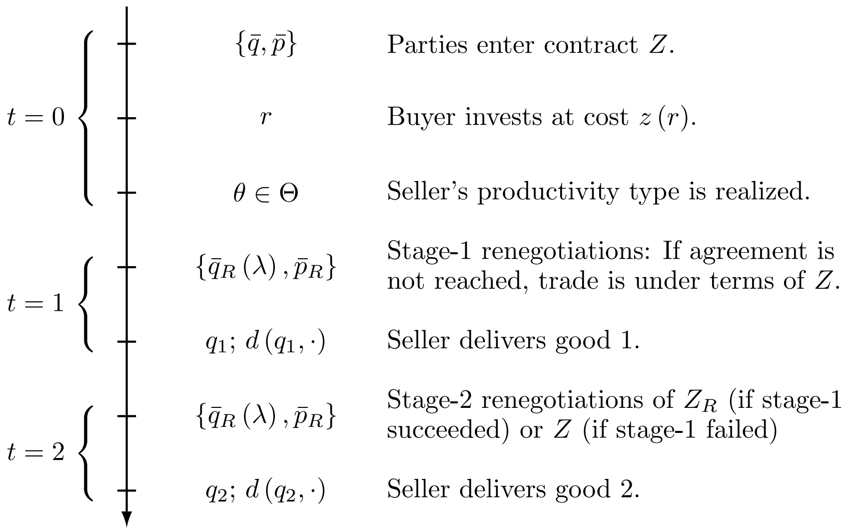
where the quality and price specifications can be adapted to the realized state λ for both the first and the second period, both before and after the first round of trade; see Figure 2 for the respective timeline of this *full-renegotiation* contract. I briefly discuss the underlying timing and bargaining structure for each of the renegotiation technologies before proceeding to the equilibrium analysis in the next Section.

For the second scenario under *contract rigidity*, I take the initial contract Z to be inalienable at stage $t=1$ and allow for renegotiation only after the closing of the first round of trade. A possible explanation for such a renegotiation restriction may be asymmetric type observability. This means that the seller observes her type at stage $t=0$ while the buyer observes θ in $t=1$. Alternatively, one may assume that both parties simultaneously observe θ, yet not until the initialization of the production process of good 1, not allowing for an interruption of production and renegotiation of specifications until after stage $t=1$. This is the case if harvest quality is not observable until the cutter physically casts off and renegotiation is not feasible by the time the fisherman is out of harbor.

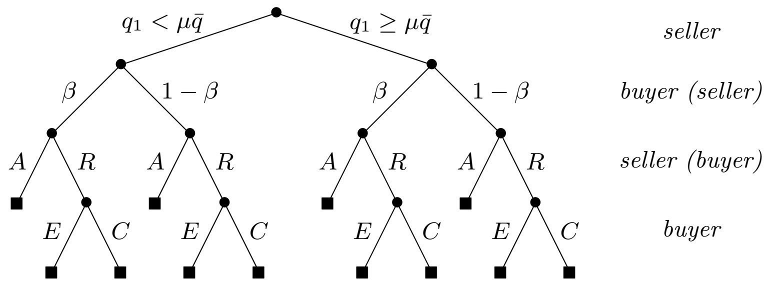
The timing is as follows: After Z is entered, the buyer invests and type θ is realized. The seller then settles on the quality of the first delivery. After this first exchange, the parties can renegotiate quality $\bar{q}$ and price $\bar{p}$ for the second good and agree on contract Z_R. Since the model is one of perfect information, it is straightforward that parties choose a quality level q such that the surplus from trade in $t=2$ is maximized, $\bar{q}_R \in \overline{Q}$, and bargain over their respective shares (reflected by price $\bar{p}_R$) of the trade surplus $\pi(\lambda)$. Note that by time-separability of $W(\cdot)$ the modified quality level is independent of q_1. If renegotiations shall fail, the parties honor contract Z (or do not trade if the buyer has decided to terminate) for the terms of trade of good 2. After the parties have collected their legal claims determined by the legal mechanism $D(\vec{q},\tau)$ the game ends.

Stage-2 price bargaining. *Given q_1, the buyer (seller) makes a take-it-or-leave-it offer with*

Figure 2: Timing of the model with unrestricted renegotiation



probability β (probability $1-\beta$). The seller (buyer) can accept 'A' or reject 'R' this offer. If it is accepted, the game ends and trade is according to Z_R and $d(q_2,\bar{q}_R)$. If the seller (buyer) rejects, then the buyer decides whether to exit 'E' or continue 'C' to trade under contract Z.

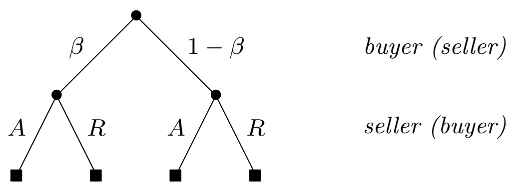


I consider a probabilistic proposal model (see, e.g., Binmore, 1987) that is asymmetric as to the parties' legal claims. By contract Z, the seller is given the right to deliver the second period good but forfeits this right by delivering a good with sufficiently low quality. I assume that by rejecting ('R') the seller's offer, the buyer does not waive her right to terminate.[24] This implies that in case of a rejected take-it-or-leave-it offer, the buyer can choose to exit 'E' or continue trade 'C' under Z. His valuation of each of these options is determined by $D(\vec{q},\tau)$. Since termination implies an end of the trade relationship with no trade surplus realized, parties' second period payoffs add up to zero.

[24]The asymmetry that arises from assigning the exit option exclusively to the buyer is related to the bargaining setup in Shaked (1994) or MacLeod and Malcomson (1993). The deterministic subgames are similar to Model 2 in Lyon and Rasmusen (2004).

A *frictionless renegotiation* technology implies that the terms of trade in Z for both $i = 1, 2$ can be changed and adapted to the state λ realized at stage $t = 0$. Before the seller enters production of good 1, the parties meet to agree on $\bar{q}_R(\lambda)$ and a transfer $\bar{p}_R$ that reflects their relative bargaining positions. As in the case under contract rigidity, I assume probabilistic take-it-or-leave-it offers for the bargaining routine. If no agreement is reached, then trade in the first round is under the terms of contract Z. After the delivery of good 1 parties may re-enter renegotiations under the stage-2 price bargaining routine. Note that by Definition 3, the breakup rule is conditional on the quality of the first delivery; exit 'E' is therefore not an option in stage-1 renegotiations.

Stage-1 price bargaining. *After state λ is realized, the buyer (seller) makes a take-it-or-leave-it offer with probability β $(1-\beta)$. The seller (buyer) can accept 'A' or reject 'R' this offer. If it is accepted, stage-1 is according to Z_R; if it is rejected, the parties trade under the terms of contract Z.*



5 Equilibrium strategies

Before proceeding to the main implications of contract termination on the efficiency of investment and trade, I first derive parties' equilibrium strategies given ϕ. The question of interest is for each of the renegotiation scenarios whether or not there exists a property rights bundle ϕ^* such that the first-best outcome can be implemented by a simple repeat transaction contract. I will first analyze the setup under contract rigidity and then proceed to the cases without renegotiation and with frictionless renegotiation. The insights from the semi-renegotiated contract will help understand the underlying dynamics, and the results for the full-renegotiation case are straightforward implications. The employed equilibrium concept is subgame perfection; the equilibrium is derived by backward induction.

Stage-2 price bargaining If stage-2 renegotiations fail and the buyer opts for 'C', then trade takes place as specified in Z. In that case, the seller maximizes her second period payoffs $\bar{s}(q_2, \theta)$ over quality q_2. By equation (5) it is straightforward to see that it cannot be his optimal strategy to deliver a quality level above and beyond the level specified in the contract. This is because for any $q_2 > \bar{q}$, damages are equal to zero, yet costs of production are increasing in q_2. A supraconforming $q_2 > \bar{q}$ is therefore strictly dominated by $q_2 = \bar{q}$ for any state λ. By rearranging the seller's payoffs, the second period quality can be written as

$$\sigma_2 \in \arg\max_{q_2 \leq \bar{q}} w\left(\rho^*, \theta, q_2\right) - \bar{b}\left(\rho^*, \bar{q}\right) \tag{11}$$

and is equal to $\sigma_2 = \min\left\{\sigma^*\left(\theta\right), \bar{q}\right\}$. This is by Definition 1 a first-best quality level for all θ such that $\sigma^*\left(\theta\right) \leq \bar{q}$. I will refer to such a first-best quality up to full conformity as *constrained first best* denoted by $\bar{\sigma}\left(\theta\right) \equiv \min\left\{\sigma^*\left(\theta\right), \bar{q}\right\}$. Expectation damages make the seller the residual claimant since the buyer's absolute share of the trade surplus—her compensated payoffs $\bar{b}\left(\rho^*, \bar{q}\right)$—is taken to be fixed, inducing undistorted activity incentives for the seller. Damages in equation (5), however, are such that the seller delivers as if the buyer had invested efficiently and $r = \rho^*$. For this reason, quality levels are inefficiently high for the true $r < \rho^*$ and inefficiently low for $r > \rho^*$ (see Lemma 1). While second period quality is independent of r, the period surplus from trade under contract Z is increasing in the level of investment and denoted by

$$\bar{\pi}\left(\lambda\right) = w\left(\lambda, \bar{\sigma}\left(\theta\right)\right)$$

If, for state λ, stage-2-renegotiations succeed, then parties will have agreed on a quality level $\bar{q}_R\left(\lambda\right)$ that maximizes the second period gains of trade,

$$\bar{q}_R\left(\lambda\right) \in \arg\max_{q_2 \in \overline{Q}} w\left(\lambda, q_2\right). \tag{12}$$

The revised contract Z_R is *simple* in the sense of Definition 2 and specifies a fixed quality $\bar{q}_R = \bar{q}_R\left(\lambda\right)$ to be delivered in exchange for $\bar{p}_R$. Note that while parties contract under perfect information and agree on a Pareto-optimal quality level, the seller's actual quality decision may not be efficient. By equation (5), the seller may in fact deviate from contract provision $\bar{q}_R\left(\lambda\right)$ and again deliver as if the buyer had efficiently invested. To see this, notice that the delivered second period quality is such that the seller's second period payoffs $\bar{s}_R\left(q_2, \theta\right) = \bar{p}_R - c\left(q_2, \theta\right) - d\left(q_2, \bar{q}_R\right)$ are maximized, hence

$$\sigma_R \in \arg\max_{q_2 \leq \bar{q}_R(\lambda)} w\left(\rho^*, \theta, q_2\right) - \bar{b}_R \tag{13}$$

where $\bar{b}_R$ is a constant. In case of buyer's underinvestment $r < \rho^*$, the no-windfall-gains assumption implicit in equation (5), inducing the upper bound $\bar{q}_R\left(\lambda\right)$ for σ_R, is a binding constraint. Given ρ^*, the quality from seller's unconstrained optimization is equal to $\sigma^*\left(\theta\right) > \sigma^o\left(\lambda\right)$, which is, however, strictly dominated by a fully conforming $\bar{q}_R\left(\lambda\right) = \sigma^o\left(\lambda\right)$. The surplus $\pi\left(\lambda\right)$ from trade under Z_R in this case is on the Pareto-frontier and denoted by

$$\pi\left(\lambda \mid r < \rho^*\right) = w\left(\lambda, \sigma^o\left(\lambda\right)\right).$$

If, on other hand, the buyer's investment exceeds the efficient level, then the reverse logic applies, the no-windfall-gains assumption is not binding and $\sigma_R = \sigma^*\left(\theta\right) < \bar{q}_R\left(\lambda\right)$ for all types

θ. This yields a trade surplus of

$$\pi\left(\lambda \mid r \geq \rho^*\right) = w\left(\lambda, \sigma^*\left(\theta\right)\right).$$

Here, the negative compensation bias from Lemma 1 serves as a binding constraint, inducing a suboptimal trade surplus $w\left(\lambda, \sigma^*\left(\theta\right)\right) < w\left(\lambda, \sigma^o\left(\lambda\right)\right)$. As is straightforward (and shown in Lemma 2), renegotiation of Z is always in the mutual interest of both contract parties as there are never joint losses incurred from renegotiation.

Lemma 2 (Renegotiation surplus)**.** *The renegotiation surplus* $g\left(\lambda\right) = \pi\left(\lambda\right) - \bar{\pi}\left(\lambda\right)$ *is nonnegative for all states* λ.

Proof. Let there be three cases: *1.* $r < \rho^*$, *2.* $r = \rho^*$, and *3.* $r > \rho^*$.

1. For $r < \rho^*$: It is to be shown that $\pi\left(\lambda\right) = w\left(\lambda, \sigma^o\left(\lambda\right)\right) \geq w\left(\lambda, \sigma_2\right) = \bar{\pi}\left(\lambda\right)$ for $\sigma_2 = \bar{\sigma}\left(\theta\right)$. As $\sigma^o\left(\lambda\right) \in \arg\max_{q_2} w\left(\lambda, q_2\right)$, the inequality holds strict for all θ such that $\sigma^o\left(\lambda\right) \neq \bar{q}$ and is in equality if, given r, the optimal quality is just conforming, $\sigma^o\left(\lambda\right) = \bar{q}$.
2. For $r = \rho^*$: Similar to the argument in (1.), the inequality is strict if θ such that $\sigma^*\left(\theta\right) \neq \bar{q}$.
3. For $r > \rho^*$: Since $\sigma_R = \sigma^*\left(\theta\right)$, $\pi\left(\lambda\right) = w\left(\lambda, \sigma^*\left(\theta\right)\right) \geq w\left(\lambda, \sigma_2\right) = \bar{\pi}\left(\lambda\right)$ holds by the argument of constrained maximization (no-windfall-gains assumption) under Z. Q.E.D.

Trade under the renegotiated contract Z_R is never Pareto-inferior to trade under the initial agreement Z. Hence, by information symmetry, renegotiation failure cannot be on the equilibrium path (although parties may agree on $Z_R = Z$). The modified quality specification is given in equation (12), price $\bar{p}_R$ for the good delivered is determined by the stage-2 price bargaining routine. This transfer consists of the price for the seller's delivery minus the price of the buyer's exit option. As termination is particularly detrimental for the seller (recall: the buyer is compensated for $q_2 = 0$), we can interpret the renegotiation of the contract as the seller buying the buyer's right to breakup. Lemma 3 shows that this game yields an asymmetric Nash-bargaining solution, where the parties' legal claims from options 'C' and 'E' are the disagreement points and the buyer's offer probability β his share of the renegotiation surplus. Note that if the buyer can credibly exercise her (off-equilibrium) exit threat 'E', then the second period gains of trade are equal to zero and the renegotiation surplus simply $g\left(\lambda\right) = \pi\left(\lambda\right)$. The resulting payoffs $\tilde{b}\left(\lambda, \phi, q_1\right)$ and $\tilde{s}\left(\lambda, \phi, q_1\right)$ for the buyer and the seller, respectively, are referred to as *continuation values* of the contract.

Lemma 3 (Continuation values)**.** *The continuation values* $\tilde{b}\left(\lambda, \phi, q_1\right)$ *for the buyer and* $\tilde{s}\left(\lambda, \phi, q_1\right)$ *for the seller as result of an asymmetric Nash-bargaining solution are equal to*

$$\begin{pmatrix} \tilde{b}\left(\lambda, \phi, q_1\right), \\ \tilde{s}\left(\lambda, \phi, q_1\right) \end{pmatrix} = \begin{cases} \begin{pmatrix} \bar{b}\left(\rho^*, \bar{q}\right) + \beta\pi\left(\lambda\right), \\ -\bar{b}\left(\rho^*, \bar{q}\right) + \left(1-\beta\right)\pi\left(\lambda\right) \end{pmatrix} & \textit{if } q_1 < \mu\bar{q} \textit{ and } r \leq \rho^* \\ \\ \begin{pmatrix} \bar{b}\left(r, \sigma_2\right) + \beta g\left(\lambda\right), \\ \bar{\pi}\left(\rho^*, \theta\right) - \bar{b}\left(\rho^*, \bar{q}\right) + \left(1-\beta\right) g\left(\lambda\right) \end{pmatrix} & \textit{if otherwise.} \end{cases}$$

The proof is relegated to Appendix A. As can be seen from the case differentiation, both parties can influence their second period payoffs by choosing appropriate levels of investment r and quality q_1. For the buyer, the investment level determines whether or not exit threat 'E' is indeed credible. Lemma 3 establishes this credibility result and shows that if she overinvests such that $r > \rho^*$, then the continuation values are independent of breakup rule μ and quality q_1. This is a straightforward implication of the renegotiation setup: Recall that if one of the parties rejects a bargaining offer, it is never optimal for the buyer to exit the contract since by Lemma 1 the call option 'C' yields strictly larger payoffs than 'E'. This is by the negative compensation bias $h(r, \sigma_2) < 0$ for $r > \rho^*$ and the buyer's payoffs under contract Z strictly larger than the compensation for breakup, $\bar{b}(r, \sigma_2) = \bar{b}(\rho^*, \bar{q}) - h(r, \sigma_2) > \bar{b}(\rho^*, \bar{q})$. If, on the other hand, investment falls short of the efficient level, then the compensation bias is positive and $\bar{b}(r, \sigma_2) < \bar{b}(\rho^*, \bar{q})$. Hence, exit '$E$' is the buyer's best response to a rejection of her own (the seller's) renegotiation offer x_S (x_B). Anticipating this, the seller can "choose" the renegotiation game (i.e. his outside option) to be played by presenting a sufficiently high quality q_1. Assumption 2 ensures that if the seller delivers a good of quality $q_1 \geq \mu\bar{q}$, the buyer's only credible option is to continue 'C' and call for trade under contract Z. If, however, $q_1 < \mu\bar{q}$, then the buyer's exit threat is indeed credible and her dominant outside option choice is 'E.'

Comparative static results for the continuation values with respect to q_1 are presented in Corollary 1. It can be seen that these continuation values exhibit a discontinuity at the breakup threshold $\mu\bar{q}$. Given some parameter restrictions, the seller benefits from a quality level that is sufficiently high to not yield an exit threat to the buyer.

Corollary 1. *Let $\delta(\tilde{b}) \equiv \tilde{b}\left(\lambda, \phi, q_1 \mid q_1 \geq \mu\bar{q}\right) - \tilde{b}\left(\lambda, \phi, q_1 \mid q_1 < \mu\bar{q}\right)$ for the buyer and $\delta(\tilde{s}) \equiv \tilde{s}\left(\lambda, \phi, q_1 \mid q_1 \geq \mu\bar{q}\right) - \tilde{s}\left(\lambda, \phi, q_1 \mid q_1 < \mu\bar{q}\right)$ for the seller. Then*

1. *$\delta(\tilde{b}) \leq 0$ for all β and r; "$<$" if $\theta > 0$ and $r < \rho^*$, or for all $\beta > 0$ if $\theta > 0$ and $r = \rho^*$;*
2. *$\delta(\tilde{s}) \geq 0$ for all β and r; "$>$" if $r < \rho^*$, or for all $\beta > 0$ if $r = \rho^*$.*

Proof. 1. (a) For $r \leq \rho^*$: By the payoffs in Lemma 3:

$$\begin{array}{rcl} \tilde{b}\left(\lambda, \phi, q_1 \mid q_1 \geq \mu\bar{q}\right) = \bar{b}(r, \sigma_2) + \beta g(\lambda) & & \bar{b}(\rho^*, \bar{q}) + \beta\pi(\lambda) = \tilde{b}\left(\lambda, \phi, q_1 \mid q_1 < \mu\bar{q}\right). \\ = -h(r, \sigma_2) + \beta g(\lambda) = -\beta\bar{\pi}(\lambda) & \leq & h(r, \sigma_2) = \beta\pi(\lambda) = \end{array} \tag{14}$$

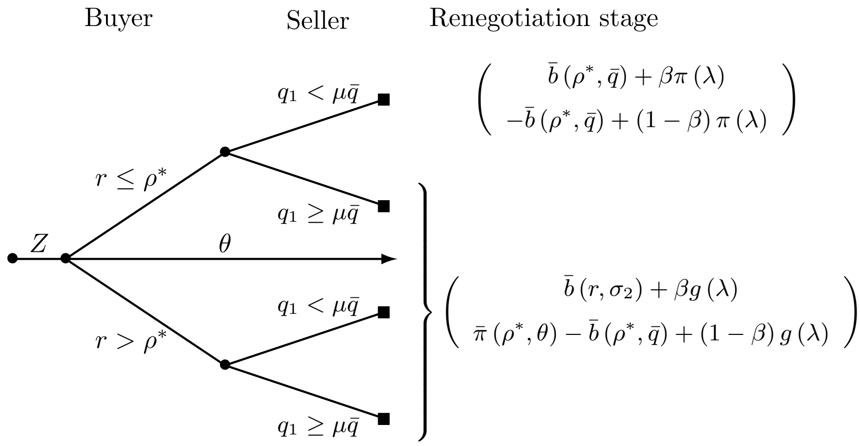
Note that $h(r, \sigma_2) = 0$ if $r = \rho^*$ or $\sigma_2 = 0$. Since $\tau = E$ is not an equilibrium strategy for the buyer, $\sigma_2 = 0$ if and only if $\theta = 0$. In that case, the expression in equation (14) is reduced to $-\beta 0 = 0$. If $r = \rho^*$, then the inequality is strict only if the LHS of (14) is negative, which is true for $\beta > 0$ and $\theta > 0$. If $r < \rho^*$ and $\theta > 0$, then the RHS is strictly positive, the inequality in (14) is strict for all β.

(b) For $r > \rho^*$: Straightforward by the payoffs in Lemma 3.

2. (a) For $r \leq \rho^*$: By the payoffs in Lemma 3,

$$\begin{array}{rcl} \tilde{s}\left(\lambda, \phi, q_1 \mid q_1 \geq \mu\bar{q}\right) & & \tilde{s}\left(\lambda, \phi, q_1 \mid q_1 < \mu\bar{q}\right). \\ = \bar{\pi}(\rho^*, \theta) - \bar{b}(\rho^*, \bar{q}) + (1-\beta) g(\lambda) & & -\bar{b}(\rho^*, \bar{q}) + (1-\beta)\pi(\lambda) = \\ = \bar{\pi}(\rho^*, \theta) = w(\rho^*, \theta, \sigma_2) & \geq & (1-\beta) w(\lambda, \sigma_2) = (1-\beta)\bar{\pi}(\lambda) = \end{array} \tag{15}$$

Figure 3: The continuation game



Recall from equation (11) that $\sigma_2 \in \arg\max_{q_2 \leq \bar{q}} w(\rho^*, \theta, q_2)$, and for $r < \rho^*$ it holds true for all θ that

$$w(\lambda, \sigma_2) = v(r, \sigma_2) - c(\sigma_2, \theta) < v(\rho^*, \sigma_2) - c(\sigma_2, \theta) = w(\rho^*, \theta, \sigma_2).$$

Hence, the inequality in equation (15) is strict for all β. If, on the other hand, $r = \rho^*$, then $w\left(\lambda, \sigma_2 \mid r = \rho^*\right) = w(\rho^*, \theta, \sigma_2)$, then the inequality in (15) is strict if and only if $\beta > 0$.

(b) For $r > \rho^*$: Straightforward by the payoffs in Lemma 3. Q.E.D.

The game can be reduced to a two-stage sequential move game: First, after contract Z is entered the buyer invests in r. Then at the second stage, after observing θ, the seller delivers quality q_1 after which the reduced extensive form game ends. Both r and q_1 trigger renegotiation and continuation values as given in Lemma 3. Figure 3 depicts the structure of this reduced *continuation game.*

First-period quality By inducing the discontinuity of second period payoffs, the buyer's threat gives rise to a holdup problem since the seller's strategic stage-1 "choice" of buyer's stage-2 outside option deviates from the optimal quality level. This is because the seller will be inclined to exert excessive costs in order to prevent buyer's μ-holdup in the stage-2 price bargaining game. To see this, note that as valuation and cost functions are additively separable, the optimal quality level is equal to $\sigma^o(\lambda)$. If the seller's optimization problem is time-separable, then, analogously to σ_2 in equation (11), he will deliver a good 1 of quality $q_1 = \bar{\sigma}(\theta)$. For $r > \rho^*$ the optimal level will be strictly larger than the first-best, for $r < \rho^*$ it will be lower than the *constrained* first-best for all θ such that $\sigma^o(\lambda)$ and higher for all θ such that $\sigma^o(\lambda) > \bar{q}$. By Corollary 1, however, the seller's first period optimization problem

$$\sigma_1 \in \arg\max_{q_1 \leq \bar{q}} \widetilde{S}(\lambda, \phi, q_1) = w(\rho^*, \theta, q_1) - \bar{b}(\rho^*, \bar{q}) + \tilde{s}(\lambda, \phi, q_1) \tag{16}$$

is not time-separable for all investment levels. This is an immediate consequence of the conditionality of the breakup rule. The incremental effect of q_1 on the seller's continuation values $\tilde{s}(\lambda, \phi, q_1)$, denoted by $\delta(\tilde{s})$, renders the seller's second period payoffs a function of the first period quality level. His first period decision thus reflects his "choice" of the renegotiation game to be played. A sufficiently high q_1 will deprive the buyer of her exit threat and in return improve the seller's bargaining *position* by raising his outside option value. As is shown in Lemma 4, if $\delta(\tilde{s}) > 0$ (and the buyer's exit threat indeed credible) then there exists a subset $\widetilde{\Theta} \subset \Theta$ of productivity types θ for which a deviation from the constrained first-best strategy $\bar{\sigma}(\theta)$ is dominant. Hence, instead of delivering a good of quality $\sigma_1 = \sigma^*(\theta) < \mu\bar{q}$, these sellers will strategically *overshoot* and incur additional production costs to be able to deliver a good of quality $\sigma_1 = \mu\bar{q}$ and thus prevent the buyer from exercising her exit threat. As a result, for $r < \rho^*$ the delivered quality level will be even larger and thus more suboptimal, whereas for $r > \rho^*$ quality level σ_1 is unchanged since breakup 'E' is not a credible option in the price bargaining game. This asymmetry with respect to r follows from the negative compensation bias for overinvestment.

The incentive to overshoot holds for types $\theta \in \widetilde{\Theta}$ such that the additional costs of excessive quality $\mu\bar{q} > \sigma^*(\theta)$ in the first period are offset by the positive incremental effect of $\delta(\tilde{s})$ in the second period. The productivity type $\tilde{\theta} = \min \widetilde{\Theta}$ is the lowest for which this holds true. This implies that all types below this threshold will deliver a good of quality $\sigma_1 < \mu\bar{q}$, all types equal or above deliver $\sigma_1 \geq \mu\bar{q}$. The proof of Lemma 4 formally develops these conditions.

Lemma 4 (Quality)**.** *The seller's equilibrium strategy σ_1 will be constrained first-best if and only if $\delta(\tilde{s}) = 0$. If $\delta(\tilde{s}) > 0$, then for a nonempty subset $\widetilde{\Theta}$ it holds that $\sigma_1 = \mu\bar{q} > \sigma^*(\theta)$, hence quality level q_1 is inefficiently high with strictly positive probability.*

Proof. The proof consists of two parts: I first argue that for $\delta(\tilde{s}) > 0$ the seller's production incentives are distorted; I then show that for some parameter restrictions this is true with strictly positive probability.

1. If the incremental effect of q_1 on $\tilde{s}(\lambda, \phi, q_1)$ is equal to zero, then the seller's production will be undistorted and constrained first best, $\sigma_1 = \bar{\sigma}(\theta) \equiv \min\{\sigma^*(\theta), \bar{q}\}$. If $\delta(\tilde{s}) > 0$, however, the seller will account for the intertemporal effect of q_1 on his second period payoffs.
2. To determine the range of seller types that will overshoot and deliver quality $\sigma_1 = \mu\bar{q} > \sigma^*(\theta)$, let r and β such that $\delta(\tilde{s}) > 0$ (Corollary 1). By Lemma 3, the seller's first period optimization problem can then be characterized as

$$\tilde{\sigma}_1(\lambda, \phi) \in \arg\max_{q_1 \leq \bar{q}} w(\rho^*, \theta, q_1) - \bar{b}(\rho^*, \bar{q}) + 1_{(q_1 \geq \mu\bar{q})}\left[w(\rho^*, \theta, \sigma_2) - (1-\beta)\, w(\lambda, \sigma_2)\right]$$

with $1_{(q_1 \geq \mu\bar{q})}$ equal to 1 if $q_1 \geq \mu\bar{q}$, 0 otherwise. The term $1_{(q_1 \geq \mu\bar{q})}\left[w(\rho^*, \theta, \sigma_2) - (1-\beta)\, w(\lambda, \sigma_2)\right]$ gives the incremental effect of a delivery $\mu\bar{q}$ on $\widetilde{S}(\lambda, \phi, q_1)$. The seller's payoffs thus exhibit a discontinuity at this breakup threshold. Moreover, let $\bar{\theta}^{\mu}$ such that $\sigma^*\left(\bar{\theta}^{\mu}\right) = \mu\bar{q}$, then the intertemporal effect translates into a discontinuity at the borderline productivity type $\bar{\theta}^{\mu} = \sup \widetilde{\Theta}$,

$$\lim_{\theta \to \bar{\theta}^{\mu}} \left[\widetilde{S}(\lambda, \phi, \mu\bar{q}) - \widetilde{S}(\lambda, \phi, \sigma^*(\theta))\right] = w\left(\rho^*, \bar{\theta}^{\mu}, \mu\bar{q}\right) - (1-\beta)\, w\left(r, \bar{\theta}^{\mu}, \mu\bar{q}\right) > 0 \qquad (17)$$

for all $r < \rho^*$ or $\beta > 0$. This expression gives the seller's value of *overshooting.* For $\theta > \bar{\theta}^{\mu}$ he will deliver a quality $\sigma_1 = \bar{\sigma}(\theta)$. For lower types, $\theta < \bar{\theta}^{\mu}$, however, he will not deliver an optimal quality

$q_1 = \sigma^*(\theta)$ as long as this (second period) value of $\mu\bar{q} > \sigma^*(\theta)$ more than offsets the additional costs of excessive delivery (first period payoff losses), i.e. as long as $\widetilde{S}(\lambda, \phi, \sigma^*(\theta)) < \widetilde{S}(\lambda, \phi, \mu\bar{q})$ or, for $\sigma_2 = \sigma^*(\theta)$ since $\theta < \bar{\theta}^{\mu}$,

$$w(\rho^*, \theta, \mu\bar{q}) > (1-\beta)\, w(\lambda, \sigma^*(\theta)).$$

Let $\tilde{\theta}$ be the seller type for which the additional costs of excessive $q_1 = \mu\bar{q}$ just offset the second period gains and

$$w\big(\rho^*, \tilde{\theta}, \mu\bar{q}\big) = (1-\beta)\, w\big(r, \tilde{\theta}, \sigma^*\big(\tilde{\theta}\big)\big) \tag{18}$$

By equation (17) it is straightforward that $\tilde{\theta} < \bar{\theta}^{\mu}$ for all β (for all $\beta > 0$ if $r = \rho^*$). Note that $(1-\beta)\, w\big(r, \tilde{\theta}, \sigma^*\big(\tilde{\theta}\big)\big)$ is non-negative, hence $0 < \tilde{\theta}$ since $w(\rho^*, 0, \mu\bar{q}) < 0$ for $\mu > 0$ and $\bar{q} > 0$. Note that $\tilde{\sigma}_1(\lambda, \phi) = \bar{\sigma}(\theta)$ if $\mu = 0$. Let $\widetilde{\Theta} = \big[\tilde{\theta}, \bar{\theta}^{\mu}\big)$, then by $0 < \tilde{\theta} < \bar{\theta}^{\mu}$ it holds true that $\widetilde{\Theta} \nsubseteq \emptyset$ and $\widetilde{\Theta} \subset \Theta$. Seller types larger equal $\tilde{\theta}$ and lower than $\bar{\theta}^{\mu}$ will by the continuity of $F(\theta)$ with positive probability deliver an *excessive* quality level $q_1 = \mu\bar{q} > \sigma^*(\theta)$. Q.E.D.

Given μ, the seller's first period strategy for the subgame with $r > \rho^*$ and $\delta(\tilde{s}) = 0$ is equal to a constrained first best $\bar{\sigma}(\theta)$. For the case with a credible exit threat, $r \leq \rho^*$ and $\delta(\tilde{s}) > 0$, the delivered quality of good 1 is denoted by

$$\tilde{\sigma}_1(\lambda, \phi) = \begin{cases} \sigma^*(\theta) & \text{if } \theta < \tilde{\theta} \text{ or } \theta \in \big[\bar{\theta}^{\mu}, \bar{\theta}\big) \\ \mu\bar{q} & \text{if } \theta \in \big[\tilde{\theta}, \bar{\theta}^{\mu}\big) \\ \bar{q} & \text{if } \theta \geq \bar{\theta}, \end{cases} \tag{19}$$

where the threshold of efficient breach $\bar{\theta}$ such that $\sigma^*\left(\bar{\theta}\right) = \bar{q}$ and $\bar{\theta}^{\mu} = \sup \widetilde{\Theta}$ such that $\sigma^*\left(\bar{\theta}^{\mu}\right) = \mu\bar{q}$.

The μ-holdup problem is a straightforward implication of the breakup rule. Notice the analogy of μ-holdup with a moral hazard problem that arises from the fact that beside the contracted quality level $\bar{q}$ the parties implicitly agree on a performance level $\bar{\sigma}(\theta)$, given $\bar{q}$. Both parties to the contract anticipate the seller's decision to efficiently breach the contract and deliver a nonconforming quality level shall the productivity type θ be sufficiently low. Therefore, by relying on the default rule of *efficient expectation damages* in equation (5) (or a price function $p(q_i)$ in equation (6)), they appreciate the seller's optimization. Along with these two quality specifications, two compliance concepts can be identified. While the legal mechanism is based on compliance with the terms of trade $\bar{q}$, which is verifiable since both q_1 and $\bar{q}$ are verifiable, efficiency considerations are concerned with compliance with the implicit agreement to produce and deliver a constrained efficient $\bar{\sigma}(\theta)$ that is nonverifiable and constitutes the seller's hidden action. Lemma 4 shows that these two concepts are not aligned for $\mu > 0$. Moreover, as is established in Corollary 2, the less restricted is the breakup rule, i.e. the higher μ, the more pronounced the distortion of the seller's performance incentives and the stronger the μ-holdup effect (moral hazard) will be.

Corollary 2. *For $\delta\big(\tilde{s}\big) > 0$, the probability of an excessive quality level $\sigma_1 = \mu\bar{q} > \sigma^*(\theta)$ is increasing in μ and decreasing in r.*

Proof. Let $\left|\widetilde{\Theta}\right|$ the measure of overshooting types and as such the probability of inefficiently high deliveries. This probability is (1.) increasing in μ and (2.) decreasing in r.

1. Let by definition of $\tilde{\theta}$ in equation (18) $H \equiv w\big(\rho^*, \tilde{\theta}, \mu\bar{q}\big) - (1-\beta)\, w\big(r, \tilde{\theta}, \sigma^*\big(\tilde{\theta}\big)\big) = 0$. By the implicit function theorem it is known that $\partial\tilde{\theta}/\partial\mu = -\left(H_\mu/H_{\tilde{\theta}}\right)$ where H_μ and $H_{\tilde{\theta}}$ denote first derivatives of H with respect to μ and $\tilde{\theta}$, respectively,

$$\begin{aligned} H_\mu &: \frac{\partial w\big(\rho^*, \tilde{\theta}, \mu\bar{q}\big)}{\partial q_1}\bar{q} < 0 \\ H_{\tilde{\theta}} &: \underbrace{\frac{\partial w\big(\rho^*, \tilde{\theta}, \mu\bar{q}\big)}{\partial\tilde{\theta}} - (1-\beta)\,\frac{\partial w\big(r, \tilde{\theta}, \sigma^*\big(\tilde{\theta}\big)\big)}{\partial\tilde{\theta}}}_{>0;\ =0 \text{ for } r=\rho^* \text{ and } \beta=0} \underbrace{- (1-\beta)\,\frac{w\big(r, \tilde{\theta}, \sigma^*\big(\tilde{\theta}\big)\big)}{\partial\sigma^*\big(\tilde{\theta}\big)}\frac{\partial\sigma^*\big(\tilde{\theta}\big)}{\partial\tilde{\theta}}}_{<0;\ =0 \text{ for } r=\rho^* \text{ or } \beta=1} > 0. \end{aligned}$$

   The second term for $H_{\tilde{\theta}}$ is negative by concavity of $w(\cdot)$ in q_i and the fact that for $r < \rho^*$ a quality level of $\sigma^*(\theta)$ is excessive. Further note that for a fixed q_i the gains of trade increase with the buyer's productivity type. Thus, due to $v_{q_i r} > 0$, the difference in the first term is positive, rendering $H_{\tilde{\theta}} > 0$. Hence, $\partial\tilde{\theta}/\partial\mu > 0$ if r and β such that $\delta(\tilde{s}) > 0$.
   Since both $\bar{\theta}^\mu$ and $\tilde{\theta}$ are increasing in μ and $\bar{\theta}^\mu = \tilde{\theta} = 0$ if μ, to establish $\left|\widetilde{\Theta}\right|_\mu > 0$ it needs to hold that $\partial\tilde{\theta}/\partial\mu < \partial\bar{\theta}^\mu/\partial\mu$. The following equality holds by the definition of $\bar{\theta}^\mu$ and equation (18):

$$w\left(\rho^*, \bar{\theta}^\mu, \mu\bar{q}\right) - w\left(\rho^*, \bar{\theta}^\mu, \sigma^*\left(\bar{\theta}^\mu\right)\right) = w\big(\rho^*, \tilde{\theta}, \mu\bar{q}\big) - (1-\beta)\, w\big(r, \tilde{\theta}, \sigma^*\big(\tilde{\theta}\big)\big).$$

   Note that $\tilde{\theta}$ is monotonically decreasing in β. I only establish the result for $\beta = 1$, the general result follows straight from these arguments. The expression is rewritten as

$$w\left(\rho^*, \bar{\theta}^\mu, \mu\bar{q}\right) - w\left(\rho^*, \bar{\theta}^\mu, \sigma^*\left(\bar{\theta}^\mu\right)\right) = w\big(\rho^*, \tilde{\theta}, \mu\bar{q}\big).$$

   Suppose $\partial\tilde{\theta}/\partial\mu \geq \partial\bar{\theta}^\mu/\partial\mu$. As both $\tilde{\theta}$ and $\bar{\theta}^\mu$ are increasing in μ, the equality holds true if $w\left(\rho^*, \bar{\theta}^\mu, \sigma^*\left(\bar{\theta}^\mu\right)\right)$ is decreasing in $\bar{\theta}^\mu$, which leads to a contradiction.

2. First note that $\bar{\theta}^\mu$ is independent of r. For $\left|\widetilde{\Theta}\right|_r < 0$ it needs to hold that $\tilde{\theta}_r > 0$; $\partial\tilde{\theta}/\partial r = -\left(H_r/H_{\tilde{\theta}}\right) > 0$. From (a) we know that $H_{\tilde{\theta}} > 0$, moreover

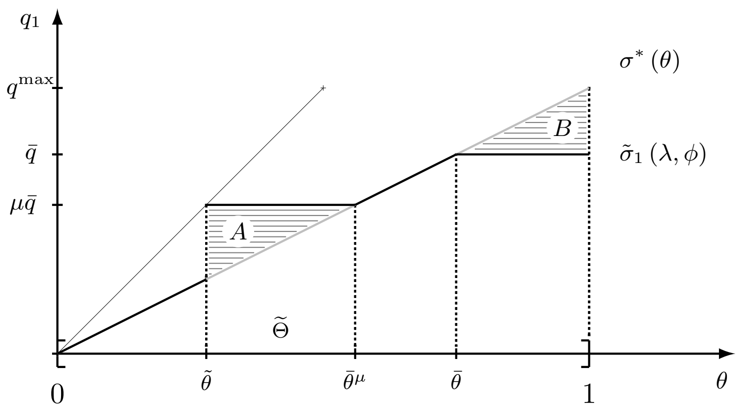
$$H_r \quad : \quad -(1-\beta)\,\frac{\partial w\big(r, \tilde{\theta}, \sigma^*\big(\tilde{\theta}\big)\big)}{\partial r} < 0$$

   which is straightforward by $v_r > 0$. As $\tilde{\theta} < \bar{\theta}^\mu$, $\tilde{\theta}_r > 0$ and $\bar{\theta}^\mu_r = 0$, the probability of overshooting is decreasing in r. Q.E.D.

By equation (18), the threshold $\tilde{\theta}$ is a function of r, ϕ, and $\bar{q}$. Consequently, the equilibrium probability for the buyer to be granted the procedural decision right, denoted by a measure $\big|\big[0, \tilde{\theta}\big)\big|$, is endogenously determined through the buyer's choice of r and the seller's equilibrium behavior, delineating the borderlines between this and the model by Aghion, Dewatripont, and Rey (1994). Note that for a full restriction and $\mu = 0$, the seller will never be inclined to deliver an excessively high quality level in period $t = 1$ and $\tilde{\sigma}_1 = \bar{\sigma}(\theta)$ for all θ.

A stylized picture of the seller's strategy $\tilde{\sigma}_1(\lambda, \phi)$ for the level of his first period production given a positive μ is presented in Figure 4. The lower ray through the origin depicts the undistorted production level $\sigma^*(\theta)$. If $\bar{q} < q^{\max}$, then the seller will delivery a fully conforming first commodity for all $\theta \geq \bar{\theta}$. The shaded area B represents this inefficiency from underperformance. Area A indicates the inefficiency arising from seller's moral hazard or μ-holdup. He delivers a

Figure 4: $\tilde{\sigma}_1(\lambda, \phi)$



good of quality $\mu\bar{q}$ for a nonatomic set $\widetilde{\Theta}$ if $\mu > 0$. Eventually, the upper ray through the origin plots the $\left(\mu\bar{q}, \tilde{\theta}\right)$ pairs for $\mu \in [0, 1]$.

Specific investment While a full restriction of the buyer's exit option restores the seller's *ex-post* incentives to produce (constrained) efficient quality, such an extreme breakup rule may at the same time dilute the buyer's *ex-ante* incentives to invest. In order to reconcile the model's implications with the literature on breakup restrictions, I first comment on the effect of the buyer's procedural decision rights on the seller's *ex-ante* incentives if he were the party to invest. The literature suggests that restricting the buyer's right to prematurely exit the contract protects the seller's investment incentives (in addition to the effects in Lemma 4). The following Proposition summarizes these insights. The proof is straightforward from Lemma 4 and the standard holdup results of Klein, Crawford, and Alchian (1978), Goldberg and Erickson (1987) or Crawford (1990), among other, and therefore omitted.

Proposition 1. *Suppose the seller invests in $\hat{r}$ at cost $z(\hat{r})$ such that $c_{\hat{r}}(\hat{r}, \theta, q_i) < 0$ and $c_{q_i\hat{r}}(\hat{r}, \theta, q_i) < 0$. Then a breakup rule such that $\mu = 0$ is optimal.*

This result changes substantially, however, if instead it is assumed that the investing party is the beneficiary rather than the victim of termination. In that case, the buyer at stage $t = 0$ maximizes her expected payoffs $\widehat{B}(r) \equiv \int_{\Theta} \widetilde{B}(\lambda, \phi) f(\theta) d\theta - z(r)$ over investment r, where $\widetilde{B}(\lambda, \phi) = \bar{b}(r, \tilde{\sigma}_1(\lambda, \phi)) + \tilde{b}(\lambda, \phi, \tilde{\sigma}_1(\lambda, \phi))$, and such that

$$\rho \in \arg\max_{r \in \mathbb{R}} \int_{\Theta} \widetilde{B}(\lambda, \phi) f(\theta) d\theta - z(r). \tag{20}$$

To grasp the intuition, first consider two aspects with regard to buyer's investment incentives that have been extensively discussed in the context of single transaction contracts (cf. Edlin, 1996) and whose implications carry over to repeat transaction contracts. First, an expectation damage remedy, when based on the realized investment level, may induce incentives that lead to overinvestment (see, e.g. Shavell, 1980; Rogerson, 1984). This will indeed be the case if expectation damages serve as a full insurance remedy that give the buyer the full value of investment with certainty, i.e. even when trade does not occur. Referring to Fuller and Perdue (1936) who suggest that only "reasonable" investment be protected by breach remedies, Cooter and Eisenberg (1985:1467) limit expectation damages to what they are under efficient investment. That way, if damages are based on the hypothetical, efficient level and therefore independent of actual investment, the full insurance argument ceases to apply and the incentive to overinvest is eliminated.

Second, even if efficient expectation damages are the default remedy for seller's breach of contract, the buyer's investment incentives may be diluted due to a β-holdup problem as result of her imperfect bargaining power in contract renegotiations. In general, parties will efficiently invest if they can recoup the full returns of their expenditures. If their fraction of the renegotiation surplus, however, is less than one, their incentives are distorted and underinvestment will be the result. Putting it in this paper's notation and trade technology: Given $\bar{q}$ such that there exists a positive renegotiation surplus $g(\lambda) > 0$, if probability β of the buyer's offer is less than unity then $r < \rho^*$.

This underinvestment result will hold for all $\beta < 1$, however, only if termination is not an option and there is trade in the second period with certainty both on *and* off the equilibrium path, that means if breakup is noncredible for $\mu = 0$. To see this, suppose μ is strictly positive and, given that she underinvests for some $\beta < 1$, the buyer's exit threat indeed credible. Her valuation of this *ex-post* decision right comprises two components: First, the effect on the buyer's first period payoffs through the impact of the exit threat on quality level $\sigma_1 = \tilde{\sigma}_1(\lambda, \phi)$, amounting to $\bar{b}(r, \tilde{\sigma}_1(\lambda, \phi)) - \bar{b}(r, \bar{\sigma}(\theta)) < 0$; and second, the buyer's (nonnegative) continuation value of option 'E' relative to 'C', equal to $-\delta(\tilde{b})$ by Corollary 1. The full *threat value* is equal to

$$\int_{\tilde{\theta}}^{\bar{\theta}^{\mu}} \left[h(r, \sigma^*(\theta)) - h(r, \mu\bar{q})\right] f(\theta)\, d\theta + \int_{0}^{\tilde{\theta}} \left[h(r, \sigma^*(\theta)) + \beta\bar{\pi}(\lambda)\right] f(\theta)\, d\theta. \tag{21}$$

As is the driving effect in Lemma 5, the buyer's bargaining leverage induced by μ yields additional returns on investment r. The breakup rule therefore enhances the buyer's (exogenous) bargaining power β, and if this rent-seeking effect is strong and her *breakup-rent* effect high enough, it may fully restore her investment incentives when she would otherwise underinvest for $\beta < 1$. Lemma 5 formalizes these results. It states that for procedural decision rights with a positive breakup rule parameter $\hat{\mu}(\beta, \bar{q})$, the buyer efficiently invests, yet that for all $\mu < \hat{\mu}(\beta, \bar{q})$ investment r falls short of the efficient level ρ^*. Moreover, it also shows that the buyer will never overinvest even if her bargaining leverage exceeds the level of efficiency restoration. This implication is a direct consequence (and indeed the intention (Edlin, 1996)) of the application of efficient expectation damages due to the negative compensation bias for $r > \rho^*$. Hence, by overinvesting, the buyer forfeits the credibility of her exit threat, depriving herself of the positive investment returns inherent in equation (21). The proofs of the Lemma and the following Corollary are relegated to Appendix B.

Lemma 5 (Investment)**.** *Buyer's specific investment r is a function of $\phi = (\beta, \mu)$ and quality level $\bar{q}$. For a repeat transaction contract Z there exists a $\hat{\mu}(\beta, \bar{q}) > 0$ such that the buyer efficiently invests $r = \rho^*$ for $\mu \geq \hat{\mu}(\beta, \bar{q})$ and underinvests for all β if $\mu < \hat{\mu}(\beta, \bar{q})$. Moreover, it holds that $\hat{\mu}(1, q^{max}) = 0$.*

The Corollary to Lemma 5 provides comparative statics results of the investment restoring $\hat{\mu}(\beta, \bar{q})$ and comments on its feasibility. As the buyer's incentive dilution, i.e. the degree of underinvestment, increases with lower β and $\bar{q}$, a stronger rent-seeking effect is required to restore efficient investment incentives. For low values of β and $\bar{q}$ an infeasible $\hat{\mu}(\beta, \bar{q})$ outside the unit interval may be the result.

Corollary 3. (1) $\hat{\mu}_\beta(\beta, \bar{q}) < 0$*;* (2) $\hat{\mu}_{\bar{q}}(\beta, \bar{q}) < 0$*;* (3) $\hat{\mu}(\beta, \bar{q})$ *is not within the unit interval for sufficiently small values of β and $\bar{q}$.*

Given β and $\bar{q}$, for the semi-renegotiated contract under contract rigidity the *subgame perfect equilibrium (SPE)* strategies are functions of θ and $\phi = (\beta, \mu)$ and denoted by $\vec{\rho}(\phi) = (\rho, \tau)$ for the buyer and $\vec{\sigma}(\lambda, \phi) = (\sigma_1, \sigma_2)$ for the seller, where $\lambda = (\rho(\phi), \theta)$. They are characterized by the results of Lemmata 4 and 5, and are given as

$$\langle \vec{\rho}(\phi), \vec{\sigma}(\lambda, \phi) \rangle = \begin{cases} \big\langle \big(\rho < \rho^*, C\big), \big(\bar{\sigma}(\theta), \sigma^o(\rho, \theta)\big) \big\rangle & \text{if } \mu = 0 \\ \big\langle \big(\rho < \rho^*, C\big), \big(\tilde{\sigma}_1(\lambda, \phi), \sigma^o(\rho, \theta)\big) \big\rangle & \text{if } 0 < \mu < \hat{\mu}(\beta, \bar{q}) \\ \big\langle \big(\rho^*, C\big), \big(\tilde{\sigma}_1(\lambda, \phi), \sigma^*(\theta)\big) \big\rangle & \text{if } \hat{\mu}(\beta, \bar{q}) \leq \mu. \end{cases} \tag{22}$$

In the next section, I investigate the properties of this SPE with respect to the property rights bundle ϕ. So far, the breakup rule parameter μ has been viewed as an exogenous model parameter. For the remainder of the paper I will treat it as institutional decision variable and analyze its strategic dimension, in particular its efficiency properties given an exogenous offer probability β, i.e. a particular realization of the *material* decision right. The emphasis at this stage is on how exogenous bargaining power and the resulting β-holdup can be mitigated by an appropriate decision rights structure other than vertical integration. I will abstract from the question of who specifies the breakup rule and simply report results on existence or nonexistence of a $\phi^* = (\beta, \mu^*)$ that implements the benchmark outcome.

6 Optimal breakup rules

Before deriving the optimal breakup rule for a rigid as well as a fully renegotiable contract, let me first briefly comment on the case of parties' full commitment not to renegotiate the contract *ex-post.* In that case, the buyer cannot hold up the seller in the stage-2 price bargaining game. If $q_1 < \mu\bar{q}$ and $r < \rho^*$ such that $\bar{b}(r, 0) = \bar{b}(\rho^*, \bar{q}) > \bar{b}(r, \sigma_2)$, however, the buyer will in equilibrium terminate the contract since by the negative compensation bias the effective payoffs for $q_2 = 0$ are higher than for continuation and $q_2 = \sigma_2$. Then, as shown in Lemma 4, the seller will be inclined to exert extra costs to prevent the buyer from exercising her exit option, which again results in μ-holdup effects as discussed in the previous section. Anticipated contract breakup deprives him of his *continuation values*,

$$\delta(\bar{s}) = \bar{s}\left(\sigma_2, \theta \mid \tau = C\right) - \bar{s}\left(\sigma_2, \theta \mid \tau = E\right) = w\left(\rho^*, \theta, \sigma_2\right) > 0. \tag{23}$$

Analogously to Corollary 1, the continuation value $\delta(\bar{s})$ denotes the seller's relative payoffs from performance in period $t = 2$. Note, further, that for a just efficient investment level $r = \rho^*$ and the compensation bias equal to zero, the buyer will be indifferent between termination and continuation. Suppose she cannot credibly commit *ex-ante* not to terminate *ex-post* in case of indifference; i.e. she breaks this tie in favor of contract discontinuation with some nonzero probability. Then, $\delta(\bar{s})$ will be strictly positive with nonzero probability and the seller inclined to overshoot. The following Proposition follows straight from Lemmata 4 and 5.

Proposition 2 (No renegotiation)**.** *Let $\bar{q} = \overline{Q}$. Suppose the parties cannot renegotiate contract Z and the buyer breaks a tie in favor of contract termination with positive probability. Then ϕ^* exists and the SPE is first-best if and only if $\mu = 0$ and $\bar{q} = q^{max}$.*

Proof. The "if" part is straightforward from Lemma 4 since $\delta(\tilde{s}) = 0$ if $\mu = 0$. For the "only if" part note that if $\bar{q} < q^{\max}$, then by Lemma 5 the buyer will never invest efficiently since

$$\int_{\bar{\theta}}^{1} \frac{\partial v(r, \bar{q})}{\partial r} f(\theta)\, d\theta < \int_{\bar{\theta}}^{1} \frac{\partial v(r, \sigma^*(\theta))}{\partial r} f(\theta)\, d\theta$$

and his returns suboptimal. Moreover, for $\bar{q} = q^{\max}$ the buyer will terminate the contract with positive probability if $\mu > 0$, inducing the seller to overshoot in the first period. Q.E.D.

The Proposition implies that if the parties' contract choice set is "poor" and $\bar{q} \in \underline{Q}$, then $\mu = 0$ implements a second-best outcome only, with underinvestment and a vector of constrained first-best quality in both periods.

Under contract rigidity The following Proposition presents the efficiency properties of the SPE under contract rigidity with the sequence of actions depicted in Figure 1. From equation (22) it has already become clear that the equilibrium strategies are not (constrained) first-best if β and $\bar{q}$ such that $\hat{\mu}(\beta, \bar{q}) > 0$. This is because in that case the seller will only deliver a first-best second period quality if the buyer invests efficiently, induced by $\mu = \hat{\mu}(\beta, \bar{q})$. The resulting bargaining leverage, however, will cause the seller to inefficiently overshoot in the first period (μ-holdup). Moreover, a constrained first-best quality in $t = 1$ will only be delivered for $\mu = 0$. Then, however, if $g(\rho^*, \theta) > 0$ for some θ, the buyer, being deprived of her breakup rents, will underinvest for all β (β-holdup).[25] Then, the second period quality falls short of

[25] Since $\bar{q} < q^{\max}$ in order for $g(\rho^*, \theta) > 0$ and since the first period not renegotiated, the fact that $\bar{\sigma}_1 = \bar{q} < \sigma^*(\theta)$ and $v_r(r, \bar{q}) < v_r(r, \sigma^*(\theta))$ for some θ dilutes the buyer's investment incentives even if he receives the entire stage-2 renegotiation surplus. See also the proof of Lemma 5.

the efficient level, $\sigma^o(\lambda) < \sigma^*(\theta)$ for all θ. A second-best breakup rule μ^{**} thus balances the two effects of buyer's rent-seeking and trades off the inefficiencies from underinvestment (and second period quality) on the one hand and excessive first period quality on the other.

Proposition 3 (Contract rigidity)**.** *Suppose semi-renegotiation of Z. An optimal decision right structure ϕ^* such that the SPE outcome is first-best exists if and only if $\beta = 1$ and $\bar{q} = q^{max}$ such that $\mu^* = \hat{\mu}(\beta, \bar{q}) = 0 = g(\rho^*, \theta)$ for all θ. A second-best outcome is otherwise implemented by a strictly positive breakup rule μ^{**} that balances β-holdup and μ-holdup.*

Proof. Given the SPE strategies in equation (22), the parties' joint expected surplus is denoted by

$$\widehat{\Pi}(\phi) = \int_{\Theta} W(\vec{\rho}(\phi), \theta, \vec{\sigma}(\lambda, \phi)) f(\theta) d\theta - z(\rho),$$

where

$$W(\vec{\rho}(\phi), \theta, \vec{\sigma}(\lambda, \phi)) = w(\rho, \theta, \sigma_1) + w(\rho, \theta, \sigma^o(\rho(\phi), \theta)). \tag{24}$$

1. The result for the first-best outcome is straightforward from equation (22). By Lemma 5, the buyer's investment is efficient only if $\mu = \hat{\mu}(\beta, \bar{q})$. By Lemma 4 and the buyer's equilibrium investment $r \leq \rho^*$, the seller will overshoot with positive probability if $\mu > 0$. Efficient quality delivery (up to $\bar{q}$ in period $t = 1$) is achieved with $\mu = 0$. A first-best outcome as in Definition 1 is only implemented if $\hat{\mu}(\beta, \bar{q}) = 0$ for $\beta = 1$ and $\bar{q} = q^{\max}$.

2. A second-best breakup rule μ^{**} trades off the inefficiencies from overshooting and underinvestment and is bounded by 0 and $\hat{\mu}$. This rule is defined as

$$\mu^{**} \in \arg \max_{\mu \in [0,1]} \widehat{\Pi}(\phi). \tag{25}$$

Recall that $\sigma_2 = \sigma^o(\cdot) \in \arg\max_{q_2} w(\rho, \theta, q_2)$ and ρ a function of ϕ. The first order condition for this optimization problem is equal to

$$\frac{\partial \rho}{\partial \mu}\left\{\frac{\partial \tilde{\theta}}{\partial \rho}\beta w\big(\rho, \tilde{\theta}, \sigma^*(\tilde{\theta})\big) f(\tilde{\theta}) + \int_{\Theta} \frac{\partial w(\rho, \theta, \sigma_1)}{\partial \rho} f(\theta) d\theta + \int_{\Theta} \frac{\partial w(\rho, \theta, \sigma_2)}{\partial \rho} f(\theta) d\theta - \frac{\partial z(\rho)}{\partial \mu}\right\} + \frac{\partial \tilde{\theta}}{\partial \mu}\beta w\big(\rho, \tilde{\theta}, \sigma^*(\tilde{\theta})\big) f(\tilde{\theta}) + \bar{q}\int_{\tilde{\theta}}^{\bar{\theta}^{\mu}} \frac{\partial w(\rho, \theta, \mu\bar{q})}{\partial \sigma_1} f(\theta) d\theta \overset{!}{=} 0. \tag{26}$$

Substituting for the FOC of the buyer's optimization problem with respect to r in equation (A40) [Appendix B], i.e. by an envelope theorem, the FOC in (26) can be rewritten as

$$\frac{\partial \rho}{\partial \mu}\left\{-\frac{\partial \tilde{\theta}}{\partial \rho} f(\tilde{\theta}) \left[h(\rho, \mu\bar{q}) - (1-\beta) h\big(\rho, \sigma^*(\tilde{\theta})\big)\right] + (1-\beta)\int_{\Theta} \frac{\partial w(\rho, \theta, \sigma_2)}{\partial \rho} f(\theta) d\theta\right\} + \frac{\partial \tilde{\theta}}{\partial \mu}\beta w\big(\rho, \tilde{\theta}, \sigma^*(\tilde{\theta})\big) f(\tilde{\theta}) + \bar{q}\int_{\tilde{\theta}}^{\bar{\theta}^{\mu}} \frac{\partial w(\rho, \theta, \mu\bar{q})}{\partial \sigma_1} f(\theta) d\theta \overset{!}{=} 0. \tag{27}$$

Evaluated at $\mu = 0$, the FOC is positive and equal to

$$\frac{\partial \rho}{\partial \mu}(1-\beta)\int_{\Theta} \frac{\partial w(\rho, \theta, \sigma_2)}{\partial \rho} f(\theta) d\theta > 0.$$

The second-best rule therefore allows for breakup to induce investment closer to the efficient level.

Q.E.D.

Edlin (1996) shows that if parties enter a *Cadillac* contract, then renegotiation does not harm the parties' performance and investment incentives (given that the role of contract breach is preassigned by upfront payments). The results of Proposition 3 imply that this is not generally true when considering a repeat transaction contract model. While, given $\bar{q} = q^{\max}$, in the no-renegotiation case in Proposition 2 a restriction on the procedural decision right was sufficient for a first-best outcome, with semi-renegotiation it takes a particular property rights bundle $\phi = (1, 0)$ to implement the efficient benchmark outcome. If contract choice is unrestricted and $\bar{q} = q^{\max}$, then $\beta = 1$ is necessary to yield undiluted investment incentive, and rent-seeking through $\mu > 0 = \hat{\mu}(1, q^{\max})$ is not favorable as it distorts the seller's quality decisions. Moreover, for a restricted contract choice set $\underline{Q}$, the assumption of contract rigidity with semi-renegotiation renders the first-best benchmark non-implementable since the buyer underinvests even for full bargaining power $\beta = 1$, and additional bargaining leverage through $\mu > 0$ is required to restore his efficient incentives. This, however, will in return induce a μ-problem with respect to the seller's quality delivery.

Under frictionless renegotiation For the final part of the paper, I assume renegotiation of Z to be without any frictions. In such a setting, the equilibrium results for the semi-renegotiated contract serve as disagreement point payoffs for the stage-1 price bargaining game. The argument for this is as follows: If parties have failed to agree in $t = 1$, they trade good 1 under the terms of contract Z and re-enter renegotiations before the delivery of good 2 (cf. Figure 2). At this point, they will engage in stage-2 renegotiations with continuation values as given in Lemma 3. By backward induction, when engaging in stage-1 renegotiations, the disagreement point payoffs are equal to what the parties will receive if stage-1 renegotiations shall fail and trade is under the terms of Z in $t = 1$ and of Z_R in $t = 2$. Given state λ and property rights bundle ϕ, by equation (22) these payoffs amount to

$$\widetilde{S}(\lambda, \phi, \tilde{\sigma}_1(\lambda, \phi)) = w(\rho^*, \theta, \tilde{\sigma}_1(\lambda, \phi)) - \bar{b}(\rho^*, \bar{q}) + \tilde{s}(\lambda, \phi, \tilde{\sigma}_1(\lambda, \phi)) \tag{28}$$

for the seller and

$$\widetilde{B}(\lambda, \phi, \tilde{\sigma}_1(\lambda, \phi)) = \bar{b}(r, \tilde{\sigma}_1(\lambda, \phi)) + \tilde{b}(\lambda, \phi, \tilde{\sigma}_1(\lambda, \phi)) \tag{29}$$

for the buyer. Because λ is observable to both parties and constant over time, from equation (12) it is known that the new time-invariant quality level for delivery of good 1 and good 2 is equal to $\bar{q}_R(\lambda)$ and maximizes the gains of trade $W(\lambda, C, \vec{q})$. In equilibrium, $r = \rho(\phi) \leq \rho^*$ holds, thus by equation (13) the seller produces $\sigma_R = \bar{q}_R(\lambda)$ in both periods. Moreover, $\sigma_R \geq \mu \bar{q}_R(\lambda)$ for all μ, hence the seller is not inclined to overshoot and $\sigma_1 = \sigma_2 = \bar{q}_R(\lambda)$ is independent of μ. The equilibrium quality levels are then $\vec{\sigma}^o(\lambda) = (\sigma^o(\lambda), \sigma^o(\lambda))$. As the buyer's investment is a function of ϕ and denoted by $r = \rho(\phi)$, the seller's equilibrium strategy vector can be rewritten as $\vec{\sigma}^o(\rho(\phi), \theta)$. Analogously to Lemma 5, an appropriate $\mu = \hat{\mu}^*(\beta, \bar{q})$, if it exists given β and $\bar{q}$, fully restores the buyer's efficient investment incentives. Hence, if $\mu = \hat{\mu}^* (\beta, \bar{q})$, then $r = \rho(\beta, \hat{\mu}^*(\beta, \bar{q})) = \rho^*$ and $\vec{\sigma}^o(\rho(\beta, \hat{\mu}^*(\beta, \bar{q})), \theta) = \vec{\sigma}^o(\rho^*, \theta) = \vec{\sigma}^*(\theta)$.

Proposition 4 (Full-renegotiation). *Suppose full renegotiation of Z. A breakup rule $\hat{\mu}^*(\beta, \bar{q}) = \mu^*$ such that the first-best outcome is implemented exists if β and $\bar{q}$ are sufficiently high.*

Proof. The proof follows directly from Lemmata 4 and 5. It is easy to see that the underlying bargaining structure yields an asymmetric Nash-bargaining solution (cf. Lemma 3). The parties will agree on a price $\bar{p}_R$ such that both receive their disagreement point payoffs plus a fraction β of the first-stage renegotiation surplus $G(\lambda)$. Since, given r, the equilibrium quality levels are optimal and $\vec{\sigma}^o(\lambda) = (\sigma^o(\lambda), \sigma^o(\lambda))$, the negotiation surplus is equal to the difference between the optimal trade surplus and the trade surplus from the semi-renegotiated contract as given in equation (24),

$$G(\lambda) = W(\lambda, \vec{\sigma}^o(\lambda)) - \widetilde{W}(\vec{\rho}(\phi), \theta, \vec{\sigma}(\lambda, \phi)).$$

Since the second period payoffs are $\pi(\lambda)$ in both scenarios, the renegotiation surplus can be rewritten as

$$G(\lambda) = w(\lambda, \sigma^o(\lambda)) - w(\lambda, \tilde{\sigma}_1(\lambda, \phi)).$$

The seller will deliver optimal quality levels, given r, and the buyer's investment decision (as in Lemma 5) is a function of ϕ and $\bar{q}$. She maximizes her expected payoffs

$$\widehat{B}(r) = \int_\Theta \left[\widetilde{B}(\lambda, \phi, \tilde{\sigma}_1(\lambda, \phi)) + \beta G(\lambda)\right] f(\theta)\, d\theta - z(r).$$

Suppose $\beta = 1$ and $\mu = 0$. By Lemma 4 it follows that $\tilde{\sigma}_1(\lambda, \phi) = \bar{\sigma}(\theta)$, and

$$\rho \in \arg\max_r \widehat{B}(r) = \int_\Theta \widehat{W}(\lambda, C, \vec{\sigma}^o(\lambda))\, f(\theta)\, d\theta - \bar{S}^e$$

with $\bar{S}^e$ the seller's expected payoffs under contract Z and off-equilibrium quality levels $\tilde{\sigma}_1(\lambda, \phi)$ and $\sigma_2 = \bar{\sigma}(\theta)$. Since $\bar{S}^e$ is independent of r, by the definition of the first-best investment level in equation (4), the buyer will efficiently invest, $\rho = \rho^*$. Hence, for $\beta = 1$ and complete rent extraction by the buyer, the first-best outcome is implemented for $\mu = 0$. For $\beta < 1$ and less-than-complete rent extraction, the implications are as in Lemma 5. A positive breakup parameter μ complements the buyer's bargaining power $\beta < 1$. For sufficiently high β there exists a $\mu = \hat{\mu}^*(\beta, \bar{q}) = \mu^*$ such that $\rho = \rho^*$. Q.E.D.

In Corollary 3, I briefly comment on the existence of an investment restoring $\hat{\mu}(\beta, \bar{q})$. While in case of contract rigidity, a $\hat{\mu}(\beta, \bar{q}) > 1$ may still give rise to a second-best breakup rule within the bounds of the unit interval, $\mu^{**} < 1$, a first-best rule μ^* exists if and only if $\hat{\mu}^*(\beta, \bar{q})$ exists. Proposition 5 rounds off this existence result.

Proposition 5 (Existence). *Let $\underline{q}(\beta) \in \overline{Q}$ such that $\hat{\mu}^*\left(\beta, \underline{q}(\beta)\right) = 1$ and $\underline{\beta} > 0$ such that $\underline{q}\left(\underline{\beta}\right) = q^{max}$ and $\underline{\mathcal{B}} = \left[\underline{\beta}, 1\right]$. For any contract Z with $\bar{q} \in \left[\underline{q}(\beta), q^{max}\right]$, there exists a first-best breakup rule such that the SPE is $\langle \vec{\rho}^*, \vec{\sigma}^*(\theta) \rangle$ if and only if $\beta \geq \underline{\beta}$. Hence, a first-best property rights bundle ϕ^* exists if and only if $\underline{\mathcal{B}}$ is nonempty.*

Proof. The proof follows straight from Assumption 2, Corollary 3, and Proposition 4. Q.E.D.

One particular implication from the literature on simple contracts is that parties may *ex-ante* enter any suboptimal contract (and for instance save on transaction costs) as long as it is renegotiable *ex-post*. For the setup under consideration here, Proposition 5 serves as a stop sign for *ex-ante* arbitrariness. It shows that although the contract is fully renegotiated, too low a contracted quality level will not allow for a first-best outcome to be implemented since a strict compliance standard does not grant the buyer sufficient breakup rents. Moreover, the effect of the procedural decision right to substitute for incomplete bargaining power (as representation of material decision rights) is limited. In particular, $\underline{\beta} > 0$ serves as lower bound of the bargaining share for which a well-tailored breakup rule can correct. Also note that entering simple contracts with $\bar{q} \in \left[\underline{q}(\beta), q^{\max}\right]$ is only reliable if *ex-post* renegotiations are without frictions.

The results for far have shown the consequences of too lax a compliance. But what happens if the lawmaker (or the contract parties themselves) gets it wrong and stipulates a strict compliance standard with $\mu = 1$ when a substantial standard is efficient? Recall from Lemma 3 that the buyer forfeits his exit threat if he overinvests. That means for any investment level $r > \rho^*$, the threat value in equation (21) is equal to zero, and overinvestment is therefore strictly dominated by $r = \rho^*$. This implies that any breakup rule higher than this investment restoring level $\hat{\mu}^*(\beta, \bar{q})$ does not affect the buyer's incentives. Hence, since the seller's equilibrium strategy vector $\sigma^*(\theta)$ is independent of μ, the SPE is first-best for all $\mu \geq \hat{\mu}^*(\beta, \bar{q})$. As a result, the parties' joint expected surplus is constant for sufficiently high levels of μ. The buyer's increased *ex-post* bargaining leverage will be fully priced in *ex-ante* yet leads to *ex-post* redistribution.

Proposition 6 (Redistribution)**.** *Any breakup rule $\mu > \mu^* = \hat{\mu}^*(\beta, \bar{q})$, if it exists, implements a first-best outcome and redistributes the realized gains of trade from the seller to the buyer.*

Proof. By Lemma 5 it holds that overinvestment is a strictly dominated strategy, hence $\rho \leq \rho^*$ for all μ. Since the seller will always deliver quality level $\sigma^o(\lambda)$ in the full-renegotiation scenario, any $\mu \geq \mu^*$ implements first-best quality and investment levels. Q.E.D.

Given Propositions 4 and 6, the SPE for a repeat transaction contract under contract rigidity (equation (22)) can be rewritten for the frictionless scenario as

$$\left\langle \vec{\rho}(\phi), \vec{\sigma}(\lambda, \phi) \right\rangle = \begin{cases} \left\langle \left(\rho(\phi) < \rho^*, C\right), \left(\sigma^o(\rho(\phi), \theta), \sigma^o(\rho(\phi), \theta)\right) \right\rangle & \text{if } \mu < \hat{\mu}^*(\beta, \bar{q}) \\ \left\langle \left(\rho^*, C\right), \left(\sigma^*(\theta), \sigma^*(\theta)\right) \right\rangle & \text{if } \hat{\mu}^*(\beta, \bar{q}) \leq \mu. \end{cases} \tag{30}$$

Hence, the seller overshoots only *off* the equilibrium path. By the assumption of perfect state observability, the parties are able to agree on equilibrium quality levels on the Pareto-frontier, the optimization problem with respect to μ is therefore reduced to inducing efficient equilibrium investment. Granting the breakup option with positive probability and allowing the buyer to engage in rent-seeking has positive social value. The buyer's opportunism is in fact required to achieve a first-best outcome. Suppose the buyer were able to fully commit not to cancel the contract, i.e. exercise his exit threat, by $\mu = 0$ or an upfront payment that ensures that he will never do so (cf. Edlin, 1996), then his investment incentives will be diluted (unless $\bar{q} = q^{\max}$ and $\beta = 1$). Hence, having the ropes untied by his seamen might not be a bad strategy for Ulysses after all.

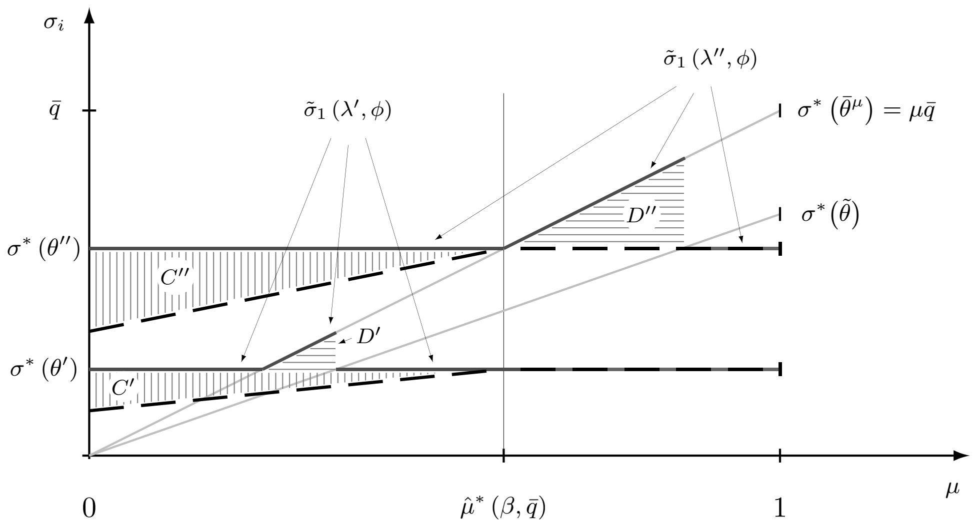
Figure 5 plots the seller's strategy σ_i for productivity levels θ' and θ'', where $\theta' < \theta'' = \bar{\theta}^{\hat{\mu}^*(\beta,\bar{q})} < \bar{\theta}$. The efficient quality level $\sigma^*(\theta)$ is independent of μ and plotted as a horizontal line in the μ-σ_i plain. The light gray lines depict the efficient production level given μ for types $\bar{\theta}^{\mu} = \sup \widetilde{\Theta}$ and $\tilde{\theta} = \min \widetilde{\Theta}$, $\sigma^*\left(\bar{\theta}^{\mu}\right)$ and $\sigma^*\big(\tilde{\theta}\big)$ respectively. As shown in Corollary 2, the two borderline types are increasing in μ at different rates, so are the efficient quality levels as function of μ. The dashed line gives the seller's equilibrium quality choice σ_i for $i = 1, 2$ as defined in equation (30). The redistributive nature of breakup parameters $\mu > \hat{\mu}^*(\beta, \bar{q})$ is depicted by the kink of σ_i at $\hat{\mu}^*(\beta, \bar{q})$. Too lax a compliance standard with $\mu < \hat{\mu}^*(\beta, \bar{q})$ results in insufficient investment $\rho(\phi) < \rho^*$ and suboptimal quality $\sigma^o(\rho(\phi), \theta) < \sigma^*(\theta)$ (the associated performance inefficiencies are indicated by the shaded areas C' and C''), while stricter compliance standards yield a first-best outcome.

The dark gray lines plot the seller's first period strategy $\tilde{\sigma}_1(\lambda, \phi)$ in the semi-renegotiation scenario as given in equation (22). The shaded areas D' and D'' correspond to area A in Figure 4. They indicate the inefficiencies arising from seller's overshooting for values of μ such that $\sigma^*\big(\tilde{\theta}\big) < \sigma^*(\theta) < \sigma^*\left(\bar{\theta}^{\mu}\right)$, given $\theta \in \{\theta', \theta''\}$. Notice that, while Figure 4 keeps μ constant to illustrate the interval of types θ that are prone to μ-holdup, Figure 5 takes particular levels of μ as given to point out the effect of this institutional decision variable on seller's choice. From the graph for the first period strategy in the semi-renegotiation scenario it becomes apparent that the first-best breakup rule $\hat{\mu}^*(\beta, \bar{q})$ (Proposition 4 for the full-renegotiation scenario) results in a first-best first period quality for all $\theta < \tilde{\theta}(\hat{\mu}^*(\beta, \bar{q}))$ and for all $\theta \geq \bar{\theta}^{\hat{\mu}^*(\beta,\bar{q})}$. All θ in-between, however, will overshoot, reducing the expected joint surplus below its maximum level and thus diluting the buyer's ex-ante investment incentives. Insufficient investment $r < \rho^*$ will in return result in insufficiently low quality $\bar{q}_R(\lambda) < \sigma^*(\theta)$ in the second period. To align the buyer's investment incentives (and align the seller's second period production incentives) in the semi-renegotiation scenario, a stricter compliance standard such that $\hat{\mu}(\beta, \bar{q}) = \mu > \hat{\mu}^*(\beta, \bar{q})$, i.e. higher than in the full-renegotiation case, is necessary. This will, however, result in an even stronger distortion of the seller's first-period incentives, as formally shown in Lemma 4 and insinuated in Figure 4, taking us straight back to the formal argument in Proposition 3.

7 Conclusions and legal implications

For a multi-period trade relationship with relationship-specific investment, the property rights literature proposes vertical integration to silence opportunistic renegotiation and internalize intertemporal effects, eventually protecting the contract parties' investment horizon and aligning their *ex-ante* and *ex-post* incentives. Due to a possible holdup problem, long-term contracts are said to be inferior to vertical integration since parties' commitment not to renegotiate the contract is difficult to accomplish. Note, however, that if renegotiation were such that the investing party receives the entire renegotiation surplus, then incentives would in fact be efficient. In this paper, I consider a contractual solution and assume that neither party has the right to unilaterally change the terms of trade (quality and price provisions) and that

Figure 5: Seller's equilibrium strategies for $\theta' < \theta'' < \bar{\theta}$



renegotiation gives the buyer (seller) a fraction β $(1-\beta)$ of a potential renegotiation surplus. In addition to these (partial) *material* decision rights, I assume that the buyer is granted the right to decide whether or not trade in period t is to be continued after the seller's $(t-1)$th delivery. This (conditional) *procedural* decision right is conditioned on the seller's action and implemented through a monotonic breakup rule that allows for rightful contract termination if the seller delivers below a certain threshold. I show that the buyer's exit option gives rise to opportunistic rent-seeking that mitigates the holdup problem from less-than-perfect bargaining power (β-holdup). Holding up the seller in *ex-post* renegotiations yields additional breakup rents that increase the buyer's returns on investment and induce efficient incentives where she would otherwise (if this exit option were not granted) underinvest. The buyer's opportunism thus generates social value; put differently, without her opportunistic behavior a first-best outcome is only reached for quite restrictive parameter constellations. The exit option thus complements incomplete property rights (in the sense usually applied in the law and economics literature) to prevent a (β)-holdup problem. I thus show that a simple contractual solution in line with legal practice exists. In the context of repeat trade, it suffices to properly assign the decision rights on the durability of the trade relationship to restore an efficient outcome.

The results allow for a number of legal implications. Examples for such a conditional breakup rule are encountered, e.g., for U.S. contract law in the *Uniform Commercial Code (UCC)* (cf. White and Summers, 2000). Its Section §2-612 governs *installment contracts* that "require or authorize the delivery of goods in separate lots to be separately accepted" and stipulates that a buyer may terminate[26] the whole contract only if a defect with respect to one or more (delivered)

[26] A word on terminology: In this paper I refer to "putting an end to a contract but retaining any remedies for breach of contract" as contract *termination.* The UCC refers to these facts as *cancellation.* Termination

installments "substantially" impairs the value of the entire contract. Patterson (1987:189), for instance, therefore attests the *UCC* a "bias in favor of the [...] continuation of contracts in general and installment contracts in particular," and Quinn (1978:2-385) plainly asserts that the "*UCC* loves the installment contract, and, once it is in place, bends over backwards to keep it in place." The existence of such a conditional breakup rule in legal practice is not limited law in the U.S., but international commercial law gives rules "consistent" (Speidel, 1992:140) with the ones observed in the U.S. (cf. Bugge, 1999; Katz, 2005), yet uses different terminology: The *Convention on Contracts for the International Sale of Goods* requires "fundamental breach" in order for the buyer to "avoid" (cancel) the contract (Hull, 2007:150).

Comment 6 of *UCC* Section §2-612 offers guidelines as to the nature of nonconformities that may be considered when determining such substantial impairment. It states that "whether the nonconformity in any given installment justifies cancellation as to the future depends not on whether such nonconformity indicates an intent or likelihood that the future deliveries will also be defective, but whether the nonconformity substantially impairs the value of the whole contract." In terms of the employed notation this means that the law requires the decision rights to be determined based on the verifiable action space rather than the nonverifiable state space. The breakup rule in Definition 3 accounts for this conditionality on seller's actual performance and has implications on the bargaining routines in stage-1 and stage-2 renegotiations. The game to be played (via the buyer's outside options) in the latter setup is by parties' choice. In the former scenario the buyer can anticipate the seller's (off-equilibrium) delivery of the first quality level, yet cannot threaten a termination of the contract upon observation of a sufficiently low type $\theta < \tilde{\theta}$. Notice that if the breakup rule were conditioned on the seller's type, we would obtain a constrained first-best outcome even under contract rigidity (cf. Proposition 3). To see this, suppose θ is verifiable, yet writing a fully contingent contract is prohibitively costly, hence Z incomplete and simple. While in the stage-2 price bargaining game the buyer exercises her exit threat if θ is sufficiently low, the seller will not benefit from overshooting. This is because any noncompliance with the implicit agreement to produce and deliver a (constrained) first-best is now verifiable; hence, a moral hazard problem (μ-holdup) will not arise. Therefore, by efficient expectation damages, the seller will deliver a constrained first-best quality vector for all θ while the breakup rule can be adjusted such that the buyer's investment incentives are undiluted. The model's results suggest that under certain conditions (in particular verifiability of state variable θ) the guidelines in Comment 6 of Section §2-612 of the Uniform Commercial Code may indeed distract trade and facilitate suboptimal outcomes. Whether or not this still would hold if, hypothetically, the legal rule were to condition on a nonverifiable state variable θ remains to be subject to future research.

The legal literature on contract termination restrictions has argued in favor of a deviation from the strict compliance rules in order to protect investment incentives. These implications,

in the UCC means that "all obligations which are still executory on both sides are discharged [i.e. no damages for nondelivered future installments upon breakup can be recovered] but any rights based on prior breach or performance survive (§2-106)."

however, only hold true if the investing party is the victim of termination, i.e. the seller (Proposition 1). If the beneficiary (of termination) is the investor, i.e. the buyer, a restriction of the exit option aligns the seller's performance incentives, yet it may render the buyer's investment incentives distorted and insufficient. Allowing for buyer's opportunistic rent-seeking and thus increasing her returns on investment through the appropriation of additional breakup rents, can restore a second or even first-best outcome (Propositions 3 and 4). If contract renegotiation is frictionless, this effect is bounded by the level of efficient investment, too high a breakup rule parameter does therefore not do any harm in terms of efficiency (although it touches upon distributional issues; Proposition 6). Moreover, if the buyer's bargaining power is sufficiently low, a strict breakup rule such that $\mu = 1$ may indeed be necessary to induce efficient investment (Proposition 5). This implication clearly competes with the legal literature on compliance standards in U.S. and international contract law that promotes a restriction of buyer's exit options (e.g., Llewellyn, 1937:375ff).

References

Aghion, P., and P. Bolton (1987): "Contracts as a Barrier to Entry," *American Economic Review*, 77(3), 388–401.

Aghion, P., M. Dewatripont, and P. Rey (1994): "Renegotiation Design with Unverifiable Information," *Econometrica*, 62(2), 257–282.

Anderhub, V., M. Königstein, and D. Kübler (2003): "Long-Term Work Contracts Versus Sequential Spot Markets: Experimental Evidence on Firm-Specific Investment," *Labour Economics*, 10(4), 407–425.

Ayres, I., and R. Gertner (1989): "Filling Gaps in Incomplete Contracts: An Economic Theory of Default Rules," *Yale Law Journal*, 99, 87–130.

Baird, D. C., R. H. Gertner, and R. C. Picker (1994): *Game Theory and the Law*. Harvard University Press, Cambridge, Mass.

Bernheim, B. D., and M. D. Whinston (1998): "Exclusive Dealing," *Journal of Political Economy*, 106(1), 64–103.

Binmore, K. (1987): "Perfect Equilibria in Bargaining Models," in *The Economics of Bargaining*, ed. by K. Binmore, and P. Dasgupta. Basil Blackwell, Oxford.

Bolton, P., and M. Dewatripont (2005): *Contract Theory*. MIT Press, Cambridge, Mass.

Bugge, L. J. (ed.) (1999): *Revision of Uniform Commercial Code Article 2 - Sales. With Comments. Draft, March 1, 1999*. National Conference of Commissioners on Uniform State Law, Chicago, Ill.

Che, Y.-K., and T.-Y. Chung (1999): "Contract Damages and Cooperative Investments," *RAND Journal of Economics*, 30(1), 84–105.

Che, Y.-K., and D. Hausch (1999): "Cooperative Investments and the Value of Contracting," *American Economic Review*, 89(1), 125–147.

Che, Y.-K., and J. Sakovics (2004): "A Dynamic Theory of Holdup," *Econometrica*, 72(4), 1063–1103.

Comino, S., A. Nicolò, and P. Tedeschi (2006): "Termination Clauses in Partnerships," Working Paper 20060505, Università degli Studi di Milano-Bicocca, Dipartimento di Statistica.

Cooter, R. D., and M. A. Eisenberg (1985): "Damages for Breach of Contract," *California Law Review*, 73(5), 1432–1489.

Corbin, A. (1963): *Corbin on Contracts*. West, St. Paul.

Cramton, P., R. Gibbons, and P. Klemperer (1987): "How to Dissolve a Partnership Efficiently," *Econometrica*, 55(3), 615–632.

Craswell, R. (1989): "Performance, Reliance, and One-Sided Information," *Journal of Legal Studies*, 18(2), 365–401.

Crawford, V. P. (1990): "Relationship-Specific Investment," *Quarterly Journal of Economics*, 105(2), 561–574.

Crocker, K. J., and S. E. Masten (1988): "Mitigating Contractual Hazards: Unilateral Options and Contract Length," *RAND Journal of Economics*, 19(3), 327–343.

——— (1991): "Pretia ex Machina? Prices and Process in Long-Term Contracts," *Journal of Law and Economics*, 34(1), 69–99.

Crocker, K. J., and K. J. Reynolds (1993): "The Efficiency of Incomplete Contracts: An Empirical Analysis of Air Force Engine Procurement," *RAND Journal of Economics*, 24(1), 126–146.

Edlin, A. S. (1996): "Cadillac Contracts and Up-front Payments: Efficient Investment Under Expectation Damages," *Journal of Law, Economics, and Organization*, 12(1), 98–118.

Edlin, A. S., and S. Reichelstein (1996): "Holdups, Standard Breach Remedies, and Optimal Investment," *American Economic Review*, 86(3), 478–501.

Farrell, J., and C. Shapiro (1989): "Optimal Contracts with Lock-In," *American Economic Review*, 79(1), 51–68.

Fellingham, J. C., D. P. Newman, and Y. S. Suh (1985): "Contracts without Memory in Multiperiod Agency Models," *Journal of Economic Theory*, 37(2), 340–355.

Fuller, L. L., and W. R. Perdue (1936): "The Reliance Interest in Contract Damages," *Yale Law Journal*, 46(1), 52–96.

Goetz, C. J., and R. Scott (1981): "Principles of Relational Contracts," *Virginia Law Review*, 67, 1089–1151.

Goldberg, V. P. (1976): "Regulation and Administered Contracts," *Bell Journal of Economics*, 7(2), 426–448.

Goldberg, V. P., and J. R. Erickson (1987): "Quantity and Price Adjustment in Long-Term Contracts: A Case Study of Petroleum Coke," *Journal of Law and Economics*, 30(2), 369–398.

Grossman, S. J., and O. D. Hart (1986): "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy*, 94(4), 691–719.

Hart, O. D. (1989): "An Economist's Perspective on the Theory of the Firm," *Columbia Law Review*, 89(7), 1757–1774.

Hart, O. D., and J. Moore (1988): "Incomplete Contracts and Renegotiation," *Econometrica*, 56(4), 755–785.

——— (1990): "Property Rights and the Nature of the Firm," *Journal of Political Economy*, 98(6), 1119–1158.

Hermalin, B. E., A. W. Katz, and R. Craswell (2007): "Contract Law," in *Handbook of Law and Economics*, ed. by A. M. Polinsky, and S. Shavell, vol. 1, chapter 1. Elsevier Science, Amsterdam.

Hull, B. D. (2007): *United States and International Sales, Lease and Licensing Law: Cases and Problems*. Aspen Publishers, New York.

Joskow, P. L. (1985): "Vertical Integration and Long-Term Contracts: The Case of Coal-Burning Electric Generating Plants," *Journal of Law, Economics and Organization*, 1(1), 33–80.

——— (1987): "Contract Duration and Relationship-Specific Investments: Empirical Evidence from Coal Markets," *American Economic Review*, 77(1), 168–185.

Katz, A. W. (2005): "Remedies for Breach of Contract Under the CISG," *International Review of Law and Economics*, 25(3), 378–396.

Kenney, R. W., and B. Klein (1983): "The Economics of Block Booking," *Journal of Law and Economics*, 26(3), 497–540.

Klein, B. (1980): "Transaction Cost Determinants of "Unfair" Contractual Arrangements," *American Economic Review*, 70(2), 356–362.

Klein, B., R. G. Crawford, and A. Alchian (1978): "Vertical Integration, Appropriable Rents and the Competitive Contracting Process," *Journal of Law and Economics*, 21(2), 297–326.

Leitzel, J. (1989): "Damage Measures and Incomplete Contracts," *RAND Journal of Economics*, 20(1), 92–101.

Llewellyn, K. (1937): "On Warranty of Quality, and Society: II," *Columbia Law Review*, 37(3), 341–409.

Lyon, T. P., and E. Rasmusen (2004): "Buyer-Option Contracts Restored: Renegotiation, Ineffcient Threats, and the Hold-Up Problem," *Journal of Law, Economics, and Organization*, 20(1), 148–169.

MacLeod, W. B., and J. M. Malcomson (1993): "Investments, Holdup, and the Form of Market Contracts," *American Economic Review*, 83(4), 811–837.

MacLeod, W. B., and V. Nakavachara (2007): "Can Wrongful Discharge Law Enhance Employment?," *Economic Journal*, 117(521), 218–278.

Masten, S. E. (2007): "Long-Term Contracts and Short-Term Commitment: Price Determination of Heterogeneous Freight Transactions," Unpublished, University of Michigan, Stephen M. Ross School of Business.

Muehlheusser, G. (2007): "Regulating Damage Clauses in (Labor) Contracts," *Journal of Institutional and Theoretical Economics*, 163(4), 531–551.

Nash, J. F. (1950): "The Bargaining Problem," *Econometrica*, 18(2), 155–162.

Nöldeke, G., and K. M. Schmidt (1995): "Option Contracts and Renegotiation: A Solution to the Hold-up Problem," *RAND Journal of Economics*, 26(2), 163–179.

Patterson, E. H. (1987): "UCC Section 2-612(3): Breach of an Installment Contract and a Hobson's Choice for the Aggrieved Party," *Ohio State Law Journal*, 48, 177–196.

Quinn, T. M. (1978): *Uniform Commercial Code Commentary and Law Digest*. Warren, Gorham & Lamont, Boston.

Rasmusen, E. B., J. M. Ramseyer, and J. S. Wiley (1991): "Naked Exclusion," *American Economic Review*, 81(5), 1137–1145.

Rogerson, W. P. (1984): "Efficient Reliance and Damage Measures for Breach of Contract," *RAND Journal of Economics*, 15(1), 39–53.

——— (1992): "Contractual Solutions to the Hold-Up Problem," *Review of Economic Studies*, 59(4), 777–793.

Rubinstein, A. (1982): "Perfect Equilibrium in a Bargaining Model," *Econometrica*, 50(1), 97–109.

Schmitz, P. W. (2001): "The Hold-Up Problem and Incomplete Contracts: A Survey of Recent Topics in Contract Theory," *Bulletin of Economic Research*, 53(1), 1–17.

Schwartz, A., and R. E. Scott (2003): "Contract Theory and the Limits of Contract Law," *Yale Law Journal*, 113, 541–619.

Schweizer, U. (2006): "Cooperative Investments Induced by Contract Law," *RAND Journal of Economics*, 37(1), 134–145.

Segal, I., and M. D. Whinston (2000): "Naked Exclusion: Comment," *American Economic Review*, 90(1), 296–309.

Shaked, A. (1994): "Opting Out: Bazaars versus 'High-Tech' Markets," *Investigaciones Econónomicas*, 18(3), 421–432.

Shavell, S. (1980): "Damage Measures for Breach of Contract," *Bell Journal of Economics*, 11(2), 466–490.

——— (2007): "Contractual Holdup and Legal Intervention," *Journal of Legal Studies*, 36(2), 325–354.

Simon, H. A. (1951): "A Formal Theory of the Employment Relationship," *Econometrica*, 19(3), 293–305.

Speidel, R. E. (1992): "Buyer's Remedies of Rejection and Cancellation under the UCC and the Convention," *Third Annual Journal of Contract Law Conference, Toronto, 20 October, 1992*, pp. 131–140.

Spier, K. E., and M. D. Whinston (1995): "On the Efficiency of Privately Stipulated Damages for Breach of Contract: Entry Barriers, Reliance, and Renegotiation," *RAND Journal of Economics*, 26(2), 180–202.

Strausz, R. (2006): "Interim Information in Long-Term Contracts," *Journal of Economics and Management Strategy*, 15(4), 1041–1067.

Sutton, J. (1986): "Non-Cooperative Bargaining Theory: An Introduction," *Review of Economic Studies*, 53(5), 709–724.

Tirole, J. (1999): "Incomplete Contracts: Where Do We Stand?," *Econometrica*, 67(4), 741–781.

Watson, J. (2007): "Contract, Mechanism Design and Technological Detail," *Econometrica*, 75(1), 55–81.

Watson, J., and C. Wignall (2007): "Hold-Up and Durable Trading Opportunities," Unpublished manuscript, University of California, San Diego.

Whaley, D. J. (1974): "Tender, Acceptance, Rejection and Revocation. The UCC's 'TARR'-Baby," *Drake Law Review*, 24, 52–.

White, J. J., and R. S. Summers (2000): *Uniform Commercial Code*. West Group, St. Paul, Minn., 5 edn.

Williamson, O. E. (1971): "The Vertical Integration of Production: Market Failure Considerations," *American Economic Review*, 61(2), 112–123.

——— (1979): "Transaction-Cost Economics: The Governance of Contractual Relations," *Journal of Law and Economics*, 22(2), 233–261.

——— (1985): *The Economic Institutions of Capitalism*. Free Press, New York.

Appendix A: Probabilistic proposal bargaining

Proof of Lemma 3 (Continuation values)

Proof. The parties' outside option payoffs are as follows:

$$\text{buyer plays continue `}C\text{'} \quad : \quad \left(\bar{b}\left(r,\sigma_2\right), \bar{\pi}\left(\rho^*,\theta\right) - \bar{b}\left(\rho^*,\bar{q}\right)\right) \tag{A31}$$

$$\text{buyer plays exit `}E\text{'} \quad : \quad \begin{cases} \left(\bar{b}\left(\rho^*,\bar{q}\right), -\bar{b}\left(\rho^*,\bar{q}\right)\right) & \text{if } q_1 < \mu\bar{q} \\ \left(-\bar{s}_2^e, \bar{s}_2^e\right) & \text{if } q_1 \geq \mu\bar{q}. \end{cases} \tag{A32}$$

The seller will accept the buyer's renegotiation offer x_S if it grants him payoffs that are at least as high as under his respective outside option value. Analogously, the buyer will accept the seller's offer x_B if she is at least as well off as under the respective outside option.

For the subgame starting after the rejection of an offer x_S or x_B, the buyer's play $\tau = E$ is strictly dominated if $r > \rho^*$. This implies that at this stage of the game, the buyer will not exercise her breakup option and an exit threat is not credible. The relevant outside option is therefore 'C.' To see this, not that by Lemma 1 it holds that $\bar{b}\left(\rho^*,\bar{q}\right) < \bar{b}\left(r,\sigma_2\right) = \bar{b}\left(\rho^*,\bar{q}\right) - h\left(r,q_2\right)$. If $r \leq \rho^*$ and $\bar{b}\left(\rho^*,\bar{q}\right) \geq \bar{b}\left(r,q_2\right)$, Assumption 2 ensures that the buyer's exit threat is credible (i.e. the payoffs from exit not dominated in the subgame starting after rejection) if and only if $q_1 < \mu\bar{q}$. Suppose the buyer plays 'E' if $q_1 \geq \mu\bar{q}$; then it needs to hold that $-\bar{s}_2^e > \bar{b}\left(r,\sigma_2\right) = \bar{b}\left(\rho^*,\bar{q}\right) - h\left(r,\sigma_2\right)$. Rearranging this expression yields $\mathbb{E}\left(\bar{\pi}\left(\rho^*,\theta\right)\right) < h\left(r,\sigma_2\right)$ with $\mathbb{E}$ an expectation operator over *cdf* $F\left(\theta\right)$. By monotinicity of $v\left(\cdot\right)$ in r and q_2 it holds that $h\left(r,\sigma_2\right)$ is maximized for $r = 0$ and θ such that $\sigma_2 = \bar{q}$. Since by Assumption 1 this inequality is violated, it does not hold for any pair of r and q_2, establishing the non-credibility of 'E' if $q_1 \geq \mu\bar{q}$.

Let $r > \rho^*$. With probability β, the buyer makes an offer x_S yielding her payoffs (if accepted) of $\pi\left(\lambda\right) - x_S$, where $\pi\left(\lambda\right)$ is defined in Lemma 2. Similarly, with probability $1-\beta$ the seller's offer x_B yields his own payoffs $\pi\left(\lambda\right) - x_B$. The payoff vectors are

$$\begin{pmatrix} \pi\left(\lambda\right) - x_S \\ x_S \end{pmatrix} = \begin{pmatrix} \pi\left(\lambda\right) - \bar{\pi}\left(\rho^*,\theta\right) + \bar{b}\left(\rho^*,\bar{q}\right) \\ \bar{\pi}\left(\rho^*,\theta\right) - \bar{b}\left(\rho^*,\bar{q}\right) \end{pmatrix} \quad , \quad \begin{pmatrix} x_B \\ \pi\left(\lambda\right) - x_B \end{pmatrix} = \begin{pmatrix} \bar{b}\left(r,\sigma_2\right) \\ \pi\left(\lambda\right) - \bar{b}\left(r,\sigma_2\right) \end{pmatrix}.$$

This yields continuation values

$$\begin{aligned} \tilde{b}\left(\lambda,\phi,q_1 \mid r > \rho^*\right) &= \beta\left(\pi\left(\lambda\right) - x_S\right) + \left(1-\beta\right)x_B = \beta\left[\pi\left(\lambda\right) - \bar{\pi}\left(\rho^*,\theta\right) + \bar{b}\left(\rho^*,\bar{q}\right)\right] + \left(1-\beta\right)\bar{b}\left(r,\sigma_2\right) \\ &= \bar{b}\left(r,\sigma_2\right) + \beta\left[\pi\left(\lambda\right) - \bar{\pi}\left(\rho^*,\theta\right) + h\left(r,\sigma_2\right)\right] = \bar{b}\left(r,\sigma_2\right) + \beta\left[\pi\left(\lambda\right) - \bar{\pi}\left(\lambda\right)\right] \\ &= \bar{b}\left(r,\sigma_2\right) + \beta g\left(\lambda\right) \end{aligned} \tag{A33}$$

for the buyer and

$$\begin{aligned} \tilde{s}\left(\lambda,\phi,q_1 \mid r > \rho^*\right) &= \beta x_S + \left(1-\beta\right)\left(\pi\left(\lambda\right) - x_B\right) = \beta\left(\bar{\pi}\left(\rho^*,\theta\right) - \bar{b}\left(\rho^*,\bar{q}\right)\right) + \left(1-\beta\right)\left(\pi\left(\lambda\right) - \bar{b}\left(r,\sigma_2\right)\right) \\ &= \bar{\pi}\left(\rho^*,\theta\right) - \bar{b}\left(\rho^*,\bar{q}\right) + \left(1-\beta\right)\left[\pi\left(\lambda\right) - \bar{\pi}\left(\rho^*,\theta\right) + h\left(r,\sigma_2\right)\right] \\ &= \bar{\pi}\left(\rho^*,\theta\right) - \bar{b}\left(\rho^*,\bar{q}\right) + \left(1-\beta\right)g\left(\lambda\right) \end{aligned} \tag{A34}$$

for the seller. By the above credibility argument it holds true that the renegotiation game yields the continuation values in (A33) and (A34) also for $r \leq \rho^*$ and $q_1 \geq \mu\bar{q}$, i.e. $\tilde{b}\left(\lambda,\phi,q_1 \mid r > \rho^*\right) = \tilde{b}\left(\lambda,\phi,q_1 \mid r \leq \rho^*, q_1 \geq \mu\bar{q}\right)$ and $\tilde{s}\left(\lambda,\phi,q_1 \mid r > \rho^*\right) = \tilde{s}\left(\lambda,\phi,q_1 \mid r \leq \rho^*, q_1 \geq \mu\bar{q}\right)$.

For $r \leq \rho^*$ and $q_1 < \mu\bar{q}$, continuation values $\tilde{b}$ and $\tilde{s}$ are determined in the same way. The renegotiation payoffs for buyer's and seller's take-it-or-leave-it offer are

$$\begin{pmatrix} \pi\left(\lambda\right) - x_S \\ x_S \end{pmatrix} = \begin{pmatrix} \pi\left(\lambda\right) + \bar{b}\left(\rho^*,\bar{q}\right) \\ -\bar{b}\left(\rho^*,\bar{q}\right) \end{pmatrix} \quad , \quad \begin{pmatrix} x_B \\ \pi\left(\lambda\right) - x_B \end{pmatrix} = \begin{pmatrix} \bar{b}\left(\rho^*,\bar{q}\right) \\ \pi\left(\lambda\right) - \bar{b}\left(\rho^*,\bar{q}\right) \end{pmatrix}.$$

The resulting continuation values are

$$\tilde{b}\left(\lambda,\phi,q_1 \mid r \leq \rho^*, q_1 < \mu\bar{q}\right) = \bar{b}\left(\rho^*,\bar{q}\right) + \beta\pi\left(\lambda\right) \tag{A35}$$

for the buyer and

$$\tilde{s}\left(\lambda, \phi, q_1 \mid r \leq \rho^*, q_1 < \mu\bar{q}\right) = -\bar{b}\left(\rho^*, \bar{q}\right) + (1-\beta)\,\pi\left(\lambda\right) \tag{A36}$$

for the seller. It is straightforward to see that the renegotiation game proposed in Section 4 implements an asymmetric Nash-bargaining solution with the outside option payoffs in equations (A31) and (A32) as disagreement point payoffs and β the buyer's bargaining share of the renegotiation surplus $g(\lambda)$ (and $\pi(\lambda)$ in case of a credible exit threat for $q_1 < \mu\bar{q}$). Q.E.D.

Appendix B: Buyer's investment decision

Proof of Lemma 5 (Investment)

Proof. For $r \leq \rho^*$ the expected first and second period payoffs as function of the seller's equilibrium strategy $\tilde{\sigma}_1(\lambda, \phi)$ are given as

$$\begin{aligned}
\mathbb{E}\bar{b}\left(r, \tilde{\sigma}_1(\lambda,\phi) \mid r \leq \rho^*\right) &= \int_0^{\tilde{\theta}} \left[\bar{b}\left(\rho^*, \bar{q}\right) - h\left(r, \sigma^*(\theta)\right)\right] f(\theta)\, d\theta + \int_{\tilde{\theta}}^{\bar{\theta}^{\mu}} \left[\bar{b}\left(\rho^*, \bar{q}\right) - h\left(r, \mu\bar{q}\right)\right] f(\theta)\, d\theta + \\
&\quad \int_{\bar{\theta}^{\mu}}^{\bar{\theta}} \left[\bar{b}\left(\rho^*, \bar{q}\right) - h\left(r, \sigma^*(\theta)\right)\right] f(\theta)\, d\theta + \int_{\bar{\theta}}^{1} \left[\bar{b}\left(\rho^*, \bar{q}\right) - h\left(r, \bar{q}\right)\right] f(\theta)\, d\theta \\
&= -\int_0^{\tilde{\theta}} h\left(r, \sigma^*(\theta)\right) f(\theta)\, d\theta - \int_{\tilde{\theta}}^{\bar{\theta}^{\mu}} h\left(r, \mu\bar{q}\right) f(\theta)\, d\theta \\
&\quad - \int_{\bar{\theta}^{\mu}}^{\bar{\theta}} h\left(r, \sigma^*(\theta)\right) f(\theta)\, d\theta - \int_{\bar{\theta}}^{1} h\left(r, \bar{q}\right) f(\theta)\, d\theta + \bar{b}\left(\rho^*, \bar{q}\right),
\end{aligned} \tag{A37}$$

and

$$\begin{aligned}
\mathbb{E}\tilde{b}\left(\lambda, \phi, \tilde{\sigma}_1(\lambda,\phi) \mid r \leq \rho^*\right) &= \int_0^{\tilde{\theta}} \left[\bar{b}\left(\rho^*, \bar{q}\right) + \beta w\left(\lambda, \sigma_R\right)\right] f(\theta)\, d\theta + \\
&\quad \int_{\tilde{\theta}}^{\bar{\theta}} \left[\bar{b}\left(r, \sigma^*(\theta)\right) + \beta g(\lambda)\right] f(\theta)\, d\theta + \int_{\bar{\theta}}^{1} \left[\bar{b}\left(r, \bar{q}\right) + \beta g(\lambda)\right] f(\theta)\, d\theta \\
&= \beta \int_{\Theta} w\left(\lambda, \sigma_R\right) f(\theta)\, d\theta - \int_{\tilde{\theta}}^{\bar{\theta}} \left[h\left(r, \sigma^*(\theta)\right) + \beta w\left(\lambda, \sigma^*(\theta)\right)\right] f(\theta)\, d\theta \\
&\quad - \int_{\bar{\theta}}^{1} \left[h\left(r, \bar{q}\right) + \beta w\left(\lambda, \bar{q}\right)\right] f(\theta)\, d\theta + \bar{b}\left(\rho^*, \bar{q}\right);
\end{aligned} \tag{A38}$$

for $r > \rho^*$ they are equal to

$$\mathbb{E}\bar{b}\left(r, \sigma_1(\lambda,\phi) \mid r > \rho^*\right) = \bar{b}\left(\rho^*, \bar{q}\right) - \int_0^{\bar{\theta}} h\left(r, \sigma^*(\theta)\right) f(\theta)\, d\theta - \int_{\bar{\theta}}^{1} h\left(r, \bar{q}\right) f(\theta)\, d\theta$$

and, since $\sigma_R = \sigma^*(\theta)$,

$$\begin{aligned}
\mathbb{E}\tilde{b}\left(\lambda, \phi, \tilde{\sigma}_1(\lambda,\phi) \mid r > \rho^*\right) &= \beta \int_{\Theta} w\left(\lambda, \sigma^*(\theta)\right) f(\theta)\, d\theta - \int_0^{\bar{\theta}} \left[h\left(r, \sigma^*(\theta)\right) + \beta w\left(\lambda, \sigma^*(\theta)\right)\right] f(\theta)\, d\theta \\
&\quad - \int_{\bar{\theta}}^{1} \left[h\left(r, \bar{q}\right) + \beta w\left(\lambda, \bar{q}\right)\right] f(\theta)\, d\theta + \bar{b}\left(\rho^*, \bar{q}\right).
\end{aligned}$$

To establish the results of Lemma 5, I first show that there is no overinvestment $r > \rho^*$ (and $\hat{\mu}(1, q^{\max}) = 0$ and then proof the claims made.

1. An investment level $r > \rho^*$ is a strictly dominated strategy for the buyer, since (a) her expected payoffs $\widehat{B}(r)$ exhibit a negative discontinuity at $r = \rho^*$ and (b) marginal payoffs for $r > \rho^*$ are negative. The buyer's choice of r can thus be restricted to $r \in [0, \rho^*]$.

(a) For any level investment level $r+\Delta > \rho^*$ the buyer forfeits her exit threat of value

$$\lim_{\Delta \searrow 0} \left[\widehat{B}\left(r \mid r=\rho^*\right) - \widehat{B}\left(r \mid r+\Delta=\rho^*\right) \right] = \beta \int_0^{\tilde{\theta}} w\left(\rho^*, \theta, \sigma^*\left(\theta\right)\right) f\left(\theta\right) d\theta > 0$$

for seller's types $\theta < \tilde{\theta}$. This threat value is strictly positive for $\mu > 0$ and $\beta > 0$.

(b) The FOC for $r > \rho^*$ to maximize the buyer's payoffs $\widehat{B}(r)$ is given as

$$\begin{aligned} 2 \left[\int_0^{\bar{\theta}} \frac{\partial v\left(r, \sigma^*\left(\theta\right)\right)}{\partial r} f\left(\theta\right) d\theta + \int_{\bar{\theta}}^1 \frac{\partial v\left(r, \bar{q}\right)}{\partial r} f\left(\theta\right) d\theta \right] + \\ \beta \int_{\bar{\theta}}^1 \left[\frac{\partial v\left(r, \sigma^*\left(\theta\right)\right)}{\partial r} - \frac{\partial v\left(r, \bar{q}\right)}{\partial r} \right] f\left(\theta\right) d\theta - \frac{\partial z\left(r\right)}{\partial r} &\overset{!}{=} 0 \end{aligned} \tag{A39}$$

From equation (4) in Definition 1 it is known that the buyer's investment is first-best if

$$\int_\Theta \frac{\partial \widehat{W}\left(\lambda, C, \vec{\sigma}^*\left(\theta\right)\right)}{\partial r} = 0.$$

Note that in equilibrium it holds true that $\tau = C$. If $\beta < 1$ or $\bar{q} < q^{\max}$ (or both) such that

$$\int_{\bar{\theta}}^1 \frac{\partial v\left(r, \bar{q}\right)}{\partial r} f\left(\theta\right) d\theta < \int_{\bar{\theta}}^1 \frac{\partial v\left(r, \sigma^*\left(\theta\right)\right)}{\partial r} f\left(\theta\right) d\theta,$$

then the LHS of (A39) is negative and decreasing in r for $r \geq \rho^*$. If, on the other hand, $\beta = 1$ and $\bar{q} = q^{\max}$ such that $\bar{\theta} = 1$, then the FOC in equation (A39) holds if and only if (by the assumptions for $v(\cdot)$ and $z(\cdot)$, the sufficient condition is satisfied) $r = \rho^*$. In that case, any positive μ will by Lemma 4 distort the seller's first period production incentives, hence $\hat{\mu}\left(1, q^{\max}\right) = 0$.

2. For $r \leq \rho^*$, the first order condition $\frac{\partial \widehat{B}(r)}{\partial r} \overset{!}{=} 0$ for ρ to be maximizer of $\widehat{B}(r)$ is equal to

$$\begin{aligned} \frac{\partial z\left(r\right)}{\partial r} \overset{!}{=}& \frac{\partial \tilde{\theta}\left(r\right)}{\partial r} f(\tilde{\theta}) \left[h\left(r, \mu \bar{q}\right) - \left(1-\beta\right) h\big(r, \sigma^*(\tilde{\theta})\big) + \beta w\big(r, \tilde{\theta}, \sigma^*(\tilde{\theta})\big) \right] + \\ & \int_0^{\tilde{\theta}} \left[\frac{\partial v\left(r, \sigma^*\left(\theta\right)\right)}{\partial r} + \beta \frac{\partial v\left(r, \bar{q}_R\right)}{\partial r} \right] f\left(\theta\right) d\theta + \int_{\tilde{\theta}}^{\bar{\theta}^\mu} \left[\frac{\partial v\left(r, \mu \bar{q}\right)}{\partial r} + \beta \frac{\partial v\left(r, \bar{q}_R\right)}{\partial r} \right] f\left(\theta\right) d\theta + \\ & \int_{\bar{\theta}^\mu}^{\bar{\theta}} \left[\frac{\partial v\left(r, \sigma^*\left(\theta\right)\right)}{\partial r} + \beta \frac{\partial v\left(r, \bar{q}_R\right)}{\partial r} \right] f\left(\theta\right) d\theta + \int_{\bar{\theta}}^1 \left[\frac{\partial v\left(r, \bar{q}\right)}{\partial r} + \beta \frac{\partial v\left(r, \bar{q}_R\right)}{\partial r} \right] f\left(\theta\right) d\theta \end{aligned} \tag{A40}$$

where by $\bar{q}_R(\lambda)$ in equation (13) it holds that $\frac{\partial w(\lambda, \bar{q}_R(\lambda))}{\partial r} = \frac{\partial v(r, \bar{q}_R)}{\partial r}$. Suppose that $\beta = 1$, i.e. the buyer makes a take-it-or-leave-it offer in the renegotiation game with probability 1 and thus receives the entire renegotiation surplus $g(\lambda)$ for $\theta \geq \tilde{\theta}$ and the entire second period trade surplus of $\pi(\lambda)$ for $\theta < \tilde{\theta}$. He thus receives the full returns for each unit of investment r. Moreover, let $\mu = 0$, then $\tilde{\theta} = \bar{\theta}^\mu = \frac{\partial \tilde{\theta}(r)}{\partial r} = 0$ and the FOC in equation (A40) simplifies and reads

$$\int_0^{\bar{\theta}} \left[\frac{\partial v\left(r, \sigma^*\left(\theta\right)\right)}{\partial r} + \frac{\partial v\left(r, \bar{q}_R\right)}{\partial r} \right] f\left(\theta\right) d\theta + \int_{\bar{\theta}}^1 \left[\frac{\partial v\left(r, \bar{q}\right)}{\partial r} + \frac{\partial v\left(r, \bar{q}_R\right)}{\partial r} \right] f\left(\theta\right) d\theta \overset{!}{=} \frac{\partial z\left(r\right)}{\partial r}. \tag{A41}$$

If $\bar{q} < q^{\max}$, then by $\bar{q}_R\left(\rho^*, \theta\right) = \sigma^*\left(\theta\right)$ for all θ (equations (12) and (13)) it holds that

$$\int_{\bar{\theta}}^1 \frac{\partial v\left(r, \bar{q}\right)}{\partial r} f\left(\theta\right) d\theta < \int_{\bar{\theta}}^1 \frac{\partial v\left(r, \sigma^*\left(\theta\right)\right)}{\partial r} f\left(\theta\right) d\theta$$

and the LHS in equation (A41) smaller than necessary by FOC (4) for $r = \rho^*$. By convexity of

$z(r)$, the buyer will invest $r < \rho^*$ for $\beta = 1$ and a breakup rule $\mu = 0$. This underinvestment effect will be stronger for lower $\bar{q}$. If a "rich" contract choice set $\overline{Q}$ allows for $\bar{q} = q^{\max}$, then by equations (A41) and (4) the buyer will efficiently invest if $\beta = 1$ and $\mu = 0$, but underinvest for $\beta < 1$.

To show that $\mu > 0$ improves the efficiency properties of r, note that for $\beta = 1$ and $\mu > 0$ the following holds true: $\tilde{\theta} > 0$, $\bar{\theta}^{\mu} > 0$, and $\frac{\partial \tilde{\theta}(r)}{\partial r} > 0$. Both $\bar{\theta}$ and $\bar{q}_R(\lambda)$ (given r) are unaffected by μ. The effect of μ on the buyer's investment incentives is characterized by the difference between the RHS in equation (A40) (for $\beta = 1$) and the LHS in (A41):

$$\frac{\partial \tilde{\theta}(r)}{\partial r} f\big(\tilde{\theta}\big)\left[h(r, \mu\bar{q}) + w\big(r, \tilde{\theta}, \sigma^*\big(\tilde{\theta}\big)\big)\right] + \int_{\tilde{\theta}}^{\bar{\theta}^{\mu}} \left[\frac{\partial v(r, \mu\bar{q})}{\partial r} - \frac{\partial v(r, \sigma^*(\theta))}{\partial r}\right] f(\theta)\, d\theta > 0. \quad \text{(A42)}$$

The first term on the LHS is positive by $h(r, \mu\bar{q}) = v(\rho^*, \mu\bar{q}) - v(r, \mu\bar{q}) > 0$ and equation (18) and increasing in μ. The second term is positive since $\sigma^*(\theta) < \mu\bar{q}$ for all $\theta < \bar{\theta}^{\mu}$ (as consequence of the value-enhancing effect of r, i.e. $v_{q_i r}(r, q_i) > 0$) and increasing in μ as $\big|\widetilde{\Theta}\big|$ is increasing in μ (Lemma 4); the same holds for $\beta < 1$. Since the effect of the buyer's breakup rents is thus monotonically increasing, and by the above argument investment level r bounded above by ρ^*, there is a $\mu = \hat{\mu}(\beta, \bar{q}) > 0$ such that this upper bound is reached. Q.E.D.

Proof of Corollary 3

Proof.

1. $\hat{\mu}_{\beta}(\beta, \bar{q}) < 0$: As is straightforward from equation (A40) for $\mu = 0$ and $\beta < 1$, the buyer's underinvestment incentives are stronger the lower her (Nash-)bargaining power β. Moreover, (A42) is less pronounced for $\beta < 1$, the effect of $\mu > 0$ on investment r thus weaker. Hence, $\hat{\mu}(\beta, \bar{q})$ decreases in β.

2. $\hat{\mu}_{\bar{q}}(\beta, \bar{q}) < 0$: As by equation (A41) a lower $\bar{q}$ aggravates the underinvestment effect for $\mu = 0$ for a given β, it increases the efficiency restoring breakup rule parameter $\hat{\mu}(\beta, \bar{q})$ that ensures the upper investment bound ρ^* be reached.

3. The existence of a $\hat{\mu}(\beta, \bar{q})$ within the unit interval is not granted. As $\hat{\mu}(\beta, \bar{q})$ grows larger for small values of β and $\bar{q}$, there may not exist a pair $(\beta, \bar{q})$ such that $\hat{\mu}(\beta, \bar{q}) \leq 1$. For instance, for $\beta = 0$ the value of the buyer's exit threat evaluated at $r = \rho^*$ is equal to zero and close to zero in the neighborhood of ρ^*. In that case, the lower $\bar{q}$, the less likely a breakup rule $\mu = 1$ be able to restore the buyer's investment incentives. Q.E.D.