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Highlights

- An expectation-based loss-averse buyer trades with a profit-maximizing seller.
- Incomplete contracts create a new type of hold-up problem.
- If credible, the buyer prefers to expect not to renegotiate.
- This gives rise to ex post materially inefficient trade.
- There is a tradeoff between maximizing efficiency and minimizing expected losses.

Incomplete Contracting, Renegotiation, and Expectation-Based Loss Aversion*

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We consider a simple trading relationship between an expectation-based loss-averse buyer and a profit-maximizing seller. When writing a long-term contract the parties have to rely on renegotiation in order to ensure materially efficient trade ex post. We show that if the buyer expects renegotiation to occur, the seller can opportunistically exploit the buyer's attachment to the expected outcome of renegotiation. In other words, incomplete contracts create a new type of hold-up problem. If credible, the buyer prefers to expect not to renegotiate, which gives rise to ex post inefficiencies. In a next step, we allow the buyer to undertake a non-contractible investment. We find that loss aversion can mitigate the traditional hold-up problem.

JEL classification: C78; D03; D86

Keywords: Behavioral Contract Theory; Expectation-Based Loss Aversion; Hold-Up Problem; Incomplete Contracts; Renegotiation

1. INTRODUCTION

Contracts observed in practice often are relatively simple. A possible reason for this could be indescribable contingencies, which prevent the contracting parties from writing a fully state-dependent long-term contract. Instead, parties write a simple state-independent "incomplete" contract—e.g., a sales contract specifying a particular good to be delivered in the future by a

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seller to a buyer at a prespecified price. With the state of the world being relevant for the buyer's benefit from and the seller's cost for provision of a certain service, the parties then have to rely on renegotiation in order to implement the efficient service ex post.

The standard approach of the incomplete contracting literature recently has been challenged by behavioral approaches—most notably by Hart and Moore (2008). Hart and Moore were the first to point out that the initial contract can shape a reference point for the parties which affects the ex post outcome. We built on this main idea by positing that the buyer is expectation-based loss averse; i.e., he has reference-dependent preferences and his reference point is affected by the concluded long-term contract. To convey the idea of our model setup, consider the following situation in the spirit of the well-known house-construction example in Hart (1995). Suppose the buyer wants to acquire a house and the seller is the owner of a construction company. At the point of contracting (and also when the construction begins), the buyer is uncertain about his needs; e.g. whether he prefers two bathrooms or one bathroom and a small study. The buyer may write a contract with the construction company that specifies each detail of the house (the sorts of radiators installed, the number of power points, etc.). This would correspond to our sales contract. The contract may also leave certain aspects unspecified. For instance, with a turnkey contract, the seller can freely choose between several acceptable solutions (like in the seller employment contract); e.g., the seller can decide which brand of radiator will be installed as long as it is guaranteed that each room is heated within an acceptable amount of time. Alternatively the contract may allow the buyer to select from a menu of options ex post; e.g. the buyer can choose between different facilities of the bathroom. Under any contract, the parties may engage—during construction—in contract renegotiation, i.e., one party requests a change order. For instance, the buyer may decide to have two separate washbasins instead of one in the bathroom. According to our model, the buyer forms expectations regarding the final value he obtains and the ultimate price he has to pay. For instance, when the buyer expects ex ante always to get a bathroom that perfectly fits his needs (which are only known ex post) and when this requires adjustments of the contract, the buyer feels a loss in the value dimension if the parties do not find an agreement ex post. Similarly, if they adjust the contract so that the buyer obtains his ideal bathroom but now has to pay a higher price than he expected to pay, he feels a loss in the price dimension.

Our main findings can be summarized as follows: First, the seller can opportunistically exploit the buyer's loss aversion at the renegotiation stage, i.e., we identify a new kind of hold-up problem created by incomplete contracts; second, expectation-based loss aversion can mitigate the traditional hold-up problem arising from non-contractible ex ante investments. We derive these findings in a simple model of bilateral trade where a profit-maximizing seller interacts with an expectation-based loss-averse buyer. The parties can sign a contract ex ante about trade ex post. When signing the contract, the ex post efficient service is unknown. Therefore, the parties may want to renegotiate the contract ex post, after the state of nature has been observed by both parties. The novelty of our paper is to assume that the buyer is expectation-based loss averse à la Kőszegi and Rabin (2006).[1] The buyer forms ex ante rational expectations about trade ex post, which shape a reference point for him separately in the "value" and the "price" dimension. In other words, the buyer feels a loss ex post if the price he has to pay exceeds his reference price or if the value he obtains from the delivered service is below his reference value.

To illustrate our first main finding consider the following stylized situation: Ex ante the buyer signed a contract with the seller about trade of a particular service at price $\bar{p}$. If the contract is executed, the buyer obtains a gross value of $\underline{v}$. Suppose the buyer expects that the seller offers to renegotiate the contract so that he obtains value $\bar{v} > \underline{v}$ but has to pay $\hat{p} > \bar{p}$. Suppose further that the buyer expects to accept this offer by the seller and fully anticipates the demanded mark-up. What is the highest price the seller can demand at the renegotiation stage? If the buyer accepts the renegotiation offer, he obtains exactly what he expected and thus his utility is $\bar{v} - \hat{p}$. Now, suppose the buyer rejects the offer and thus obtains gross value $\underline{v}$ at price $\bar{p}$. He expected to obtain value $\bar{v}$ and thus now feels a loss in the value dimension. His utility from rejecting the renegotiation offer is $\underline{v} - \bar{p} - \lambda(\bar{v} - \underline{v})$, where $\lambda > 0$ captures the buyer's loss aversion. It follows that the seller can demand a maximum mark-up of $\hat{p} - \bar{p} = (1+\lambda)(\bar{v} - \underline{v})$, which exceeds the buyer's increase in intrinsic valuation. The buyer—in a sense—is exposed to opportunism by the seller. In other words, the seller can exploit at the renegotiation stage that the buyer ex ante expected the contract to be renegotiated. The buyer's expected utility from expecting to renegotiate is $\underline{v} - \bar{p} - \lambda(\bar{v} - \underline{v})$. If the buyer expects to reject the renegotiation offer, his expected utility is $\underline{v} - \bar{p}$. Thus, for a given long-term contract, the buyer prefers ex ante that renegotiation does not take place. In our full blown model, such expectations turn out to be credible, however, only if the buyer is sufficiently loss averse. In this case the ex post outcome can be inefficient—i.e, the traded service does not maximize the material gains from trade.

The ex ante optimal contract maximizes the expected surplus of the two parties including the buyer's expected losses. We show that the optimal long-term contract typically is an employment contract that gives a sufficiently high degree of discretion (in form of a large acceptance set) to the party that is designated to choose which service is to be delivered. The advantage of an employment contract with much discretion compared to contracts with little discretion, a sales contract in particular, is that it leads to less variations in the default outcome. Little variation in the default outcome translates into little variation in the ex post outcome, such that ex post experienced losses are minimized.

In a second step, we extend our model by allowing the buyer to make a relationship-specific and non-contractible investment in the sense of Hart and Moore (1988). With relationship-specific investments an optimal long-term contract protects the buyer's sunk investment against ex post opportunism by the seller. We show that loss aversion can reduce the hold-up problem,

[1] Beginning with Heidhues and Kőszegi (2008), expectation-based loss aversion à la Kőszegi and Rabin (2006, 2007) is applied fruitfully to models of industrial organization (Heidhues and Kőszegi, 2014; Herweg and Mierendorff, 2013; Karle and Peitz, 2014; Karle and Schumacher, 2016; Rosato, 2016), contract design (Herweg, Müller, and Weinschenk, 2010; Macera, 2016; Daido and Murooka, 2016; Daido, Morita, Murooka, and Ogawa, 2013), mechanism design (Eisenhuth, 2012; Hahn, Kim, Kim, and Lee, 2017), and inventory management (Herweg, 2013).

i.e., investment incentives can be increasing in the degree of loss aversion. In other words, we derive conditions so that, under the optimal contract, a sufficiently loss-averse buyer undertakes the investment, whereas a loss-neutral buyer does not invest. Moreover, in these cases, the generated joint surplus often is higher if the buyer is sufficiently loss averse. In order to see why loss aversion may enhance the investment incentives, consider again the simple example from above. Now, however, assume that the buyer can ex ante undertake an investment at cost $\psi > 0$ that increases his value from the service specified in the contract; i.e., $\underline{v}$ becomes $\underline{v} + \Delta < \bar{v}$ if the buyer invests. Moreover, assume that the buyer always expects renegotiation to occur. The buyer undertakes the investment if and only if $\underline{v} + \Delta - \bar{p} - \lambda(\bar{v} - \underline{v} - \Delta) - \psi \geq \underline{v} - \bar{p} - \lambda(\bar{v} - \underline{v})$, which is equivalent to $\Delta(1+\lambda) \geq \psi$. Thus, with $\lambda > 0$, it is "more likely" that the investment is made by a loss-averse buyer than by a loss-neutral buyer. The reason for this is that undertaking the investment reduces the exploitation that the loss-averse buyer is exposed to in case he expects renegotiation to occur.

The remainder of the paper is organized as follows. Before introducing the baseline model without investments in Section 2, we first discuss the related literature. The baseline model is solved in Section 3. Non-contractible investments and the arising hold-up problem are analyzed in Section 4. In Section 5, we discuss the robustness and the limitations of our findings. The final Section 6 concludes the paper. All proofs are relegated to the Appendix A except for the proof of the purely technical Lemma 1, which can be found in Appendix B.

Related literature.—The theory of the firm and the literature on incomplete contracts goes back to Coase (1937) and Simon (1951). The modern game theoretic approaches, beginning with Grout (1984), abstract from ex post inefficiencies and focus on the ex ante inefficiencies caused by the hold-up problem, as introduced by Klein, Crawford, and Alchian (1978).[2]

The seminal contribution by Hart and Moore (2008) posits that a contract provides a reference point for the parties' feelings of entitlements ex post.[3] A party who feels shortchanged (relative to what she feels entitled to given the possible outcomes permitted by the contract) shades on performance, which leads to an ex post inefficiency. This theory is used by Hart (2009) to shed new light on the optimal allocation of ownership rights and indexing contracts, by Hart and Holmstrom (2010) to investigate the boundaries of the firm, and by Hart (2013) to reconsider non-contractible investments and the arising hold-up problem. All the aforementioned papers do not analyze contract renegotiation, which is at the heart of our analysis. The Hart-Moore approach is extended by Halonen-Akatwijuka and Hart (2013) in order to allow for renegotiation.

The paper closest related to our work is Herweg and Schmidt (2015), who also analyze the effects of loss aversion in an incomplete contracting model. Herweg and Schmidt posit that the reference point at the renegotiation stage directly corresponds to the default outcome determined

[2]See, for instance, Grossman and Hart (1986) and Hart and Moore (1990).

[3]Laboratory evidence supporting the Hart-Moore approach is provided by Fehr, Zehnder, and Hart (2009), Fehr, Hart, and Zehnder (2011, 2015), and Hoppe and Schmitz (2011).

by the initial contract and the realized state of the world. Their approach follows Tversky and Kahneman (1991), i.e., the parties suffer from the endowment effect/ status quo bias. Our approach—by applying expectation-based loss aversion—is more in the spirit of Kahneman and Tversky (1979), i.e., loss aversion/ prospect theory applies as an alternative theory for decisions under uncertainty. In other words, risk is key in our model but not in Herweg and Schmidt.[4] One of the main findings in Herweg and Schmidt is that, due to loss aversion, a long-term contract makes the outcome of renegotiation sticky and inefficient. They derive conditions—by comparing a particular long-term contract with a particular alternative (spot contract/ allocation of ownership rights)—so that not signing a long-term contract is optimal. We investigate an orthogonal question, namely which type of long-term contract should be concluded (seller- or buyer-employment contract, size of the acceptance set). Moreover, we show that the buyer's expectations regarding contract renegotiation can be exploited by the seller—an effect that is absent if the reference point is the status quo. Finally, we show that expectation-based loss aversion can mitigate the hold-up problem and thus increase social surplus, whereas Herweg and Schmidt (2015) show that status quo loss aversion has no effects on the investment incentives and always decreases the social surplus.

2. The Model

2.1. Trading Environment

We consider an incomplete contracting environment similar to Bolton and Dewatripont (2005). A buyer (he) requires a service which can be provided by a seller (she). The nature of the service will be commonly known when trade takes place but is unknown to the parties ex ante when they may write a long-term contract. There are three kinds of the service which the seller can deliver, $x \in \{x_1, x_2, x_3\} \equiv \mathcal{X}$ and there are three equiprobable states of the world, $\theta \in \{\theta_1, \theta_2, \theta_3\} \equiv \Theta$. The buyer's value and the seller's cost from service $x \in \mathcal{X}$ being traded in state $\theta \in \Theta$ is denoted by $v(x, \theta)$ and $c(x, \theta)$, respectively. Trade of service x in state θ can result in three different benefit-cost combinations,

$$(v(x, \theta), c(x, \theta)) \in \{(v_0, c_0), (v_L, c_L), (v_H, c_H)\}, \tag{1}$$

where

$$0 \equiv v_0 < v_L < v_H, \qquad 0 \equiv c_0 < c_L < c_H, \qquad 0 < v_H - c_H < v_L - c_L. \tag{2}$$

In other words, there exists a worthless outcome $(0, 0)$ without any gains from trade, an outcome (v_L, c_L) associated with a low value but also low costs, and a high-value/high-cost outcome (v_H, c_H). The material gains from trade are highest for the low-value/low-cost outcome (v_L, c_L),

[4]In the absence of risk, loss aversion has no effects in our model. In Herweg and Schmidt (2015), in contrast, the outcome of renegotiation is inefficient even without risk.

which will be called "materially efficient". The precise value-cost combinations of trade from a given service in a given state are depicted in the following table.[5]

	x_1	x_2	x_3
θ_1	(v_L, c_L)	$(0, 0)$	(v_H, c_H)
θ_2	(v_H, c_H)	(v_L, c_L)	$(0, 0)$
θ_3	$(0, 0)$	(v_H, c_H)	(v_L, c_L)

Table 1: *Value-cost combination* $(v(x, \theta), c(x, \theta))$ *from trading service* x *in state* θ*.*

In any state, there is one service that yields the worthless outcome, one service that yields the high-value/high-cost outcome, and one service that leads to material efficiency.

The above trading environment is highly stylized. In fact, this is the simplest setup where—for a given price—the buyer's and the seller's preferred service differ and neither party prefers the materially efficient service to be traded. Even in this simple framework, however, allowing for expectation-based loss aversion on the side of the buyer makes the analysis fairly involved. In order to reduce the number of necessary case distinctions, we assume the following:

Assumption 1. $v_L > \max\{2c_L, v_H/2\}$.

According to Assumption 1, the gains from materially efficient trade are sufficiently large; i.e., the buyer's benefit from the low-value service is at least twice as large as the seller's associated cost. Furthermore, the increase in the buyer's benefit is higher when switching from the worthless service to the low-value service than when switching from the low-value service to the high-value service.

2.2. Contracts, Renegotiation, and the Sequence of Events

At date 0, the seller can make a take-it-or-leave-it contract offer to the buyer. Let $\tilde{\mathcal{X}} = \mathcal{P}(\mathcal{X})\backslash\emptyset$, where $\mathcal{P}(\cdot)$ denotes the power set. The state of the world is not verifiable and thus cannot be contracted upon. A contract offer $C = (E, \mathcal{A}, \bar{p})$ specifies an acceptance set $\mathcal{A} \in \tilde{\mathcal{X}}$ from which party $E \in \{B, S\}$ is designated to freely choose service $x \in \mathcal{A}$ to be delivered at a pre-specified price $\bar{p} \in \mathbb{R}$. Due to the symmetry of states and services, there are effectively five different contractual forms. First, a *buyer employment contract* (i.e., $E = B$) or a *seller employment contract* (i.e., $E = S$) with *large acceptance set* (i.e., $|\mathcal{A}| = 3$), under which the designated party can freely choose any of the three services ex post. Second, a *buyer employment contract* or a *seller employment contract* with *medium acceptance set* (i.e., $|\mathcal{A}| = 2$), under which the designated party can choose between two pre-specified services ex post. Finally, if $\mathcal{A}$ is a

[5] We analyze a more general model with more states and more services in Herweg, Karle, and Müller (2016). The main findings carry over to this general model with $n \geq 3$ states and services.

singleton (i.e., $|\mathcal{A}| = 1$), the offered contract is a *sales contract* specifying a particular service to be delivered. The set of all feasible contract offers is denoted by $\mathcal{C} = \{B, S\} \times \tilde{\mathcal{X}} \times \mathbb{R}$.

At date 1, upon receiving the seller's offer, the buyer decides whether to accept or to reject this offer. In order to make this decision, the buyer forms rational expectations about the value of the service he will ultimately consume and about the price he has to pay for it. For a loss-averse buyer these rational expectations formed at date 1 shape a reference point. The reference point affects the buyer's evaluation of renegotiation at date 4. We will explain this in more detail below.

In case that the buyer rejects the contract offer, the game ends and both the buyer and the seller receive their outside option $\bar{u}^B < v_L - c_L$ and $\bar{u}^S = 0$, respectively. In case of the buyer accepting the offer, the seller observes the buyer's plans regarding renegotiation.[6]

If the buyer accepted the seller's initial contract offer, at date 2, the state of the world, $\theta \in \Theta$, materializes and is observed by both the buyer and the seller. Thereafter, at date 3, renegotiation takes place with the seller offering a renegotiation contract $(x^R, p^R) \in \mathcal{X} \times \mathbb{R}$ to the buyer. At date 4, the buyer then decides whether to accept the seller's renegotiation offer. In case of rejection, the initially signed contract is implemented. Finally, at date 5, the service of the concluded contract is delivered at the specified price and payoffs are realized.

Regarding the buyer's decisions at date 1 and at date 4, we assume that if the buyer is indifferent between accepting and rejecting the seller's offer, he accepts the offer. Throughout the analysis, we focus on equilibria in pure strategies. The sequence of events is summarized in Figure 1.

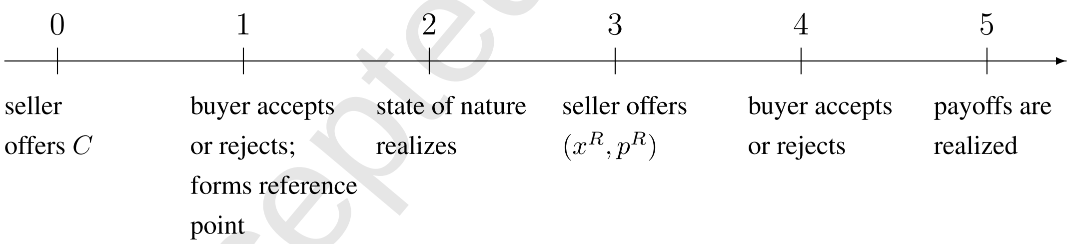

Figure 1: Sequence of events.

In order to characterize the outcome of renegotiation, it is important to know what the outcome is if renegotiation fails. To this end, let $(v^D(\theta, C), c^D(\theta, C))$ denote the "default" value-cost pair that will be implemented under contract $C \in \mathcal{C}$ if renegotiation breaks down (or is not offered in the first place) after state $\theta \in \Theta$ is realized.[7]

[6]The assumption that sellers observe not only the decision but also the plans made by the buyer guarantees equilibrium existence. This somewhat unrealistic assumption can be regarded as a shortcut for a more complex renegotiation game, as we would expect qualitatively similar results to prevail if the seller can revise its offers after a rejection (finitely often). See also the sequential negotiations in Rosato (2017), where a loss-neutral seller makes finitely many take-it-or-leave-it offers to a loss-averse buyer in an environment with exogenous breakdown risk.

[7]In Herweg and Schmidt (2015) the reference point equals the default outcome and is determined after stage 2 when the uncertainty is resolved. In our model, the reference point is determined by rational expectations about final outcomes formed at date 1—before uncertainty is resolved—and thus typically is a distribution (an expected final outcome for each state θ).

2.3. Buyer's Preferences and Seller's Profit

The buyer is expectation-based loss averse according to Kőszegi and Rabin (2006, 2007). His utility has two components: material utility and loss utility. Material utility from consuming x in state θ at price p is $v(x,\theta) - p$. Loss utility is derived by comparing the outcome in a particular dimension, "value" or "price", to its respective reference level. The reference point for a given dimension, which is determined by rational expectations formed at the end of date 1, is independent across the two dimensions and typically stochastic. At date 4, the buyer takes these expectations as given and the renegotiation contract offer is evaluated in comparison to this reference point, where losses are evaluated separately in both dimensions. Specifically, when the buyer accepts a contract offer $C \in \mathcal{C}$ at date 1, he forms expectations regarding the outcome of renegotiation. With our focus on pure strategies, when renegotiation takes place under a given long-term contract after the state of the world has been realized, the seller will offer to provide a particular service at a particular price. The buyer's expectations under contract $C \in \mathcal{C}$ about the outcome and the trade price implemented at date 4 if state $\theta \in \Theta$ is realized thus comprise a single value-cost-price triplet, which is denoted by

$$(\hat{v}(\theta, C), \hat{c}(\theta, C), \hat{p}(\theta, C)). \tag{3}$$

Define

$$\Lambda(C) \equiv \{(\hat{v}(\theta, C), \hat{c}(\theta, C), \hat{p}(\theta, C))\}_{\theta\in\Theta} \tag{4}$$

as the buyer's set of expectations regarding the outcome of renegotiation under contract $C \in \mathcal{C}$; i.e., the set $\Lambda(C)$ comprises a value-cost-price triplet for each of the three possible states of the world. For given expectations $\Lambda(C)$ under contract $C \in \mathcal{C}$, the buyer's overall utility at date 5 if the seller delivers a service resulting in value v at price p is

$$U(v, p|\Lambda(C)) = v - p - \frac{\lambda}{3}\left\{ \sum_{\{\theta\in\Theta|\hat{v}(\theta,C)>v\}} [\hat{v}(\theta, C) - v] + \sum_{\{\theta\in\Theta|\hat{p}(\theta,C)<p\}} [p - \hat{p}(\theta, C)] \right\}. \tag{5}$$

For simplicity, we abstract from any gain utility and the weight on losses is $\lambda \geq 0$.[8] Here, λ captures both the buyer's degree of reference dependence and his magnitude of loss aversion. Following the literature, we assume that the weight the buyer places on loss utility does not exceed the weight placed on material utility (Herweg, Müller, and Weinschenk, 2010; Dhami, 2016).[9]

[8] This assumption—which is also imposed by de Meza and Webb (2007) and Herweg and Mierendorff (2013)—has no qualitative effects on our results.

[9] Structural empirical estimators for the loss aversion parameter within the Kőszegi-Rabin framework are in line with our assumption. In a laboratory auction setting, Banerji and Gupta (2014) report an average estimate of $\lambda = 0.283$ with a standard error of 0.08. Similarly, also in a lab experiment on auctions, Eisenhuth and Grunewald (2017) estimated loss aversion parameter is $\lambda = 0.42$ with a standard error of 0.16. In both cases, the loss aversion parameter is significantly larger than zero and significantly smaller than one. Using field date on the behavior of cab drivers, Crawford and Meng (2011) allow for different degrees of loss aversion in the two dimensions, money and leisure, and report average values of $\lambda = 0.256$ in the former and $\lambda = 0.671$ in the latter (preferred model specification).

Assumption 2. $\lambda \leq 1$ *(no dominance of loss utility)*

The seller is risk and loss neutral. At date 5, her profit from delivering a service which costs c at price p is

$$\Pi(c, p) = p - c. \tag{6}$$

2.4. Equilibrium Concept

If the buyer is not loss averse, we apply the standard notion of subgame perfect equilibrium in pure strategies. For a loss-averse buyer we augment the concept of subgame perfect equilibrium by incorporating that the buyer's behavior has to be a *personal equilibrium* (PE) as defined in Kőszegi and Rabin (2006). The PE requires that the buyer's reference point formed at date 1 (initial contracting) is such that his behavior at date 4 (renegotiation) is consistent with his reference point; i.e., the reference point is determined by rational expectations over final outcomes at date 1—taking the seller's and the buyer's own behavior in future periods into account. At date 4, the buyer simply selects the option—accept or reject the seller's renegotiation offer—that maximizes his utility for the given reference point formed at date 1. At date 3, the seller takes the buyer's reference point formed at date 1 into account when making the renegotiation offer. At date 1, when forming his expectations, the buyer correctly anticipates that the seller will optimally react on this reference point at date 3. We will refer to an equilibrium of this type as a *subgame perfect personal equilibrium* (SP-PE). The precise definition of the SP-PE concept reads as follows.

Definition 1. *A subgame perfect personal equilibrium (SP-PE) comprises*

- *a strategy* $\sigma^S = \langle C, x^R(\theta, C), p^R(\theta, C)\rangle$ *for the seller, with* $C \in \mathcal{C}$ *denoting the seller's initial contract offer at date 0 and* $x^R : \Theta \times \mathcal{C} \to \mathcal{X}$ *and* $p^R : \Theta \times \mathcal{C} \to \mathbb{R}$ *denoting the service and the price offered by the seller in renegotiation after the buyer accepted the initial contract offer* $C \in \mathcal{C}$ *at date 1 and state of nature* $\theta \in \Theta$ *was realized at date 2;*

- *a strategy* $\sigma^B = \langle \alpha(C), \beta(\theta, C, x^R, p^R)\rangle$ *for the buyer, where* $\alpha : \mathcal{C} \to \{accept, reject\}$ *denotes the buyer's decision at date 1 whether to accept the seller's initial contract offer* $C \in \mathcal{C}$ *from date 0 and* $\beta : \Theta \times \mathcal{C} \times \mathcal{X} \times \mathbb{R} \to \{accept, reject\}$ *denotes the buyer's decision at date 4 whether to accept the seller's contract offer* $(x^R, p^R) \in \mathcal{X} \times \mathbb{R}$ *in renegotiation at date 3 after the buyer accepted the initial contract offer* $C \in \mathcal{C}$ *at date 1 and state of nature* $\theta \in \Theta$ *was realized at date 2;*

- *a set* $\{\Lambda^*(C)\}_{C \in \mathcal{C}}$ *of expectations regarding the outcome of renegotiation under any feasible contract offer* $C \in \mathcal{C}$*,*

for which the following properties hold:

(E1) At date 4,

$$\beta = \textit{accept} \iff U(v(x^R(\theta, C), \theta), p^R(\theta, C)|\Lambda^*(C)) \geq U(v^D(\theta, C), \bar{p}|\Lambda^*(C)).$$

(E2) At date 3, for realized state $\theta \in \Theta$, the contract (x^R, p^R) solves:

$$\max_{x \in \mathcal{X}, p \in \mathbb{R}} \Pi(c(x, \theta), p) \qquad \textit{subject to} \qquad U(v(x, \theta), p|\Lambda^*(C)) \geq U(v^D(\theta, C), \bar{p}|\Lambda^*(C)).$$

(E3) At date 1,

$$\alpha = \textit{accept} \iff EU(v(x^R(\theta, C), \theta), p^R(\theta, C)|\Lambda^*(C)) \geq \bar{u}^B,$$

where, for any $C \in \mathcal{C}$, $\Lambda^*(C)$ satisfies

$$(\hat{v}(\theta, C), \hat{c}(\theta, C), \hat{p}(\theta, C)) = (v(x^R(\theta, C), \theta), c(x^R(\theta, C), \theta), p^R(\theta, C)), \ \forall \theta \in \Theta. \quad (*)$$

(E4) At date 0, the initial contract $C \in \mathcal{C}$ solves:

$$\max_{\tilde{C} \in \mathcal{C}} \ E\Pi(c(x^R(\theta, \tilde{C}), \theta), p^R(\theta, \tilde{C}))$$
$$\textit{subject to} \qquad EU(v(x^R(\theta, \tilde{C}), \theta), p^R(\theta, \tilde{C})|\Lambda^*(\tilde{C})) \geq \bar{u}^B.$$

Essentially, properties (E1) to (E4) capture sequential rationality of both the buyer and the seller. Importantly, condition $(*)$ in property (E3) embodies the requirement of internal consistency imposed by personal equilibrium. For any state θ the reference point—given the contract C—has to coincide with the actual ex post (after renegotiation) outcome. In other words, on the equilibrium path, the buyer feels the sensation of a loss only by comparing a given outcome to expected outcomes in different states. The expected ex post outcome (i.e., the reference point) affects behavior of the buyer at date 4 as following his expectations typically reduces the sensation of losses. Due to this self-fulfilling prophecy nature of the PE concept, there are typically multiple PE, which in turn implies that there are often multiple SP-PE. In this case, at date 1 the buyer is assumed to choose the plan among all consistent plans that gives him the highest expected utility, i.e., the preferred personal equilibrium (PPE) in the language of Kőszegi and Rabin (2006). We call the corresponding equilibrium in which the seller correctly anticipates this behavior of the buyer as *subgame perfect preferred personal equilibrium* (SP-PPE).

Definition 2. *A subgame perfect preferred personal equilibrium (SP-PPE) is a subgame perfect personal equilibrium (SP-PE) with the additional requirement that condition $(*)$ in property (E3) of Definition 1 is replaced by:*

$$\max_{\Lambda(C)} \ EU(v(x^R(\theta, C), \theta), p^R(\theta, C)|\Lambda(C))$$

subject to

$$(\hat{v}(\theta, C), \hat{c}(\theta, C), \hat{p}(\theta, C)) = (v(x^R(\theta, C), \theta), c(x^R(\theta, C), \theta), p^R(\theta, C)), \ \forall \theta \in \Theta.$$

2.5. Benchmark Case without Loss Aversion

Consider a buyer without reference-dependent preferences who is risk neutral. Ex post the parties engage in Coasian bargaining and the efficient outcome is always implemented, irrespective of the initial contract. The initial contract, via the initial price, only determines the share of the surplus $v_L - c_L$ that accrues to each party. With the seller having all the bargaining power ex ante, the buyer always obtains his outside option $\bar{u}^B$ and the seller obtains $v_L - c_L - \bar{u}^B$.

Observation 1. *Suppose the buyer is not loss averse. The generated surplus of any long-term contract is $v_L - c_L$; i.e., in equilibrium, the contract offer made by the seller can take any form, buyer or seller employment contract with large or medium acceptance set or sales contract.*

Importantly, the seller acts as residual claimant and thus is interested in maximizing the joint surplus. This holds true also in the case of a loss-averse buyer.[10]

Our benchmark to which we compare the effects of expectation-based loss aversion is a buyer who is risk-neutral—i.e., neither loss averse nor risk averse. An alternative benchmark, which we discuss in Section 5, is a risk-averse buyer.

3. The Analysis

We solve the game by backward induction. We start by analyzing the game for a given initial contract, in particular the outcome of renegotiation. Thereafter, we investigate the optimal initial contract offer. The analysis of the renegotiation game, starting at date 3 after the realization of the state of nature, is more complicated than usual because the buyer's reference point—determined by rational expectations at date 1—affects the buyer's and the seller's behavior at the renegotiation stage. In other words, the buyer's reference point is determined in equilibrium and has to satisfy a fixed point property. Therefore, when analyzing the outcome of renegotiation, we also investigate the reference point formation at date 1; i.e., we analyze which plans/outcomes are consistent in the sense of expectations coinciding with the actual outcome (cf. condition ($*$) in property (E3) in Definition 1). The analysis of renegotiation is structured according to the size of the acceptance set specified by the initial contract.

3.1. Further Notation and Helpful Observations

To prepare the analysis it is useful to introduce some notation and general observations. The outcome of renegotiation crucially depends on the parties' threat points, i.e., what the outcome will be if renegotiation fails or is not offered in the first place. In this case the initial contract is executed and we call the corresponding outcome—the threat point—default outcome. Specifically, under a seller employment contract, i.e., for $E = S$, the seller will choose the service

[10] The initial distribution of the bargaining power does not affect the structure of the optimal long-term contract only the initial price $\bar{p}$.

resulting in the minimum cost feasible given acceptance set $\mathcal{A}$. Under a buyer employment contract, i.e., for $E = B$, the buyer will opt for a service that results in the highest value feasible given acceptance set $\mathcal{A}$. First, consider an employment contract with large acceptance set, i.e., with $|\mathcal{A}| = 3$. As a large acceptance set contains all three services, both the high-value and the worthless outcome are feasible choices irrespective of the realized state of nature. Therefore, under a buyer employment contract, the buyer will select the service resulting in the highest value v_H. Likewise, under a seller employment contract, the seller will select the service that yields the lowest cost $c_0 = 0$. Hence, for a large acceptance set, the default outcome under either type of employment contract is ex ante certain. Next, consider a buyer employment contract with medium acceptance set, i.e., with $|\mathcal{A}| = 2$. Here, the default outcome is ex ante uncertain. In two of the three states of nature the acceptance set contains a service that yields value v_H. In the remaining state, however, the highest value a service in the acceptance set yields is only v_L. Hence, under this type of contract, the default outcome is (v_H, c_H) with probability $2/3$ and (v_L, c_L) with probability $1/3$. Similarly, under a seller employment contract with medium acceptance set the default outcome is $(0, 0)$ with probability $2/3$ and (v_L, c_L) with probability $1/3$. Finally, a sales contract with $|\mathcal{A}| = 1$ ex ante allows for three different equiprobable realizations of the default outcome. Letting

$$Q_k(E, \mathcal{A}) = \text{Prob}[(v^D(\theta, C), c^D(\theta, C)) = (v_k, c_k)] \qquad \text{for} \quad k \in \{0, L, H\} \tag{7}$$

denote the ex ante probability that a contract $C = (E, \mathcal{A}, \bar{p})$ results in default outcome (v_k, c_k), where $k \in \{0, L, H\}$, we have

$$Q_H(B, \mathcal{A}) = Q_0(S, \mathcal{A}) = \begin{cases} 1 & \text{if } |\mathcal{A}| = 3 \\ \frac{2}{3} & \text{if } |\mathcal{A}| = 2 \\ \frac{1}{3} & \text{if } |\mathcal{A}| = 1 \end{cases}, \tag{8}$$

$$Q_L(B, \mathcal{A}) = Q_L(S, \mathcal{A}) = \begin{cases} 0 & \text{if } |\mathcal{A}| = 3 \\ \frac{1}{3} & \text{if } |\mathcal{A}| \leq 2 \end{cases}, \tag{9}$$

$$Q_0(B, \mathcal{A}) = Q_H(S, \mathcal{A}) = \begin{cases} 0 & \text{if } |\mathcal{A}| \geq 2 \\ \frac{1}{3} & \text{if } |\mathcal{A}| = 1 \end{cases}. \tag{10}$$

Due to the imposed symmetry, the outcome of renegotiation depends on the state of nature only via the realized default outcome.[11]

Lemma 1. *Generically, in a SP-PE, for all $C \in \mathcal{C}$, if $v^D(\theta', C) = v^D(\theta'', C)$ for $\theta', \theta'' \in \Theta$ with $\theta' \neq \theta''$, then $(\hat{v}(\theta', C), \hat{c}(\theta', C), \hat{p}(\theta', C)) = (\hat{v}(\theta'', C), \hat{c}(\theta'', C), \hat{p}(\theta'', C))$.*

For a given contract C the final—and expected—outcome is solely a function of the default outcome, but not of the state of nature. This allows us to denote the buyer's expectation regarding renegotiation in case of default outcome (v_k, c_k), where $k \in \{0, L, H\}$, under contract $C \in \mathcal{C}$ as $(\hat{v}_k(C), \hat{c}_k(C), \hat{p}_k(C))$.

[11]The proof is relegated to Appendix B.

The analysis may involve numerous case distinctions. For example, a sales contract allows for three different default outcomes. With three possible outcomes to renegotiate to, in principle, the buyer might expect $3^3 = 27$ different outcomes of renegotiation (which includes the cases in which for some or all default outcomes renegotiation effectively does not take place and the respective default outcome is implemented at price $\bar{p}$). Assumptions 1 and 2, however, allow us to reduce the number of cases that need to be considered significantly. In particular, we can rule out that the worthless service is traded ex post. With the buyer's benefit of low-value trade being at least twice as large as the seller's associated cost, $v_L > 2c_L$, the seller can always offer a trade price sufficiently high to cover her cost, which at the same time is sufficiently low for the buyer to accept low-value trade. Specifically, low-value trade is accepted by the buyer even if he expected the provision of a worthless service at a lower price (which requires that the buyer is not too loss averse).

Lemma 2. *In any SP-PE, for any $C \in \mathcal{C}$, $\hat{v}_k(C) > 0$ for $k \in \{0, L, H\}$.*

The logic underlying the proof of Lemma 2 also allows to draw the following important off-equilibrium-path implication.

Corollary 1. *Deviating from the buyer's expectations by offering renegotiation to a worthless service is never profitable for the seller.*

Lemma 2 allows us to narrow down the form a SP-PE may take and Corollary 1 restricts the set of potentially profitable deviations for the seller.

3.2. Renegotiation under Employment Contracts with a Large Acceptance Set

Suppose the buyer accepted an employment contract $C = (E, \mathcal{A}, \bar{p})$ with a large acceptance set, i.e., $|\mathcal{A}| = 3$. With every possible service being a feasible choice in the acceptance set, there is no uncertainty about the default outcome under either type of employment contract. Hence, the buyer's expectations regarding the outcome of renegotiation comprise a single value-cost-price triplet.

Buyer employment contract.—For $E = B$, if renegotiation fails or is not offered, the buyer selects the service that yields the materially inefficient high-value/high-cost outcome; i.e., $(v^D(\theta, C), c^D(\theta, C)) = (v_H, c_H)$ for all $\theta \in \Theta$. With the buyer's preferences being reference dependent, we need to know his reference point in order to be able to analyze the renegotiation game. The buyer's reference point, in turn, is shaped by his expectations regarding the outcome of renegotiation.

First, suppose the buyer expects materially efficient renegotiation to occur and denote these expectations by $\Lambda(C) = \{(v_L, c_L, \hat{p}^L_H)\} =: \Lambda^L_B$. The buyer expects that he always obtains gross value v_L and pays price $\hat{p}^L_H$. As renegotiation in this case involves a decrease in value compared to the default outcome, the buyer has to expect to be offered a discount price, i.e., $\hat{p}^L_H < \bar{p}$.

In order to establish that there is a SP-PE with materially efficient renegotiation, we have to show that there is a price expectation $\hat{p}_H^L$ that is consistent with subsequent optimal play of the buyer and the seller. With the seller having all the bargaining power at the renegotiation stage, the only price compatible with equilibrium makes the buyer indifferent between accepting and rejecting the seller's renegotiation offer. The equilibrium price thus equates

$$U(v_L, \hat{p}_H^L | \Lambda_B^L) = v_L - \hat{p}_H^L \quad \text{with} \quad U(v_H, \bar{p} | \Lambda_B^L) = v_H - \bar{p} - \lambda(\bar{p} - \hat{p}_H^L). \tag{11}$$

If the buyer accepts the renegotiation offer, the actual outcome in each dimension coincides with his expectations and thus no sensations of losses are incurred. The buyer's utility is the intrinsic utility from obtaining value v_L and paying price $\hat{p}_H^L$. If, on the other hand, the buyer rejects the offer, his intrinsic utility is $v_H - \bar{p}$. Now, he experiences the sensation of a loss in the price dimension because he expected to pay only $\hat{p}_H^L$ but actually has to pay $\bar{p} > \hat{p}_H^L$. The price that results from (11) is given by

$$\hat{p}_H^L = \bar{p} - \frac{v_H - v_L}{1 + \lambda}. \tag{12}$$

Importantly, note that the price reduction, $\bar{p} - \hat{p}_H^L$, is smaller than the reduction in value, $v_H - v_L$, when switching from the high-value to the low-value service. The buyer expects to receive a price discount and thus suffers a loss when he has to pay $\bar{p}$. This makes him willing to accept the renegotiation offer already for a mild price reduction, which falls short of the reduction in intrinsic value. In other words, the buyer expecting materially efficient renegotiation creates an opportunity for the seller to exploit the buyer—i.e., a novel kind of hold-up arises. This outcome constitutes a SP-PE only if the seller cannot benefit from making a different offer at the renegotiation stage. Not surprisingly, with the associated profits for the seller from renegotiation being larger than $(v_L - c_L) - (v_H - c_H)$, there is no profitable deviation. Thus, materially efficient renegotiation is always consistent with SP-PE. The buyer's expected utility in this case amounts to

$$EU(\Lambda_B^L) = v_L - \bar{p} + \frac{v_H - v_L}{1 + \lambda}. \tag{13}$$

Instead of expecting materially efficient renegotiation, however, the buyer might as well expect renegotiation not to occur and thus to obtain a high-value service at price $\bar{p}$, i.e., $\Lambda(C) = \{(v_H, c_H, \bar{p})\} =: \Lambda_B^H$. If renegotiation indeed does not occur, the buyer neither feels a loss in the value nor in the price dimension and his utility amounts to $U(v_H, \bar{p} | \Lambda_B^H) = v_H - \bar{p}$. Despite these expectations, at the renegotiation stage the seller might offer to deliver the materially efficient service at a discount price $p^R < \bar{p}$. If the buyer accepts this offer, he obtains a lower intrinsic value, which causes him to feel a loss in the value dimension, and pays a lower price, such that his utility amounts to $U(v_L, p^R | \Lambda_B^H) = v_L - p^R - \lambda(v_H - v_L)$. Thus, the buyer accepts this offer for any price lower or equal to $p^R = \bar{p} - (1 + \lambda)(v_H - v_L)$. The seller has no incentive to deviate from the buyer's expectation if $p^R - c_L \leq \bar{p} - c_H$ or, equivalently, if the buyer's loss aversion is rather strong, i.e., if $\lambda \geq \tilde{\lambda}$ with

$$\tilde{\lambda} := \frac{c_H - c_L}{v_H - v_L} - 1. \tag{14}$$

Since renegotiation to the delivery of a worthless service never is profitable for the seller (cf. Corollary 1), $\lambda \geq \tilde{\lambda}$ not only is necessary but also sufficient for renegotiation never to take place being consistent with SP-PE. The buyer's expected utility in this case is

$$EU(\Lambda_B^H) = v_H - \bar{p}. \tag{15}$$

Finally, by Lemma 2, the buyer expecting renegotiation to result in the delivery of a worthless service, $\hat{v}_H = 0$, is incompatible with equilibrium.

As $\lambda > 0$, comparison of (13) and (15) reveals that the buyer strictly prefers the materially inefficient no-renegotiation outcome. Expecting renegotiation not to occur is consistent with equilibrium, however, only if the buyer's attachment to high value, captured by his degree of loss aversion λ, is sufficiently strong.

Proposition 1. *Consider a buyer employment contract with large acceptance set, i.e., $C = (B, \mathcal{A}, \bar{p})$ with $|\mathcal{A}| = 3$. Then $\Lambda^*(C) = \Lambda_B^L$ is always consistent with SP-PE. Moreover, in the SP-PPE, $\Lambda^*(C) = \Lambda_B^L$ if $\lambda < \tilde{\lambda}$ and $\Lambda^*(C) = \Lambda_B^H$ if $\lambda \geq \tilde{\lambda}$.*

According to Proposition 1, while always constituting a SP-PE, materially efficient renegotiation is consistent with SP-PPE only for mild degrees of loss aversion. In other words, the more loss-averse the buyer is, the less likely it is that the parties always agree upon implementing the materially efficient outcome ex post. The reason is that the buyer is exploited by the seller at the renegotiation stage in case of materially efficient renegotiation. Thus, he is better off by not expecting to renegotiate the contract with the seller in the first place. This is a credible plan, however, only if the buyer is sufficiently loss averse. If the buyer is highly loss averse, it is too costly for the seller to compensate the buyer for the reduction in value that goes along with the implementation of the materially efficient outcome.

Note that a buyer employment contract with large acceptance set achieves the maximum feasible overall surplus if $\lambda < \tilde{\lambda}$: on the one hand, there is always materially efficient trade ex post, and, on the other hand, any losses are eliminated because the buyer knows for sure that he will pay $\hat{p}_H^L$ and will obtain value v_L. Thus, partly foreshadowing our main result, if the buyer is only mildly loss averse, a buyer employment contract with large acceptance set represents an optimal contract.

Seller employment contract.— For $E = S$, if renegotiation fails or is not offered, the seller selects the service that she can deliver without cost; i.e., $(v^D(\theta, C), c^D(\theta, C)) = (0, 0)$ for all $\theta \in \Theta$.

By Lemma 2 renegotiation will always take place because the worthless service is never traded ex post. The natural candidate for contract renegotiation is materially efficient renegotiation, which in this case always constitutes the SP-PPE. Denote the buyer's corresponding expectations by $\Lambda^L(C) = \{(v_L, c_L, \hat{p}_0^L)\} =: \Lambda_S^L$. The renegotiation price equates $U(v_L, \hat{p}_0^L|\Lambda_S^L)$ with $U(0, \bar{p}|\Lambda_S^L)$, and thus is given by

$$\hat{p}_0^L \quad = \bar{p} + (1+\lambda)v_L. \tag{16}$$

Again, the seller can exploit that the buyer expects renegotiation to occur in the sense that the price mark-up exceeds the buyer's increase in intrinsic valuation. The buyer's expected utility in this case is

$$EU(\Lambda_S^L) = -\lambda v_L - \bar{p}. \tag{17}$$

Proposition 2. *Consider a seller employment contract with large acceptance set, i.e., $C = (S, \mathcal{A}, \bar{p})$ with $|\mathcal{A}| = 3$. Then $\Lambda^*(C) = \Lambda_S^L$ is always consistent with SP-PPE.*

Again partly foreshadowing our main insight, in our setup, a seller employment contract with a large acceptance set always is an optimal contract. It always leads to the implementation of the materially efficient service ex post. Furthermore, there is no uncertainty for the buyer, neither regarding the ultimate price he has to pay, nor regarding his valuation of the delivered service. Thus, the buyer does not incur a loss on the equilibrium path.

This strong finding in favor of a seller employment contract with large acceptance set is due to Assumption 1. If Assumption 1 does not hold, no renegotiation—i.e., trading the worthless service in each state at price $\bar{p}$, may be consistent with a SP-PE. Suppose the buyer expects renegotiation not to occur, i.e., $\Lambda(C) = \{(0, 0, \bar{p})\} =: \Lambda_S^0$. The buyer's expected utility in this case is

$$EU(\Lambda_S^0) = -\bar{p}, \tag{18}$$

which is higher than $EU(\Lambda_S^L)$ and $EU(\Lambda_S^H)$. Thus, whenever Λ_S^0 constitutes a credible plan, it is the buyer's most preferred plan under a seller employment contract with large acceptance set. The plan is indeed credible if and only if $\lambda \geq v_L/c_L - 1 =: \tilde{\tilde{\lambda}}$.

Proposition 3. *Suppose that $v_L \leq 2c_L$. Consider a seller employment contract with large acceptance set, i.e., $C = (S, \mathcal{A}, \bar{p})$ with $|\mathcal{A}| = 3$. Then $\Lambda^*(C) = \Lambda_S^L$ is always consistent with SP-PE. Moreover, in the SP-PPE, $\Lambda^*(C) = \Lambda_S^L$ if $\lambda < \tilde{\tilde{\lambda}}$ and $\Lambda^*(C) = \Lambda_S^0$ if $\lambda \geq \tilde{\tilde{\lambda}}$.*

Hence, if Assumption 1 is relaxed, for the seller employment contract with a large acceptance set a similar structure can be observed as for the corresponding buyer employment contract. The loss-averse buyer is exploited by the seller when renegotiation occurs. Thus, the buyer is better off by not expecting to renegotiate the contract with the seller, which is a credible plan if the buyer is sufficiently loss averse. In this case, ex post trade is materially inefficient.[12]

[12] If we keep Assumption 1 but relax Assumption 2, then Proposition 3 still holds. Now, however $\tilde{\tilde{\lambda}} > 1$. Recall that Assumptions 1 and 2 have to be jointly satisfied to rule out that the worthless service is traded ex post. If one of the two assumptions is violated, renegotiation does not take place for the worthless default outcome if the buyer is sufficiently loss averse.

3.3. Some Further Helpful Observations

Under a sales contract or an employment contract with a medium acceptance set there are ex ante several potential default outcomes. Therefore, it is necessary to establish some further (rather technical) results that will allow to put a great deal of additional structure on the following analysis.

First, the buyer cannot rationally expect renegotiation from a worthless service to the low-value service to occur at a lower mark-up price than renegotiation from the low-value service to a high-value service. This is because, according to Assumption 1, the increase in value is higher when switching from a worthless service to the low-value service than when switching from the low-value service to a high-value service.

Lemma 3. *In any SP-PE, for any $C \in \mathcal{C}$, if $\hat{v}_0(C) = v_L$ and $\hat{v}_L(C) = v_H$, then $\hat{p}_L(C) < \hat{p}_0(C)$.*

Second, the buyer's expectation regarding the material value after renegotiation is monotonic in the material value of the default outcome; i.e., a default outcome with a higher material value is always expected to be renegotiated to a service with a weakly higher ex post value than a default outcome with a lower material value.

Lemma 4. *Generically, in any SP-PE, (i) $\hat{v}_L(C) \leq \hat{v}_H(C)$ for a buyer employment contract with medium acceptance set, (ii) $\hat{v}_0(C) \leq \hat{v}_L(C)$ for a seller employment contract with medium acceptance set, and (iii) $\hat{v}_0(C) \leq \hat{v}_L(C) \leq \hat{v}_H(C)$ for a sales contract.*

3.4. Renegotiation under a Sales Contract

Suppose the buyer accepted a sales contract, i.e., $C = (E, \mathcal{A}, \bar{p})$ with $|\mathcal{A}| = 1$. Now, any of the three value-cost combinations can occur as default outcome. The buyer thus has to form expectations regarding the outcome of renegotiation for three situations; first, if the default is the worthless outcome $(0, 0)$; second, if the default is the materially efficient low-value/low-cost outcome (v_L, c_L); third, if the default is the high-value/high-cost outcome (v_H, c_H).[13] Lemmas 2 and 4 leave us with four sets of expectations to consider.

First, suppose the buyer expects renegotiation always to lead to provision of the materially efficient service, i.e.,

$$\Lambda(C) = \{(v_L, c_L, \hat{p}_0^{LLL}), (v_L, c_L, \bar{p}), (v_L, c_L, \hat{p}_H^{LLL})\} =: \Lambda^{LLL} \tag{19}$$

Regarding the trade price, the buyer expects to obtain a discount in comparison to the price specified in the original contract if $v^D(\theta, C) = v_H$, i.e., $\hat{p}_H^{LLL} < \bar{p}$. On the other hand, he expects to be charged a mark-up if $v^D(\theta, C) = 0$, i.e., $\hat{p}_0^{LLL} > \bar{p}$. With the seller having all the bargaining power at the renegotiation stage, the consistent prices are pinned down

[13] Formally, the buyer's set of expectations comprises three value-cost-price triplets, $\Lambda(C) = \{(\hat{v}_0(C), \hat{c}_0(C), \hat{p}_0(C)), (\hat{v}_L(C), \hat{c}_L(C), \hat{p}_L(C)), (\hat{v}_H(C), \hat{c}_H(C), \hat{p}_H(C))\}$.

$U(v_L, \hat{p}_0^{LLL}|\Lambda^{LLL}) = U(0, \bar{p}|\Lambda^{LLL})$ and $U(v_L, \hat{p}_H^{LLL}|\Lambda^{LLL}) = U(v_H, \bar{p}|\Lambda^{LLL})$. Thus, the renegotiation prices for the high-value default and the worthless default are

$$\hat{p}_H^{LLL} = \bar{p} - \frac{v_H - v_L}{1 + \lambda Q_H} \tag{20}$$

$$\text{and} \quad \hat{p}_0^{LLL} = \bar{p} + \frac{(1+\lambda)\, v_L}{1 + \lambda(Q_L + Q_H)}, \tag{21}$$

respectively.

Again, we observe that loss aversion creates scope for the seller to exploit the buyer during renegotiation. First, expecting a price concession in case of a high-value default outcome makes the buyer accept a price concession that falls short of the actual reduction in value, $\bar{p} - \hat{p}_H^{LLL} < v_H - v_L$. Second, due to the buyer's attachment to value v_L, the renegotiated mark-up in case of a worthless default outcome also exceeds the buyer's actual increase in value, $\hat{p}_0^{LLL} - \bar{p} > v_L$.

If the buyer expects renegotiation always to result in materially efficient trade, there is no scope for the seller to profitably deviate from the buyers expectations. The buyer's expected utility under materially efficient renegotiation is

$$EU(\Lambda^{LLL}) \;=\; v_L - \bar{p} - Q_0(1+\lambda)v_L + Q_H \frac{1 - \lambda(1 - Q_H)}{1 + \lambda Q_H} (v_H - v_L). \tag{22}$$

Materially efficient renegotiation is not always consistent with SP-PPE. Suppose that the buyer expects the worthless default outcome to be renegotiated to the provision of the materially efficient service at a positive mark-up and renegotiation not to occur in the two other cases. Let these expectations be denoted by

$$\Lambda(C) = \{(v_L, c_L, \hat{p}_0^{LLH}), (v_L, c_L, \bar{p}), (v_H, c_H, \bar{p})\} =: \Lambda^{LLH}, \tag{23}$$

where $\bar{p} < \hat{p}_0^{LLH}$. The buyer's price expectations are pinned down by $U(v_L, \hat{p}_0^{LLH}|\Lambda^{LLH}) = U(0, \bar{p}|\Lambda^{LLH})$, which can be solved for

$$\hat{p}_0^{LLH} = \bar{p} + \frac{1+\lambda}{1 + \lambda(Q_L + Q_H)}\, v_L. \tag{24}$$

Again, the mark-up in prices is higher than the actual increase in value, $\hat{p}_0^{LLH} - \bar{p} \geq v_L$, i.e., the buyer is exploited because of his attachment with regard to the value dimension. If $v^D(\theta, C) = v_H$, however, the seller might possibly benefit from deviating from the buyer's expectations by offering provision of the materially efficient service at a discount price. The seller refrains from offering renegotiation to the efficient service if and only if the buyer is fairly loss averse, i.e., $\lambda \geq 3\tilde{\lambda}$, where $\tilde{\lambda}$ is defined by (14). The buyer's expected utility under expectations Λ^{LLH} is

$$EU(\Lambda^{LLH}) \;=\; v_L - \bar{p} - Q_0(1+\lambda)v_L + Q_H[1 - \lambda(1 - Q_H)](v_H - v_L). \tag{25}$$

Regarding the two sets of expectations considered so far, what is the buyer's preferred plan consistent with subsequent equilibrium play? Comparison of (22) and (25) reveals that the buyer prefers less variation in prices, as embodied by expectations Λ^{LLH}, over stability in the value dimension at a low level, as embodied by expectations Λ^{LLL}, whenever the former expectations are consistent with SP-PE, i.e., whenever $\lambda \geq 3\tilde{\lambda}$.

Finally, there are two further sets of expectations in accordance with Lemmas 2 and 4: first, the buyer expects to always obtain the high-value service, $\Lambda(C) = \Lambda^{HHH}$; second, the buyer expects to obtain the low-value service if $v^D(\theta, C) = 0$ and the high-value service otherwise, $\Lambda(C) = \Lambda^{LHH}$. These expectations, however, are never part of the SP-PPE.

Proposition 4. *Consider a sales contract, i.e., $C = (E, \mathcal{A}, \bar{p})$ with $|\mathcal{A}| = 1$. Then $\Lambda^*(C) = \Lambda^{LLL}$ is always consistent with SP-PE. Moreover, in the SP-PPE, $\Lambda^*(C) = \Lambda^{LLL}$ if $\lambda < 3\tilde{\lambda}$ and $\Lambda^*(C) = \Lambda^{LLH}$ for $\lambda \geq 3\tilde{\lambda}$.*

3.5. Renegotiation under Employment Contracts with a Medium Acceptance Set

Under a contract $C = (E, \mathcal{A}, \bar{p})$ with a medium acceptance set, i.e., with $|\mathcal{A}| = 2$, two default outcomes are possible, such that the buyer's expectations regarding the outcome of renegotiation comprise two value-cost-price triplets. Specifically, for a buyer employment contract, the buyer has to form expectations regarding the final outcome if the default is the low-value/low-cost outcome and if it is the high-value/high-cost outcome. Under a seller employment contract, the buyer forms expectations regarding the final outcome for the case that the default is the worthless outcome or it is the low-value/low-cost outcome.[14]

As the outcome of renegotiation under an employment contract with a medium acceptance set qualitatively resembles the outcome of renegotiation under the corresponding employment contract with a large acceptance set, we state the following result without further derivation.

Proposition 5.

(i) Consider a buyer employment contract with medium acceptance set, i.e., $C = (B, \mathcal{A}, \bar{p})$ with $|\mathcal{A}| = 2$. Then $\Lambda^*(C) = \Lambda_B^{LL} := \{(v_L, \bar{p}), (v_L, \hat{p}_H^{LL})\}$ is always consistent with SP-PE. Moreover, in the SP-PPE, $\Lambda^*(C) = \Lambda_B^{LL}$ if $\lambda < \frac{3}{2}\tilde{\lambda}$ and $\Lambda^*(C) = \Lambda_B^{LH} := \{(v_L, \bar{p}), (v_H, \bar{p})\}$ if $\lambda \geq \frac{3}{2}\tilde{\lambda}$.

(ii) Consider a seller employment contract with medium acceptance set, i.e., $C = (S, \mathcal{A}, \bar{p})$ with $|\mathcal{A}| = 2$. In the SP-PPE, $\Lambda^*(C) = \Lambda_S^{LL} := \{(v_0, \hat{p}_0^{LL}), (v_L, \bar{p})\}$ for all λ.

A seller employment contract with a medium acceptance set ensures that the materially efficient good is always traded ex post. If the buyer is only mildly loss averse, materially efficient trade takes also always place under a buyer employment contract with medium acceptance set. As we will see next, however, these contracts (just like the sales contract) are not optimal because they lead to variations in prices caused by the uncertain default outcome. Due to the uncertainty in the price dimension the buyer ex ante expects to incur losses, which reduces the ex ante expected surplus from contracting below the maximum achievable surplus.

[14]Formally, for $E = B$ we have $\Lambda(C) = \{(\hat{v}_L(C), \hat{c}_L(C), \hat{p}_L(C)), (\hat{v}_H(C), \hat{c}_H(C), \hat{p}_H(C))\}$ and for $E = S$ we have $\Lambda(C) = \{(\hat{v}_0(C), \hat{c}_0(C), \hat{p}_0(C)), (\hat{v}_L(C), \hat{c}_L(C), \hat{p}_L(C))\}$.

3.6. The Optimal Long-Term Contract

At date 0, the seller makes a take-it-or-leave-it contract offer $C \in \mathcal{C}$ to the buyer. Correctly anticipating the buyer's preferred credible plan regarding renegotiation following this initial contract offer, the price $\bar{p}$ will equate the buyer's expected utility from the perspective of date 1 with his outside option $\bar{u}^B$. The seller thus acts as residual claimant and receives the generated joint surplus, which comprises the seller's expected profit plus the buyer's expected utility (including expected losses) minus the buyer's outside option. In other words, the most attractive long-term contract pursues ex post material efficiency and minimizes the buyer's expected losses associated with renegotiation. As outlined above, this can be achieved only by employment contracts with a large acceptance set. For $|\mathcal{A}| = 3$, the trade price which equates the buyer's expected utility under his preferred plan with his outside option is

$$\bar{p}_B^* = v_L + \frac{v_H - v_L}{1+\lambda} - \bar{u}^B \quad \text{and} \quad \bar{p}_S^* = -\lambda v_L - \bar{u}^B \tag{26}$$

for the buyer and the seller employment contract, respectively.

Proposition 6. *In the SP-PPE, the seller offers a contract $C = (E, \mathcal{A}, \bar{p}_E^*)$ with $|\mathcal{A}| = 3$, where $E \in \{S, B\}$ if $\lambda < \tilde{\lambda}$ and $E = S$ if $\lambda \geq \tilde{\lambda}$.*

Under the standard approach of the incomplete contracting literature, i.e., with a loss-neutral buyer, each form of long-term contract is optimal irrespective of the size of the acceptance set or which party is designated to choose (cf. Observation 1). In particular, also a sales contract is optimal. According to Proposition 6, with a loss-averse buyer, in contrast, only employment contracts with a sufficiently large acceptance set prevail in equilibrium—e.g., employment relationships with a maximum degree of discretion in form of a complete acceptance set. Thus, our theory provides a rationale for the employment relationship if renegotiation is feasible even in the absence of non-contractible investments. Keep in mind that the strict optimality of a seller-employment contract with a large acceptance set is due to Assumption 1. If we relax Assumption 1, the seller employment contract is not necessarily optimal for high degrees of loss aversion. In a more general model, for high degrees of buyer loss aversion, we cannot expect that the parties can achieve both material efficiency and no losses.

The comparison of employment contracts and sales contracts goes back to Simon (1951). While both forms of contractual arrangement fix a trade price, the former leaves a lot of discretion to the "employer" to tell the "employee" ex post which specification of the service will be traded, whereas the latter also specifies the nature of the service ex ante. According to Simon, the advantage of the first is its flexibility, which allows for the delivered service to be efficiently adjusted to the state of the world. On the other hand, this flexibility, which is absent under a sales contract, at the same time makes the employment contract prone to abuse by the employer, who will be tempted to choose his/her most preferred service instead of the efficient service. This trade-off in the choice of the optimal long-term contract, however, disappears if Coasian bargaining is feasible ex post—i.e., if the parties can renegotiate the initial contract (Gibbons, 2005). In our setup, the advantage of an employment contract is indeed rooted in its flexibility. The channel through which this flexibility benefits the trading relationship goes beyond ensuring materially efficient trade—remember that if the buyer is only mildly loss averse, the materially efficient outcome is implemented under a sales contract as well. The advantage of the employment contract rather is that it makes the default outcome under renegotiation deterministic and thereby achieves to eliminate any losses in value or prices otherwise incurred by the buyer. Nevertheless, if one picks the "wrong" employment contract, then also abuse as discussed by Simon appears in our setting. Under a buyer employment contract, if the buyer is highly loss averse, he picks an inefficient high-value/high-cost service and is unwilling to renegotiate away from this outcome. In this case, the seller always has to provide one of the very costly services and therefore is—in a sense—abused by the buyer.

4. Non-Contractible Investments and the Hold-up Problem

In a next step, we augment our model by allowing the buyer to make a non-contractible investment at date 1 that increases his valuation at date 5 in the spirit of Hart and Moore (1988). Investment $I \in \{0, 1\}$ is associated with cost ψI for the buyer, where $\psi > 0$. The buyer's valuation $v_k(I)$ now depends on his investment I, where $v_k(1) \geq v_k(0)$ for all $k \in \{0, L, H\}$. The seller's cost is independent of the buyer's investment decision. We assume that the buyer's valuation from the worthless service is zero, irrespective of the investment decision; i.e., $v_0(1) = v_0(0) = 0$. Moreover, we impose the following restrictions on the buyer's valuation and the seller's cost.

Assumption 3.

(i) $v_L(I) > \max\{2c_L, v_H(I)/2\}$ *for all* $I \in \{0, 1\}$*;*

(ii) $1 < [v_L(1) - v_L(0)]/[v_H(1) - v_H(0)] < 2.$

Part (i) of the above assumption ensures that the previous Assumption 1 holds for all investment decisions. According to part (ii), the investment-induced increase in the buyer's value is larger—though not overly larger—when the materially efficient low-value service is traded rather than the materially inefficient high-value service.

At date 2, even though the investment is non-contractible, the buyer's investment choice is observed by the seller. In other words, the renegotiation offer made by the seller depends on the sunk investment choice which creates the classic hold-up problem.

Importantly, at date 1, when deciding whether to invest or not, the buyer correctly takes into account how his investment decision affects his reference point, such that he never feels a loss in the "investment cost" dimension.

In the following, we will analyze the optimal contract in the presence of non-contractible investments. We are particularly interested in whether buyer loss aversion exacerbates or mitigates the traditional hold-up problem, which manifests in socially undesirable low investment incentives.

Loss-Neutral Buyer and First-Best Investments.—The joint surplus is maximized for $I = 1$ if investing leads to an increase in joint surplus from materially efficient trade that exceeds the buyer's investment cost, i.e., if

$$\psi \leq v_L(1) - v_L(0) =: \psi^{FB}. \tag{27}$$

Due to the frictions caused by incomplete contracting, however, the buyer's investment incentives are inefficiently low. Note that with ex post trade being always efficient for $\lambda = 0$, the optimal long-term contract maximizes investment incentives for the buyer.[15] The loss-neutral buyer undertakes the investment if and only if

$$\psi \leq Q_L \psi^{FB} + Q_H \hat{\psi}, \tag{28}$$

where $\hat{\psi} := v_H(1) - v_H(0) < \psi^{FB}$. Obviously, investment incentives are maximized for a buyer employment contract with medium acceptance set, for which $Q_L = 1/3$ and $Q_H = 2/3$. From the social perspective, however, investment incentives are always too low. Specifically, under any form the initial contract may take, there is a range of investment costs ψ so that $I = 1$ is efficient but the buyer chooses $I = 0$; i.e., the hold-up problem leads to underinvestment.

Observation 2. *Suppose the buyer is not loss averse. Then, the range of investment costs for which the buyer undertakes the investment is maximized under a buyer employment contract with medium acceptance set. This type of contract thus is always an optimal long-term contract.*

4.1. Loss Aversion and the Hold-Up Problem

Next, we investigate how buyer loss aversion affects the hold-up problem. We restrict attention to relatively mild degrees of loss version so that materially efficient renegotiation always takes place under any contract and the case of a loss-neutral buyer represents a clear benchmark. Let

$$\tilde{\lambda}(I) \equiv \frac{c_H - c_L}{v_H(I) - v_L(I)} - 1, \tag{29}$$

and note that $\tilde{\lambda}(0) < \tilde{\lambda}(1)$.

Assumption 4. $\lambda < \min\{\tilde{\lambda}(0), 1\}$.

Assumption 4 ensures that materially efficient renegotiation always takes place in the SP-PPE irrespective of which contract was initially signed or which investment level was subsequently

[15] We say that a contract maximizes the buyer's investment incentives if it maximizes the range of investment costs ψ for which the buyer chooses $I = 1$.

chosen. As we will see, under Assumption 4 the optimal contract balances a trade-off between minimizing losses and creating investment incentives.[16]

From the analysis in Section 3, we know that, for a given level of investment, a buyer employment contract with large acceptance set eliminates any losses if the buyer's degree of loss aversion is moderate. Furthermore, as outlined above, for the case of a loss-neutral buyer a buyer employment contract with medium acceptance set induces the highest investment incentives. Thus, the natural candidate for the optimal contract is a buyer employment contract with either a large or a medium acceptance set. In fact, as we show in Appendix A, any other feasible contract is dominated by at least one of these two buyer employment contracts, which therefore are the focus of the following analysis.

Buyer employment contract with large acceptance set.—Given Assumption 4, in the SP-PPE, the buyer expects materially efficient renegotiation always to take place. Hence, given investment $I \in \{0, 1\}$, the buyer's expected utility is

$$EU(I|\Lambda_B^L) = v_L(I) - \bar{p} + \frac{v_H(I) - v_L(I)}{1+\lambda} - \psi I. \tag{30}$$

Straightforward comparison of $EU(1|\Lambda_B^L)$ and $EU(0|\Lambda_B^L)$ reveals that the buyer undertakes the investment if and only if

$$\psi \leq \frac{\lambda}{1+\lambda}\psi^{FB} + \frac{1}{1+\lambda}\hat{\psi} =: \psi_{B3}. \tag{31}$$

Interestingly, loss aversion in this case enhances investment incentives and thus reduces the hold-up problem, i.e., $\partial\psi_{B3}/\partial\lambda > 0$. At first glance, this might be surprising because the buyer is exploited by the seller in the SP-PE with efficient renegotiation and the price reduction the seller offers to the buyer in order to implement the materially efficient service is decreasing in the investment—cf. (12) and Assumption 3(ii). However, as becomes apparent from (30), due to the fact that the price reduction does not fully compensate for the reduction in intrinsic value, the buyer's expected gross utility is a convex combination of $v_L(\cdot)$ and $v_H(\cdot)$. Importantly, the weight placed on $v_L(\cdot)$ is increasing in the degree of loss aversion. Therefore, as the investment is more effective if low value rather than high value is traded by Assumption 3(ii), investment incentives are increasing in λ. Importantly, for $\lambda > 1/2$ we have $\psi_{B3} > (1/3)\psi^{FB} + (2/3)\hat{\psi}$; i.e. investment incentives under a buyer employment contract with large acceptance set are higher if the buyer is loss averse than maximum investment incentives for a loss-neutral buyer (created by a buyer employment contract with medium acceptance set). Yet, first-best investment incentives are never reached because the seller has all the bargaining power ex post.

For $\psi \leq \psi_{B3}$ the generated joint surplus is $S_{B3} = v_L(1) - c_L - \psi$. Hence, in this case, the buyer employment contract with large acceptance set is an optimal contract because it induces the efficient investment decision, leads to materially efficient trade, and avoids any losses.

[16]For higher degrees of loss aversion, i.e., if Assumption 4 is violated, a tradeoff regarding materially efficient trade arises. This tradeoff was at the heart of the analysis of Section 3.

Buyer employment contract with medium acceptance set.—Given Assumption 4, in the SP-PPE the buyer expects that the materially efficient service is always traded ex post, irrespective of his investment decision. Given investment $I \in \{0, 1\}$, the buyer's expected utility is

$$EU(I|\Lambda_B^{LL}) = v_L(I) - \bar{p} + \frac{6-2\lambda}{9+6\lambda}[v_H(1) - v_L(1)] - \psi I. \quad (32)$$

Comparison of $EU(1|\Lambda_B^{LL})$ and $EU(0|\Lambda_B^{LL})$ reveals that the buyer undertakes the investment if and only if

$$\psi \leq \frac{3+8\lambda}{9+6\lambda}\psi^{FB} + \frac{6-2\lambda}{9+6\lambda}\hat{\psi} =: \psi_{B2}. \quad (33)$$

Again, loss aversion mitigates the hold-up problem, i.e., $\partial\psi_{B2}/\partial\lambda > 0$. Moreover, $\psi_{B2} > \psi_{B3}$, such that the buyer employment contract with medium acceptance set leads to higher investment incentives than the buyer employment contract with large acceptance set—just as in the case with a loss-neutral buyer. Unlike to the case with a loss-neutral buyer, the employment contract with medium acceptance set now has the disadvantage that the final price is uncertain, such that the buyer expects to incur a loss. If $\psi \leq \psi_{B2}$, the generated joint surplus is

$$S_{B2} = v_L(1) - c_L - \frac{2\lambda}{9+6\lambda}[v_H(1) - v_L(1)] - \psi. \quad (34)$$

Optimal contract.—As mentioned before, it can be shown that the three remaining contracts, the sales contract and both seller employment contracts, are dominated by at least one of the two buyer employment contracts.[17] Thus, the question regarding the optimal contract boils down to a comparison of the buyer employment contract with large acceptance set and the buyer employment contract with medium acceptance set. Clearly, for $\psi \leq \psi_{B3}$ the buyer employment contract with large acceptance set is the uniquely optimal contract. For $\psi \in (\psi_{B3}, \psi_{B2}]$, however a tradeoff arises. Specifically, an efficient investment decision is ensured only by the buyer employment contract with medium acceptance set, whereas losses can be avoided only by a buyer employment contract with large acceptance set. As is intuitively plausible, inducing the efficient investment decision (via a medium acceptance set) is more important than avoiding losses (via a large acceptance set) if and only if the buyer is only moderately loss averse, i.e., if and only if

$$\lambda \leq \frac{9(\psi^{FB} - \psi)}{2[v_H(1) - v_L(1)] + 3(\psi^{FB} - \psi)} \equiv \hat{\lambda}(\psi). \quad (35)$$

Finally, if $\psi \in (\psi_{B3}, \psi_{B2}]$ and $\lambda > \hat{\lambda}(\psi)$, such that implementation of $I = 0$ with a buyer employment contract with large acceptance set is preferred over implementation of $I = 1$ with a buyer employment contract with medium acceptance set, or $\psi > \psi_{B2}$, such that implementation of $I = 0$ can not be avoided, then both buyer and seller employment contract with large acceptance set are optimal. In the latter case, the analysis essentially boils down to the previous case without investments.

[17] Strictly speaking these other contracts are only weakly dominated. For instance if $I = 0$ for any contract, then a seller employment contract with large acceptance set as well as a buyer employment contract with large acceptance set is optimal.

Now, we are ready to establish our main finding of this section.

Proposition 7. *Suppose that Assumptions 3 and 4 hold and that* $\hat{\lambda}(\psi_{B2}) \geq \min\{\tilde{\lambda}(0), 1\}$*. Then, under the optimal contract, the loss-averse buyer undertakes the investment while the loss-neutral buyer does not invest if and only if* $(1/3)\psi^{FB} + (2/3)\hat{\psi} < \psi \leq \psi_{B2}$*. For all other values of* ψ *the investment decisions under the optimal contract are independent of whether the buyer is loss averse.*

According to Proposition 7, loss aversion can mitigate the traditional hold-up problem. There is a range of investment costs where it is efficient to undertake the investment but in equilibrium the buyer undertakes the investment only if he is (sufficiently) loss averse. Proposition 7 is illustrated in Figure 2.

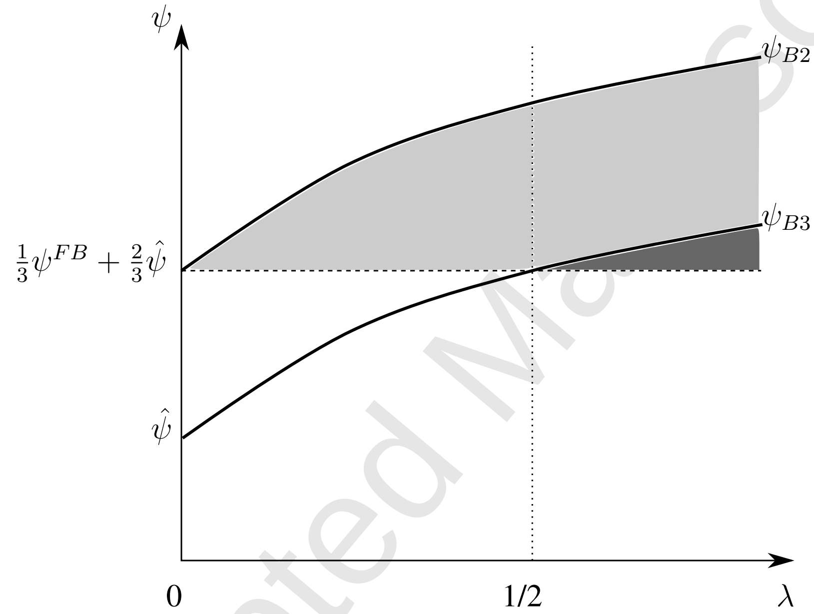

Figure 2: Investment thresholds

In the benchmark case of a loss-neutral buyer, the buyer undertakes the investment in equilibrium only if $\psi \leq (1/3)\psi^{FB} + (2/3)\hat{\psi}$. If, on the other hand, the buyer is loss averse, he undertakes the investment in equilibrium as long as $\psi \leq \hat{\psi}_{B2}$. In other words, in both the light-gray shaded area and the dark-gray shaded area, the buyer undertakes the investment only if he is loss averse. In the light-gray shaded area a buyer employment contract with medium acceptance set is optimal, whereas in the dark gray-shaded area a buyer employment contract with large acceptance set is optimal. Finally, note that loss aversion may enhance not only the level of investment, but also overall efficiency. This is easiest to see for the dark-gray shaded area. Here, if the buyer is loss averse, the first-best outcome is achieved. If the buyer is loss neutral, on the other hand, the investment decision is inefficient, i.e., $I = 0$. This is a crucial difference to Herweg and Schmidt (2015), where the investment decision is independent of the degree of loss aversion and the overall surplus is always decreasing in the degree of loss aversion.

Higher degrees of loss aversion.—We conclude this section by briefly discussing how loss aversion affects investment incentives if $\lambda > \tilde{\lambda}(0)$. For the sake of the argument, we focus on a buyer employment contract with large acceptance set. A similar pattern arises also for a buyer employment contract with medium acceptance set and for the sales contract.

For an intermediate degree of loss aversion, $\tilde{\lambda}(0) \le \lambda < \tilde{\lambda}(1)$, renegotiation takes place only if the buyer undertakes the investment. Otherwise the high-value service is always traded. By (13) and (15), the buyer prefers to invest if

$$\psi \le \frac{1}{1+\lambda}\psi^{FB} + \frac{\lambda}{1+\lambda}\hat{\psi} - \frac{\lambda}{1+\lambda}[v_H(0) - v_L(0)]. \tag{36}$$

It follows that for an intermediate degree of loss aversion investment incentives decline if the buyer becomes slightly more loss averse.

For a strong degree of loss aversion, $\lambda \ge \tilde{\lambda}(1)$, a high-value services is always traded irrespective of whether the buyer undertakes the investment. Hence, by (15), the buyer invests if $\psi \le \hat{\psi}$.

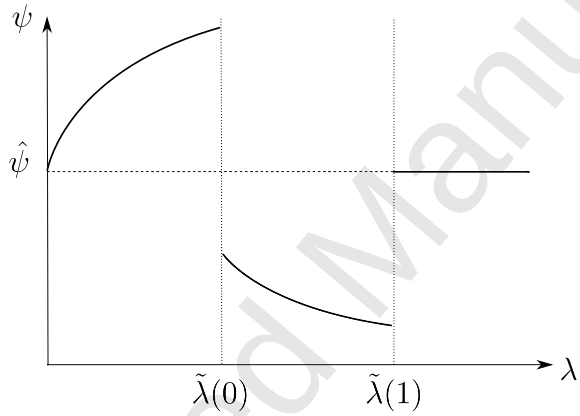

Figure 3: Critical investment cost for a large acceptance set

The investment cost threshold that governs the buyer's investment decision is depicted in Figure 3 as a function of the buyer's degree of loss aversion. The intuition behind the downward discontinuity at $\tilde{\lambda}(0)$ is as follows: The buyer always prefers no renegotiation to occur over materially efficient renegotiation because in the latter case the seller exploits the buyer's loss aversion ex post. Expecting no renegotiation to take place, however, is not always a credible plan—in particular, if the buyer invests, he is always willing to renegotiate to the materially efficient service because the investment increases the buyer's value from materially efficient trade more than it increases his value from a high-value service. In other words, not undertaking the investment is a commitment for the buyer not to renegotiate the contract ex post, which protects him from ex post opportunism by the seller.

5. Extensions and Robustness

Admittedly, regarding several aspects, our model is fairly stylized. But even solving this simple model requires an involved case-by-case analysis. However, many of the simplifying assumptions are imposed in order to reduce the number of case distinctions and are not crucial for our main findings.

Loss-averse seller.—Assuming that, next to the buyer, the seller is also expectation-based loss averse does not change the main insights. A loss-averse seller cares about reducing variations in prices and costs. Both kinds of variations are minimized for employment contracts with large acceptance sets. In other words, if the seller is also loss averse, the ex ante optimal contract balances not only materially efficiency and the buyer's expected losses but also the seller's expected losses. Note that in our setup, the buyer's expected losses are reduced by a stable default outcome. A stable default outcome also reduces the seller's expected losses ex ante and thus the two goals of minimizing the buyer's losses and minimizing the seller's losses are aligned ex ante. Moreover, if the parties have signed a sales contract and both parties expect materially efficient trade, offering materially efficient trade is in the seller's interest: the seller exploits the buyer's expectations because she has all the bargaining power. The seller now, however, suffers from the variations in ex post prices and therefore might prefer to expect that material efficient renegotiation does not take place. Thus, if both parties are loss averse, it is more "likely" that the ex post outcome is materially inefficient.

Note that the interesting effects in our model arise because the seller, who has all the bargaining power at the renegotiation stage, may exploit the buyer's loss aversion. When expecting not to renegotiate the contract ex post, the buyer is less vulnerable to exploitation by the seller ex post. This main driver exists, irrespective of whether the seller is also loss averse or not.

Allowing for both parties to be expectation-based loss averse, however, triggers a methodological problem: there does not exist an equilibrium concept for these kind of games. We need to define mutually consistent personal equilibria and have to establish that these kinds of equilibria always exist. A general analysis of expectation-based loss aversion in games, however, is beyond the scope of this paper.[18]

Buyer has bargaining power ex post.—The seller can always make take-it-or-leave-it offers to the buyer. For initial contracting, the distribution of bargaining power does not play a crucial role because the parties will always agree to write a contract that maximizes the joint surplus of both parties including potential losses. Therefore, the type of the concluded contract is independent of the ex ante bargaining power, only the initially specified price—which divides the expected surplus between the two parties—depends on it. The distribution of the bargaining power ex post, however, has an impact on the optimal long-term contract. As we have outlined above, the interesting effects arise because the loss-averse party can be exploited at the renegotiation stage, which requires that the loss-averse party does not have too much bargaining power. In the paper, we consider the extreme where the buyer is loss averse and the seller has all the bargaining power. If the buyer remains the only loss-averse party but has all the bargain-

[18]For a first attempt in this direction see Dato, Grunewald, Müller, and Strack (2017), who provide a general account of the strategic behavior of expectation-based loss-averse players in non-cooperative games.

ing power at the renegotiation stage, materially efficient renegotiation will always take place. If, on the other hand, the seller is loss averse and the buyer can make a take-it-or-leave-it offer, materially efficient trade does not always take place in the SP-PPE. With the buyer exploiting that the seller expects the contract to be renegotiated, it can be optimal and credible for the seller to expect that renegotiation does not always take place.

From a technical point of view, considering less extreme distributions of the bargaining power at the renegotiation stage—say, each party can make a take-it-or-leave-it offer with some probability—would increase the number of cases tremendously. In this case, expectations regarding the outcome of renegotiation would depend not only on the default outcome but also on which party is allowed to make the renegotiation offer.

Risk-averse buyer.—The reader might wonder to what extent loss aversion is different from risk aversion within the expected utility framework. A risk-averse buyer would also benefit from a contract that reduces ex post variations. Nevertheless, there are some important differences between a risk-averse and an expectation-based loss-averse buyer. Suppose the buyer is risk averse with utility function $V(v - p)$, where $V(\cdot)$ is increasing and concave. In this case, it can easily be seen that the materially efficient good is always traded ex post independent of the initial long-term contract. With an expectation-based loss-averse buyer, we do not predict materially efficient trade ex post for most cases—only in particular environments and even then only under the optimal contract. This is a crucial and testable difference.

As for the case with a loss-averse buyer, an employment contract with complete acceptance set minimizes the variations in $\hat{v} - \hat{p}$, which is desirable also for a risk-averse buyer, and in turn maximizes the ex ante surplus of the two parties. The reason for the parties to select an employment contract if the buyer is risk averse is solely to ensure optimal risk sharing. While a risk-averse buyer is always indifferent between a buyer employment contract and a seller employment contract, a loss-averse buyer evaluates these contracts differently. Therefore, if the buyer is loss averse, the parties conclude an employment contract not only in order to reduce the risk the buyer is exposed to, but also to maximize the material gains from trade realized ex post.

Broad Bracketing.—Following Tversky and Kahneman (1991) and Kőszegi and Rabin (2006), we assumed that the buyer evaluates losses separately in the "money" and the "value" dimension, so-called narrow bracketing (Tversky and Kahneman (1991) coined this assumption *decomposability*). Alternatively, the buyer could evaluate the joint outcome $v - p$ and feel the sensation of a loss if this joint outcome falls short of his expected outcome $\hat{v} - \hat{p}$, so-called broad bracketing. Broad bracketing is highly similar to standard risk aversion, which we discussed above. In particular, with broad bracketing, the materially efficient service is always traded ex post.

6. Conclusion

In this paper, we analyzed a simple trading relationship between a loss-averse buyer and a profit-maximizing seller. The model is in the spirit of Simon (1951)'s seminal contribution; i.e., we analyzed contractual adjustments and the employment relationship. We showed that, independent of the type of the concluded contract, if the loss-averse buyer expects the contract to be renegotiated, this can be exploited by the seller. The seller can exploit the buyer's attachment to the expected outcome and thus, for instance, convince the buyer to renegotiate to a service which gives him a higher gross surplus at a price mark-up that exceeds his increase in gross surplus. In other words, we identify a new kind of hold-up problem which is caused by the interplay of incomplete contracts and expectation-based loss aversion. This exploitation is anticipated by the buyer, whose—if being highly loss averse—preferred and also credible plan is not always to renegotiate. If this is the case, loss aversion may lead to material inefficiencies ex post.

In a second step, we introduced relationship specific investments in the spirit of Hart and Moore (1988). Here, we showed that loss aversion can mitigate the traditional hold-up problem. We identified cases, where—under the respective optimal contract—only a sufficiently loss-averse buyer undertakes the investment and this is also desirable from a welfare point of view.

In summary, we established that expectation-based loss aversion, on the one hand, can lead to a new kind of hold-up problem if the parties have to rely on incomplete contracts and thus contract renegotiation in order to implement the efficient service. On the other hand, it can mitigate the classic hold-up problem caused by non-contractible investments.

A. Proofs of Propositions and Lemmas

To ease the exposition, we suppress the dependency of Q_k on E and $\mathcal{A}$ as well as the dependency of $\hat{v}_k$, $\hat{c}_k$, and $\hat{p}_k$ on C throughout the Appendix.

Proof of Lemma 2. Let

$$\mathbf{1}_{\{k\to j\}} = \begin{cases} 1 & \text{if } \hat{v}_k = v_j \\ 0 & \text{otherwise} \end{cases} \tag{A.1}$$

denote an indicator function which takes the value one if the buyer expects default outcome (v_k, c_k), $k \in \{0, L, H\}$, to be renegotiated to outcome (v_j, c_j), $j \in \{0, L, H\}$, and which takes the value zero if the buyer expects default outcome (v_k, c_k) not to be renegotiated to outcome (v_j, c_j). By Lemma 1, $\sum_{j\in\{0,L,H\}} \mathbf{1}_{\{k\to j\}} = 1$. Furthermore, let $\hat{p}_{\{k\to j\}}$ denote the buyer's expectation regarding the trade price in case that default outcome (v_k, c_k) to be renegotiated to outcome (v_j, c_j). With this notation, if the buyer holds overall expectations Λ, his utility from obtaining value v at price p is

$$U(v, \bar{p}|\Lambda) = v - p - \lambda \sum_{k\in\{0,L,H\}} \sum_{j\in\{0,L,H\}} Q_k \mathbf{1}_{\{k\to j\}} \left([v_j - v]^+ + [p - \hat{p}_{\{k\to j\}}]^+\right). \tag{A.2}$$

Here, as well as in the rest of the Appendix, we suppress the dependency of Q_k on E and $|\mathcal{A}|$ for the sake of exposition. The proof, which proceeds by contradiction, is organized in two steps. First, we show that $\mathbf{1}_{\{0\to 0\}} = 1$ is incompatible with SP-PE, i.e., in any SP-PE a worthless default outcome is renegotiated to the provision of a valuable service. Second, we show that $\mathbf{1}_{\{k\to 0\}} = 1$ is incompatible with SP-PE for $k \in \{L, H\}$, i.e., it will never happen in a SP-PE that a valuable default outcome is renegotiated to the provision of a worthless service.

(i) Suppose there exists a SP-PE in which the buyer expects the worthless outcome not to be renegotiated, i.e., $\mathbf{1}_{\{0\to 0\}} = 1$ and $\hat{p}_{\{0\to 0\}} = \bar{p}$. In case of the realization of a worthless default outcome, suppose the seller offers materially efficient renegotiation at price $p^R > 0$ instead of adhering to the buyer's expectations. The buyer is willing to accept this renegotiation offer if

$$\begin{aligned} U(v_L, p^R|\Lambda) = {} & v_L - p^R - \lambda\left(Q_H\mathbf{1}_{\{H\to H\}} + Q_L\mathbf{1}_{\{L\to H\}}\right)[v_H - v_L] - \lambda Q_0[p^R - \bar{p}] \\ & - \lambda Q_H\left(\mathbf{1}_{\{H\to H\}}[p^R - \bar{p}] + \mathbf{1}_{\{H\to L\}}[p^R - \hat{p}_{\{H\to L\}}] + \mathbf{1}_{\{H\to 0\}}[p^R - \hat{p}_{\{H\to 0\}}]\right) \\ & - \lambda Q_L\left(\mathbf{1}_{\{L\to H\}}[p^R - \hat{p}_{\{L\to H\}}]^+ + \mathbf{1}_{\{L\to L\}}[p^R - \bar{p}] + \mathbf{1}_{\{L\to 0\}}[p^R - \hat{p}_{\{L\to 0\}}]\right) \end{aligned} \quad \text{(A.3)}$$

(at least weakly) exceeds

$$\begin{aligned} U(v_0, \bar{p}|\Lambda) = {} & v_0 - \bar{p} - \lambda\left(Q_H\mathbf{1}_{\{H\to H\}} + Q_L\mathbf{1}_{\{L\to H\}}\right)v_H - \lambda\left(Q_H\mathbf{1}_{\{H\to L\}} + Q_L\mathbf{1}_{\{L\to L\}}\right)v_L \\ & - \lambda Q_H\left(\mathbf{1}_{\{H\to L\}}[\bar{p} - \hat{p}_{\{H\to L\}}] + \mathbf{1}_{\{H\to 0\}}[\bar{p} - \hat{p}_{\{H\to 0\}}]\right) - \lambda Q_L\mathbf{1}_{\{L\to 0\}}[\bar{p} - \hat{p}_{\{L\to 0\}}], \end{aligned} \quad \text{(A.4)}$$

or, equivalently,

$$\begin{aligned} p^R \le {} & \bar{p} + v_L + \lambda\left(Q_H(\mathbf{1}_{\{H\to H\}} + \mathbf{1}_{\{H\to L\}}) + Q_L(\mathbf{1}_{\{L\to H\}} + \mathbf{1}_{\{L\to L\}})\right)v_L \\ & - \lambda\left(Q_0 + Q_L(\mathbf{1}_{\{L\to L\}} + \mathbf{1}_{\{L\to 0\}}) + Q_H\right)[p^R - \bar{p}] - \lambda Q_L\mathbf{1}_{\{L\to H\}}[p^R - \hat{p}_{\{L\to H\}}]^+ \end{aligned} \quad \text{(A.5)}$$

The seller's optimal price offer, p^{R^*}, makes (A.5) just hold with equality. Since $\hat{p}_{L\to H} > \bar{p}$, we have $[p^R - \hat{p}_{\{L\to H\}}]^+ < p^R - \bar{p}$, it holds that

$$p^{R^*} > \bar{p} + v_L - (1+\lambda)[p^{R^*} - \bar{p}] \iff p^{R^*} > \bar{p} + \frac{v_L}{1+\lambda}. \quad \text{(A.6)}$$

From (A.6), together with Assumption 1, we obtain

$$p^{R^*} - c_L > \bar{p}, \quad \text{(A.7)}$$

i.e., the seller's profit from this deviation strictly exceeds her profit from adhering to the buyer's expectations. This, however, is incompatible with SP-PE, a contradiction.

(ii) Suppose there exists a SP-PE in which the buyer expects that a valuable default outcome will be renegotiated to a worthless service, i.e., $\mathbf{1}_{\{k\to 0\}} = 1$ and $\hat{p}_{\{k\to 0\}} < \bar{p}$ for $k \in \{L, H\}$. Moreover, from step (i), we have $\mathbf{1}_{\{0\to 0\}} = 0$. For this to be consistent with SP-PE, the buyer expects to be indifferent between rejecting the seller's renegotiation offer, i.e., $U(v_0, \hat{p}_{\{k\to 0\}}|\Lambda) = U(v_k, \bar{p}|\Lambda)$, where

$$\begin{aligned} U(v_0, \hat{p}_{\{k\to 0\}}|\Lambda) = {} & v_0 - \hat{p}_{\{k\to 0\}} - \lambda\left(Q_H\mathbf{1}_{\{H\to H\}} + Q_L\mathbf{1}_{\{L\to H\}} + Q_0\mathbf{1}_{\{0\to H\}}\right)v_H \\ & - \lambda\left(Q_H\mathbf{1}_{\{H\to L\}} + Q_L\mathbf{1}_{\{L\to L\}} + Q_0\mathbf{1}_{\{0\to L\}}\right)v_L - \lambda Q_L\mathbf{1}_{\{L\to 0\}}[\hat{p}_{\{k\to 0\}} - \hat{p}_{\{L\to 0\}}]^+ \\ & - \lambda Q_H\left(\mathbf{1}_{\{H\to L\}}[\hat{p}_{\{k\to 0\}} - \hat{p}_{\{H\to L\}}]^+ + \mathbf{1}_{\{H\to 0\}}[\hat{p}_{\{k\to 0\}} - \hat{p}_{\{H\to 0\}}]^+\right). \end{aligned} \quad \text{(A.8)}$$

In case of the realization of default outcome (v_k, c_k), suppose the seller offers materially efficient renegotiation at price p^R instead of adhering to the buyer's expectations and offering the provision of a worthless service. Since default outcome v_k is itself valuable, i.e., $k \in \{L, H\}$, provision of the materially efficient service has to come along with a (weak) price reduction, i.e., $p^R \leq \bar{p}$. For the buyer to accept the seller's renegotiation offer, we must have $U(v_L, p^R|\Lambda) \geq U(v_k, \bar{p}|\Lambda)$, where

$$\begin{aligned} U(v_L, p^R|\Lambda) &= v_L - p^R - \lambda \left(Q_H \mathbf{1}_{\{H\to H\}} + Q_L \mathbf{1}_{\{L\to H\}} + Q_0 \mathbf{1}_{\{0\to H\}}\right)[v_H - v_L] \\ &- \lambda Q_L \mathbf{1}_{\{L\to 0\}}[p^R - \hat{p}_{\{L\to 0\}}]^+ - \lambda Q_H \left(\mathbf{1}_{\{H\to L\}}[p^R - \hat{p}_{\{H\to L\}}]^+ + \mathbf{1}_{\{H\to 0\}}[p^R - \hat{p}_{\{H\to 0\}}]^+\right). \end{aligned} \tag{A.9}$$

The seller's most profitable price to offer in renegotiation, p^{R^*}, makes the buyer just indifferent between accepting and rejecting the seller's offer, i.e., $U(v_L, p^{R^*}|\Lambda) = U(v_k, \bar{p}|\Lambda)$. Then, with $U(v_L, p^{R^*}|\Lambda) = U(v_0, \hat{p}_{\{k\to 0\}}|\Lambda)$, we have

$$\begin{aligned} p^{R^*} &= \hat{p}_{\{L\to 0\}} + v_L \\ &+ \lambda \left(Q_H(\mathbf{1}_{\{H\to H\}} + \mathbf{1}_{\{H\to L\}}) + Q_L(\mathbf{1}_{\{L\to H\}} + \mathbf{1}_{\{L\to L\}}) + Q_0(\mathbf{1}_{\{0\to H\}} + \mathbf{1}_{\{0\to L\}})\right) v_L \\ &- \lambda Q_L \mathbf{1}_{\{L\to 0\}} \left([p^R - \hat{p}_{\{L\to 0\}}]^+ - [\hat{p}_{\{k\to 0\}} - \hat{p}_{\{L\to 0\}}]^+\right) \\ &- \lambda Q_H \mathbf{1}_{\{H\to L\}} \left([p^R - \hat{p}_{\{H\to L\}}]^+ - [\hat{p}_{\{k\to 0\}} - \hat{p}_{\{H\to L\}}]^+\right) \\ &- \lambda Q_H \mathbf{1}_{\{H\to 0\}} \left([p^R - \hat{p}_{\{H\to 0\}}]^+ - [\hat{p}_{\{k\to 0\}} - \hat{p}_{\{H\to 0\}}]^+\right). \end{aligned} \tag{A.10}$$

Note that (A.10) requires $p^{R^*} > \hat{p}_{\{k\to 0\}}$. Then, for $\tilde{p} \in \{\hat{p}_{\{L\to 0\}}, \hat{p}_{\{H\to L\}}, \hat{p}_{\{H\to 0\}}\}$, we have $[p^{R^*} - \tilde{p}]^+ - [\hat{p}_{\{k\to 0\}} - \tilde{p}]^+ = p^{R^*} - \hat{p}_{\{k\to 0\}}$ if $\hat{p}_{\{k\to 0\}} \geq \tilde{p}$ and $[p^{R^*} - \tilde{p}]^+ - [\hat{p}_{\{k\to 0\}} - \tilde{p}]^+ < p^{R^*} - \hat{p}_{\{k\to 0\}}$ if $\hat{p}_{\{k\to 0\}} < \tilde{p}$. From (A.10) it then follows that

$$p^{R^*} > \hat{p}_{\{L\to 0\}} + v_L - \lambda \left(Q_L \mathbf{1}_{\{L\to 0\}} + \lambda Q_H(\mathbf{1}_{\{H\to L\}} + \mathbf{1}_{\{H\to 0\}})\right)(p^{R^*} - \hat{p}_{\{k\to 0\}}), \tag{A.11}$$

which, in turn, implies

$$p^{R^*} > \hat{p}_{\{L\to 0\}} + \frac{v_L}{1+\lambda}. \tag{A.12}$$

Together with Assumption 1, (A.12) implies

$$p^{R^*} - c_L > \hat{p}_{\{L\to 0\}}, \tag{A.13}$$

i.e., this deviation is indeed more profitable for the seller than adhering to the buyer's expectations. This, however, is incompatible with SP-PE, a contradiction. □

Proof of Corollary 1. The proof makes use of the notation introduced in the proof of Lemma 2. Suppose the buyer holds expectations Λ potentially consistent with SP-PE, i.e., $\mathbf{1}_{\{0\to 0\}} = \mathbf{1}_{\{L\to 0\}} = \mathbf{1}_{\{H\to 0\}} = 0$. The proof proceeds in two steps: First, we show that in case of a worthless default outcome it is never profitable for the seller to deviate from the buyer's expectations by not offering renegotiation. Second, in case of a valuable default outcome it is never profitable for the seller to deviate from the buyer's expectations by offering renegotiation to the provision of a worthless service.

(i) Suppose a worthless default outcome has been realized. The buyer's utility from this default outcome is

$$U(v_0, \bar{p}|\Lambda) = v_0 - \bar{p} - \lambda \left(Q_0 \mathbf{1}_{\{0\to H\}} + Q_L \mathbf{1}_{\{L\to H\}} + Q_H \mathbf{1}_{\{H\to H\}}\right) v_H - \lambda \left(Q_0 \mathbf{1}_{\{0\to L\}} + Q_L \mathbf{1}_{\{L\to L\}} + Q_H \mathbf{1}_{\{H\to L\}}\right) v_L - \lambda Q_H \mathbf{1}_{\{H\to L\}}[\bar{p} - \hat{p}_{\{H\to L\}}]. \quad (A.14)$$

On the other hand, the buyer's utility from accepting materially efficient renegotiation at price $p^R > \bar{p}$ is

$$\begin{aligned} U(v_L, p^R|\Lambda) = v_L - p^R - \lambda \left(Q_0 \mathbf{1}_{\{0\to H\}} + Q_L \mathbf{1}_{\{L\to H\}} + Q_H \mathbf{1}_{\{H\to H\}}\right)(v_H - v_L) \\ - \left(\lambda Q_H \mathbf{1}_{\{H\to H\}} + Q_L \mathbf{1}_{\{L\to L\}}\right)[p^R - \bar{p}] \\ - \lambda Q_H \mathbf{1}_{\{H\to L\}}[p^R - \hat{p}_{\{H\to L\}}] - \lambda Q_L \mathbf{1}_{\{L\to H\}}[p^R - \hat{p}_{\{L\to H\}}]^+ \\ - \lambda Q_0 \mathbf{1}_{\{0\to L\}}[p^R - \hat{p}_{\{0\to L\}}]^+ - \lambda Q_0 \mathbf{1}_{\{0\to H\}}[p^R - \hat{p}_{\{0\to H\}}]^+ \end{aligned} \quad (A.15)$$

Proceeding in exact analogy to part the proof of (i) of Lemma 2 allows to show that the latter offer is strictly more profitable for the seller than the former.

(ii) Suppose a valuable default outcome v_k, $k \in \{L, H\}$, has been realized. The most profitable renegotiation offer the seller can make that involves provision of a worthless service comprises a price $p_0^{R^*}$ that equates $U(v_k, \bar{p}|\Lambda)$ and

$$U(v_0, p_0^{R^*}|\Lambda) = v_0 - p_0^{R^*} - \lambda \left(Q_0 \mathbf{1}_{\{0\to H\}} + Q_L \mathbf{1}_{\{L\to H\}} + Q_H \mathbf{1}_{\{H\to H\}}\right) v_H - \lambda \left(Q_0 \mathbf{1}_{\{0\to L\}} + Q_L \mathbf{1}_{\{L\to L\}} + Q_H \mathbf{1}_{\{H\to L\}}\right) v_L - \lambda Q_H \mathbf{1}_{\{H\to L\}}[p_0^{R^*} - \hat{p}_{\{H\to L\}}]. \quad (A.16)$$

Likewise, the most profitable renegotiation offer the seller can make that involves provision of materially efficient service comprises a price $p_L^{R^*}$ that equates $U(v_k, \bar{p}|\Lambda)$ and

$$U(v_L, p_L^{R^*}|\Lambda) = v_L - p_L^{R^*} - \lambda \left(Q_0 \mathbf{1}_{\{0\to H\}} + Q_L \mathbf{1}_{\{L\to H\}} + Q_H \mathbf{1}_{\{H\to H\}}\right)(v_H - v_L) - \lambda Q_H \mathbf{1}_{\{H\to L\}}[p_L^{R^*} - \hat{p}_{\{H\to L\}}]^+. \quad (A.17)$$

Proceeding in exact analogy to part (ii) of the proof of Lemma 2 allows to show that the latter offer is strictly more profitable for the seller than the former. □

Proof of Proposition 1. The proof is provided in the main text. □

Proof of Proposition 2. First, suppose that the buyer expects materially efficient renegotiation to occur, $\Lambda^L(C) = \{(v_L, c_L, \hat{p}_0^L)\} =: \Lambda_S^L$. The highest price the seller can charge so that the buyer accepts her offer—given that this price is also the buyer's reference point—solves

$$U(v_L, \hat{p}_0^L|\Lambda_S^L) = v_L - \hat{p}_0^L \; = \; 0 - \bar{p} - \lambda(v_L - 0) = U(0, \bar{p}|\Lambda_S^L). \quad (A.18)$$

Solving yields $\hat{p}_0^L = \bar{p} + (1+\lambda)v_L$. With the seller's profits amounting to $\hat{p}_0^L - c_L$, there is no profitable deviation: first, not offering renegotiation at all results in strictly lower profits equal to $\bar{p}$; second, the highest price at which the buyer would be willing to accept a high-value/high-cost service equals $p^R = \hat{p}_0^L + (v_H - v_L)/(1+\lambda)$, which results in strictly lower profits $p^R - c_H$ than offering to deliver the efficient service at price $\hat{p}_0^L$. Thus, materially efficient renegotiation is always consistent with SP-PE. The buyer's expected utility in this case is given by (17).

Next, note that the buyer expecting renegotiation not to be offered—i.e., to obtain zero value at price $\bar{p}$, cannot be an equilibrium by Lemma 2.

Finally, the buyer might expect the seller to offer renegotiation to the materially inefficient high-value/high-cost service, $\Lambda^H(C) = \{(v_H, c_H, \hat{p}_0^H)\} =: \Lambda_S^H$. The only price $\hat{p}_0^H > \bar{p}$ compatible with these expectations is

$$\hat{p}_0^H = \bar{p} + (1+\lambda)v_H. \tag{A.19}$$

Whenever these expectations are consistent with sequential rationality, which is the case for λ sufficiently large, they are consistent with SP-PE. The buyer's expected utility in this case is

$$EU(\Lambda_S^H) = -\lambda v_H - \bar{p}. \tag{A.20}$$

However, comparison of (17) and (A.20) reveals that the buyer strictly prefers materially efficient renegotiation. □

Proof of Proposition 3. Whenever Λ_S^0 constitutes a credible plan, it is the buyer's most preferred plan. For Λ_S^0 to be a credible plan, there must not be the possibility for the seller to profitably offer renegotiation to a service with strictly positive value $v \in \{v_L, v_H\}$. The buyer rejects any such offer at price p^R if

$$v - p^R - \lambda(p^R - \bar{p}) \leq -\bar{p}. \tag{A.21}$$

If the above inequality holds for the materially efficient service under the lowest possible renegotiation price the seller finds profitable to offer in this case, i.e., $v = v_L$ and $p^R = \bar{p} + c_L$, then it holds for the high-value/ high-cost service, accordingly. Thus, no renegotiation is a credible plan if and only if $\lambda \geq v_L/c_L - 1 =: \tilde{\tilde{\lambda}}$. □

Proof of Lemma 3. Considering the relevant cases of a small acceptance set and of a seller employment contract with a medium acceptance set, the proof proceeds by contradiction.

Consider an initial contract C with a small acceptance set, i.e., $|\mathcal{A}| = 1$. Suppose $\hat{v}_0 = v_L$, $\hat{v}_L = v_H$, and $\hat{p}_0 \leq \hat{p}_L$. Note that $\hat{p}_H \leq \bar{p} < \hat{p}_0$. In equilibrium, in case of a worthless default outcome, the buyer is indifferent between accepting the seller's renegotiation offer, which yields utility $U(v_L, \hat{p}_0|\Lambda(C)) = v_L - \hat{p}_0 - \lambda Q_L(v_H - v_L) - \lambda Q_H[\hat{v}_H - v_L]^+ - \lambda Q_H(\hat{p}_0 - \hat{p}_H)$, and obtaining his default outcome, which yields utility $U(0, \bar{p}|\Lambda(C)) = -\bar{p} - \lambda Q_0 v_L - \lambda Q_L v_H - \lambda Q_H \hat{v}_H - \lambda Q_H(\bar{p} - \hat{p}_H)$, such that

$$\hat{p}_0 = \bar{p} + \frac{(1 + \lambda(Q_0 + Q_L))v_L + \lambda Q_H \hat{v}_H - \lambda Q_H[\hat{v}_H - v_L]^+}{1 + \lambda Q_H}. \tag{A.22}$$

Likewise, in equilibrium, in case of a materially efficient default outcome, the buyer is indifferent between accepting the seller's renegotiation offer, which yields utility $U^B(v_H, \hat{p}_L|\Lambda(C)) = v_H - \hat{p}_L - \lambda Q_0(\hat{p}_L - \hat{p}_0) - \lambda Q_H(\hat{p}_L - \hat{p}_H)$, and obtaining his default outcome, which yields utility $U^B(v_L, \bar{p}|\Lambda(C)) = v_L - \bar{p} - \lambda Q_L(v_H - v_L) - \lambda Q_H[\hat{v}_H - v_L]^+ - \lambda Q_H(\bar{p} - \hat{p}_H)$, such that

$$\hat{p}_L = \bar{p} - \frac{\lambda Q_0}{1 - \lambda(Q_0 + Q_H)}(\hat{p}_0 - \bar{p}) + \frac{(1 + \lambda Q_L)(v_H - v_L) + \lambda Q_H[\hat{v}_H - v_L]^+}{1 + \lambda(Q_0 + Q_H)}. \quad \text{(A.23)}$$

Combining (A.22) and (A.23) reveals that

$$\hat{p}_0 \leq \hat{p}_L \iff 0 \leq (v_H - 2v_L)(1 + \lambda Q_L) - \lambda Q_0 v_L + 2\lambda Q_H[\hat{v}_H - v_L]^+ - \lambda Q_H \hat{v}_H. \quad \text{(A.24)}$$

With

$$2\lambda Q_H[\hat{v}_H - v_L]^+ - \lambda Q_H \hat{v}_H = \left\{ \begin{array}{ll} -\lambda Q_H \hat{v}_H & \text{if } \hat{v}_H \in \{0, v_L\} \\ \lambda Q_H(v_H - 2v_L) & \text{if } \hat{v}_H = v_H \end{array} \right\} \leq 0 \quad \text{(A.25)}$$

(A.24) cannot hold, a contradiction. Thus, expectations $\hat{p}_0 \leq \hat{p}_L$ are not compatible with equilibrium.

For the case of a seller employment contract with a medium acceptance set, i.e, $E = S$ and $|\mathcal{A}| = 2$, the result follows from the above derivations by setting $Q_H = 0$. □

Proof of Lemma 4. We rule out all "non-monotonic" expectations the buyer might possibly hold as potential equilibrium expectations by identifying profitable deviations for the seller. We begin with the case of a small acceptance set, i.e., for $|\mathcal{A}| = 1$. Since, by Lemma 2, a worthless service will never be provided in equilibrium, we are left with four sets of expectations to consider.

CASE 1: $\hat{v}_0 \in \{v_L, v_H\}$, $\hat{v}_L = v_H$, $\hat{v}_H = v_L$

With $\hat{p}_H < \bar{p} < \hat{p}_L < \hat{p}_0$ (cf. Lemma 3), $U(v_H, \hat{p}_L|\Lambda(C)) = v_H - \hat{p}_L - \lambda Q_H(\hat{p}_L - \hat{p}_H)$ equals $U(v_L, \bar{p}|\Lambda(C)) = v_L - \bar{p} - \lambda Q_0(\hat{v}_0 - v_L) - \lambda Q_L(v_H - v_L) - \lambda Q_H(\bar{p} - \hat{p}_H)$, or equivalently,

$$\hat{p}_L = \bar{p} + \frac{(1 + \lambda Q_L)(v_H - v_L) + \lambda Q_0(\hat{v}_0 - v_L)}{1 + \lambda Q_H}(v_H - v_L). \quad \text{(A.26)}$$

Likewise, $U(v_L, \hat{p}_H|\Lambda(C)) = v_L - \hat{p}_H - \lambda Q_0(\hat{v}_0 - v_L) - \lambda Q_L(v_H - v_L)$ equals $U(v_H, \bar{p}|\Lambda(C)) = v_H - \bar{p} - \lambda Q_H(\bar{p} - \hat{p}_H)$, or equivalently,

$$\hat{p}_H = \bar{p} - \frac{(1 + \lambda Q_L) + \lambda Q_0(\hat{v}_0 - v_L)}{1 + \lambda Q_H}(v_H - v_L). \quad \text{(A.27)}$$

If $(c_H - c_L) > [(v_H - v_L)(1 + \lambda Q_L) + \lambda Q_0(\hat{v}_0 - v_L)]/(1 + \lambda Q_H)$, then in case of $(v^D, c^D) = (v_L, c_L)$ it is strictly more profitable for the seller not to offer renegotiation than to offer renegotiation to (v_H, c_H) at price $\hat{p}_L$. If $(c_H - c_L) < [(v_H - v_L)(1 + \lambda Q_L) + \lambda Q_0(\hat{v}_0 - v_L)]/(1 + \lambda Q_H)$, then in case of $(v^D, c^D) = (v_H, c_H)$ it is strictly more profitable for the seller not to offer renegotiation than to offer renegotiation to (v_L, c_L) at price $\hat{p}_H$. ||

CASE 2: $\hat{v}_0 = v_H$, $\hat{v}_L = v_L$, $\hat{v}_H = v_L$

With $\hat{p}_H < \bar{p} = \hat{p}_L < \hat{p}_0$, $U(v_H, \hat{p}_0|\Lambda(C)) = v_H - \hat{p}_0 - \lambda Q_H(\hat{p}_0 - \hat{p}_H) - \lambda Q_L(\hat{p}_0 - \bar{p})$ equals $U(0, \bar{p}|\Lambda(C)) = -\bar{p} - \lambda Q_0 v_H - \lambda Q_L v_L - \lambda Q_H(\bar{p} - \hat{p}_H)$, or equivalently,

$$\hat{p}_0 = \bar{p} + \frac{(1 + \lambda Q_0)v_H + \lambda(Q_L + Q_H)v_L}{1 + \lambda(Q_L + Q_H)}. \tag{A.28}$$

Likewise, $U^B(v_L, \hat{p}_H|\Lambda(C)) = v_L - \hat{p}_H - \lambda Q_0(v_H - v_L)$ equals $U^B(v_H, \bar{p}|\Lambda(C)) = v_H - \bar{p} - \lambda Q_H(\bar{p} - \hat{p}_H)$, or equivalently,

$$\hat{p}_H = \bar{p} - \frac{1 + \lambda Q_0}{1 + \lambda Q_H}(v_H - v_L). \tag{A.29}$$

If $(c_H - c_L) < (v_H - v_L)(1 + \lambda Q_0)/(1 + \lambda Q_H)$, then in case of $(v^D, c^D) = (v_H, c_H)$ it is strictly more profitable for the seller not to offer renegotiation than to offer renegotiation to (v_L, c_L) at price $\hat{p}_H$. If $(c_H - c_L) > (v_H - v_L)(1 + \lambda Q_0)/(1 + \lambda(Q_L + Q_H))$, then in case of $(v^D, c^D) = (0, 0)$ it is strictly more profitable for the seller to offer renegotiation to (v_L, c_L) at price

$$p^R = \bar{p} + \frac{1 + \lambda}{1 + \lambda(Q_L + Q_H)} v_L \in (\bar{p}, \hat{p}_0), \tag{A.30}$$

which is accepted by the buyer because $U(v_L, p^R|\Lambda(C)) = v_L - p^R - \lambda Q_0(v_H - v_L) - \lambda Q_H(p^R - \hat{p}_H) - \lambda Q_L(p^R - \hat{p}_L)$ equals $U(0, \bar{p}|\Lambda(C)) = -\bar{p} - \lambda Q_0 v_H - \lambda(Q_L + Q_H)v_L - \lambda Q_H(\bar{p} - \hat{p}_H)$, than to offer renegotiation to (v_H, c_H) at price $\hat{p}_0$. ‖

CASE 3: $\hat{v}_0 = v_H$, $\hat{v}_L = v_L$, $\hat{v}_H = v_H$

With $\hat{p}_L = \hat{p}_H = \bar{p} < \hat{p}_0$, $U(v_H, \hat{p}_0|\Lambda(C)) = v_H - \hat{p}_0 - \lambda(Q_L + Q_H)(\hat{p}_0 - \bar{p})$ equals $U(0, \bar{p}|\Lambda(C)) = -\bar{p} - \lambda Q_L v_L - \lambda(Q_0 + Q_H)v_H$, or equivalently,

$$\hat{p}_0 = \bar{p} + \frac{(1 + \lambda(Q_0 + Q_H))v_H + \lambda Q_L v_L}{1 + \lambda(Q_L + Q_H)}. \tag{A.31}$$

If $(c_H - c_L) > (v_H - v_L)[1 + \lambda(Q_0 + Q_H)]/[1 + \lambda(Q_L + Q_H)]$, then in case of $(v^D, c^D) = (0, 0)$ it is strictly more profitable for the seller to offer renegotiation to (v_L, c_L) at price

$$p^R = \bar{p} + \frac{1 + \lambda}{1 + \lambda(Q_L + Q_H)} v_L \in (\bar{p}, \hat{p}_0), \tag{A.32}$$

which is accepted by the buyer because $U(v_L, p^R|\Lambda(C)) = v_L - p^R - \lambda(Q_0 + Q_H)(v_H - v_L) - \lambda(Q_L + Q_H)(p^R - \hat{p}_H)$ equals $U(0, \bar{p}|\Lambda(C)) = -\bar{p} - \lambda(Q_0 + Q_H)v_H - \lambda Q_L v_L$, than to offer renegotiation to (v_H, c_H) at price $\hat{p}_0$. If $(c_H - c_L) < (v_H - v_L)[1 + \lambda(Q_0 + Q_H)]/[1 + \lambda(Q_L + Q_H)]$, then in case of $(v^D, c^D) = (v_L, c_L)$ it is strictly more profitable for the seller to offer renegotiation to (v_H, c_H) at price

$$p^R = \bar{p} + \frac{1 + \lambda(Q_0 + Q_H)}{1 + \lambda(Q_L + Q_H)}(v_H - v_L) \in (\bar{p}, \hat{p}_0), \tag{A.33}$$

which is accepted by the buyer because $U(v_H, p^R|\Lambda(C)) = v_H - p^R - \lambda(Q_L + Q_H)(p^R - \hat{p}_H)$ equals $U(v_L, \bar{p}|\Lambda(C)) = v_L - \bar{p} - \lambda(Q_0 + Q_H)(v_H - v_L)$, than not to offer renegotiation. ∥

For a medium acceptance set, i.e., for $|\mathcal{A}| = 2$, in the light of Lemma 2 there is only one set of non-monotonic expectations to consider. In case of a seller employment contract, $(\hat{v}_0, \hat{v}_L) = (v_H, v_L)$ can be ruled out in analogy to CASE 3. The corresponding algebraic expressions are obtained by setting $Q_H = 0$. In case of a buyer employment contract, $(\hat{v}_L, \hat{v}_H) = (v_H, v_L)$ can be ruled out in analogy to CASE 1. The corresponding algebraic expressions are obtained by setting $Q_0 = 0$. □

Proof of Proposition 4. First, we establish that expectations Λ^{LLL} are consistent with SP-PE. With $\hat{p}_H^{LLL} < \hat{p}_L^{LLL} = \bar{p} < \hat{p}_0^{LLL}$, the equilibrium price $\hat{p}_H^{LLL}$ in (20) is obtained by equating $U(v_L, \hat{p}_H|\Lambda^{LLL}(C)) = v_L - \hat{p}_H^{LLL}$ and $U(v_H, \bar{p}|\Lambda^{LLL}(C)) = v_H - \bar{p} - \lambda Q_H(\bar{p} - \hat{p}_H^{LLL})$. Likewise, the equilibrium price $\hat{p}_0^{LLL}$ in (21) is obtained by equating $U(v_L, \hat{p}_0|\ \Lambda^{LLL}(C)) = v_L - \hat{p}_0^{LLL} - \lambda Q_H(\hat{p}_0^{LLL} - \hat{p}_H^{LLL}) - \lambda Q_L(\hat{p}_0^{LLL} - \bar{p})$ and $U(0, \bar{p}|\Lambda^{LLL}(C)) = -\bar{p} - \lambda v_L - \lambda Q_H(\bar{p} - \hat{p}_H^{LLL})$. By Corollary 1, deviations in form of offering provision of a useless service are never profitable for the seller.

If $(v^D(C), c^D(C)) = (v_L, v_L)$, then the highest price $p^R > \bar{p}$ at which the buyer would accept renegotiation to (v_H, c_H) is below $\hat{p}_0^{LLL}$ and equates $U(v_H, p^R|\Lambda^{LLL}(C)) = v_H - p^R - \lambda Q_L(p^R - \bar{p}) - \lambda Q_H(p^R - \hat{p}_H^{LLL})$ and $U(v_L, \bar{p}|\Lambda^{LLL}(C)) = v_L - \bar{p} - \lambda Q_H(\bar{p} - \hat{p}_H^{LLL})$, i.e., $p^R = \bar{p} + (v_H - v_L)/[1 + \lambda(Q_L + Q_H)]$. Offering this deviation, however, is not profitable for the seller because $p^R - \bar{p} = (v_H - v_L)/[1 + \lambda(Q_L + Q_H)] < c_H - c_L$.

If $(v^D(C), c^D(C)) = (0, 0)$, then the highest price $p^R > \bar{p}$ at which the buyer would accept renegotiation to (v_H, c_H) is higher than $\hat{p}_0^{LLL}$ and equates $U(v_H, p^R|\Lambda^{LLL}(C)) = v_H - p^R - \lambda Q_H(p^R - \hat{p}_H^{LLL}) - \lambda Q_L(p^R - \bar{p}) - \lambda Q_0(p^R - \hat{p}_0^{LLL})$ and $U(0, \bar{p}|\Lambda^{LLL}(C)) = -\bar{p} - \lambda v_L - \lambda Q_H(\bar{p} - \hat{p}_H^{LLL})$, i.e., $p^R = \hat{p}_0^{LLL} + [v_H - v_L]/(1 + \lambda)$. Offering this deviation, however, is not profitable for the seller because $p^R - \hat{p}_0^{LLL} = (v_H - v_L)/(1 + \lambda) < c_H - c_L$.

If $(v^D(C), c^D(C)) = (v_H, c_H)$, then not offering renegotiation is not profitable because $\bar{p} - \hat{p}_H^{LLL} = (v_H - v_L)/[1 + \lambda Q_H] < c_H - c_L$.

Next, we determine the expectations regarding the outcome of renegotiation under a sales contract in the SP-PPE. To this end, we proceed in a series of five steps.

STEP 1: Λ^{LLH} IS CONSISTENT WITH SP-PE IF AND ONLY IF $\lambda \geq 3\tilde{\lambda}$.
With $\hat{p}_H^{LLH} = \hat{p}_L^{LLH} = \bar{p} < \hat{p}_0^{LLH}$, the equilibrium price $\hat{p}_0^{LLH}$ in (24) is obtained by equating $U(v_L, \hat{p}_0|\ \Lambda^{LLH}(C)) = v_L - \hat{p}_0^{LLH} - \lambda Q_H(v_H - v_L) - \lambda(Q_L + Q_H)(\hat{p}_0^{LLH} - \bar{p})$ and $U(0, \bar{p}|\Lambda^{LLH}(C)) = -\bar{p} - \lambda(Q_0 + Q_L)v_L - \lambda Q_H v_H$. By Corollary 1, deviations in form of offering provision of a useless service are never profitable for the seller.

If $(v^D(C), c^D(C)) = (v_L, v_L)$, then the highest price $p^R > \bar{p}$ at which the buyer would accept renegotiation to (v_H, c_H) is below $\hat{p}_0^{LLH}$ and equates $U(v_H, p^R|\Lambda^{LLH}(C)) = v_H - p^R - \lambda(Q_L + Q_H)(p^R - \bar{p})$ and $U(v_L, \bar{p}|\Lambda^{LLH}(C)) = v_L - \bar{p} - \lambda Q_H(v_H - v_L)$, i.e. $p^R = \bar{p} + (v_H -$

$v_L)(1 + \lambda Q_H)/[1 + \lambda(Q_L + Q_H)]$. Offering this deviation, however, is not profitable for the seller because $p^R - \bar{p} = (v_H - v_L)(1 + \lambda Q_H)/[1 + \lambda(Q_L + Q_H)] < c_H - c_L$.

If $(v^D(C), c^D(C)) = (0, 0)$, then the highest price $p^R > \bar{p}$ at which the buyer would accept renegotiation to (v_H, c_H) is higher than $\hat{p}_0^{LLH}$ and equates $U(v_H, p^R|\Lambda^{LLH}(C)) = v_H - p^R - \lambda(Q_L+Q_H)(p^R-\bar{p}) - \lambda Q_0(p^R - \hat{p}_0^{LLH})$ and $U(0, \bar{p}|\Lambda^{LLH}(C)) = -\bar{p} - \lambda(Q_0+Q_L)v_L - \lambda Q_H v_H$, i.e. $p^R = \bar{p} + (\hat{p}_0^{LLH} - \bar{p})\lambda Q_0/(1+\lambda) + [(1+\lambda Q_H)v_H + \lambda(Q_0+Q_L)v_L]/(1+\lambda)$. Offering this deviation, however, is not profitable for the seller because $p^R - \hat{p}_0^{LLH} = (v_H - v_L)[1 - \lambda(Q_0 + Q_L)]/(1+\lambda) < c_H - c_L$.

If $(v^D(C), c^D(C)) = (v_H, c_H)$, then the highest price $p^R < \bar{p}$ at which the buyer would accept renegotiation to (v_L, c_L) equates $U(v_L, p^R|\Lambda^{LLH}(C)) = v_L - p^R - \lambda Q_H(v_H - v_L)$ and $U(v_H, \bar{p}|\Lambda^{LLH}(C)) = v_H - \bar{p}$, i.e. $p^R = \bar{p} - (1+\lambda Q_H)(v_H - v_L)$. Offering this deviation is more profitable for the seller than not to offer renegotiation if $\bar{p} - p^R = (1+\lambda Q_H)(v_H - v_L) < c_H - c_L$. Thus, $\lambda \geq 3\tilde{\lambda}$ or, equivalently,

$$\frac{c_H - c_L}{v_H - v_L} \leq 1 + \lambda Q_H(E, \mathcal{A}) = 1 + \frac{\lambda}{3}. \tag{A.34}$$

is a necessary and sufficient condition for expectations Λ^{LLH} to be consistent with SP-PE. ||

STEP 2: NECESSARY CONDITION FOR Λ^{LHH} TO BE CONSISTENT WITH SP-PE. Consider expectations $\Lambda(C) = \{(v_L, \hat{p}_0^{LHH}), (v_H, \hat{p}_L^{LHH}), (v_H, \bar{p})\} = \Lambda^{LHH}$. With $\hat{p}_H^{LHH} = \bar{p} < \hat{p}_L^{LHH} < \hat{p}_0^{LHH}$, the expected price $\hat{p}_L^{LHH}$ is obtained by equating $U(v_H, \hat{p}_L^{LHH}|\Lambda^{LHH}) = v_H - \hat{p}_L^{LHH} - \lambda Q_H(\hat{p}_L^{LHH} - \bar{p})$ and $U(v_L, \bar{p}|\Lambda^{LHH}) = v_L - \bar{p} - \lambda(Q_L+Q_H)(v_H - v_L)$, which yields

$$\hat{p}_L^{LHH} = \bar{p} + \frac{1 + \lambda(Q_L + Q_H)}{1 + \lambda Q_H}(v_H - v_L). \tag{A.35}$$

The expected price $\hat{p}_0^{LHH}$ is obtained by equating $U(v_L, \hat{p}_0^{LHH}|\Lambda^{LHH}) = v_L - \hat{p}_0^{LHH} - \lambda(Q_L + Q_H)(v_H - v_L) - \lambda Q_L(\hat{p}_0^{LHH} - \hat{p}_L^{LHH}) - \lambda Q_H(\hat{p}_0^{LHH} - \bar{p})$ and $U(0, \bar{p}|\Lambda^{LHH}) = -\bar{p} - \lambda Q_0 v_L - \lambda(Q_L + Q_H)v_H$, which yields

$$\hat{p}_0^{LHH} = \hat{p}_L^{LHH} + \left\{\frac{1+\lambda}{1 + \lambda(Q_L + Q_H)}v_L - (v_H - v_L)\right\} \tag{A.36}$$

In case of the materially efficient default outcome (v_L, c_L) it is strictly more profitable for the seller not to offer renegotiation than to offer renegotiation to (v_H, c_H) at price $\hat{p}_L$ if $\bar{p} - c_L > \hat{p}_L - c_H$, or equivalently, $(c_H - c_L) > (v_H - v_L)[1 + \lambda(Q_L + Q_H)]/(1 + \lambda Q_H)$. Thus,

$$\frac{c_H - c_L}{v_H - v_L} \leq \frac{1 + \lambda(Q_L + Q_H)}{1 + \lambda Q_H} = 1 + \frac{\lambda}{3 + \lambda}. \tag{A.37}$$

is a necessary condition for expectations Λ^{LHH} to be consistent with SP-PE. ||

STEP 3: NECESSARY CONDITION FOR Λ^{HHH} TO BE CONSISTENT WITH SP-PE. Consider expectations $\Lambda(C) = \{(v_H, \hat{p}_0^{HHH}), (v_H, \hat{p}_L^{HHH}), (v_H, \bar{p})\} =: \Lambda^{HHH}$. With $\hat{p}_H^{HHH} =$

$\bar{p} < \hat{p}_L^{HHH} < \hat{p}_0^{HHH}$, the equilibrium price $\hat{p}_L^{HHH}$ is obtained by equating $U(v_H, \hat{p}_L^{HHH}|\Lambda^{HHH}) = v_H - \hat{p}_L^{HHH} - \lambda Q_H(\hat{p}_L^{HHH} - \bar{p})$ and $U(v_L, \bar{p}|\Lambda^{HHH}) = v_L - \bar{p} - \lambda(v_H - v_L)$, which yields

$$\hat{p}_L^{HHH} = \bar{p} + \frac{1+\lambda}{1+\lambda Q_H}(v_H - v_L). \tag{A.38}$$

The equilibrium price $\hat{p}_0^{HHH}$ is obtained by equating $U(v_H, \hat{p}_0^{HHH}|\Lambda^{HHH}) = v_H - \hat{p}_0^{HHH} - \lambda Q_L(\hat{p}_0^{HHH} - \hat{p}_L^{HHH}) - \lambda Q_H(\hat{p}_0^{HHH} - \bar{p})$ and $U(0, \bar{p}|\Lambda^{HHH}) = -\bar{p} - \lambda v_H$, which yields

$$\hat{p}_0^{HHH} = \hat{p}_L^{HHH} + \frac{1+\lambda}{1+\lambda(Q_L+Q_H)} v_L. \tag{A.39}$$

In case of the useless default outcome $(0,0)$ it is strictly more profitable for the seller to offer renegotiation to (v_L, c_L) at price

$$p^R = \bar{p} + \frac{\lambda Q_L}{[1+\lambda(Q_L+Q_H)]}\frac{(1+\lambda)}{(1+\lambda Q_H)}(v_H - v_L) + \frac{(1+\lambda)}{1+\lambda(Q_L+Q_H)} v_L \in (\hat{p}_L, \hat{p}_H), \tag{A.40}$$

which is accepted by the buyer because $U(v_L, p^R|\Lambda^{HHH}) = v_L - p^R - \lambda(v_H - v_L) - \lambda Q_L(p^R - \hat{p}_L) - \lambda Q_H(p^R - \bar{p})$ equals $U(0, \bar{p}|\Lambda^{HHH})$, than to offer renegotiation to (v_H, c_H) at price $\hat{p}_L$ if $p^R - c_L > \hat{p}_0 - c_H$, or equivalently, $(c_H - c_L) > (v_H - v_L)(1+\lambda)/(1+\lambda(Q_L+Q_H))$. Thus,

$$\frac{c_H - c_L}{v_H - v_L} \leq \frac{1+\lambda}{1+\lambda(Q_L+Q_H)} = 1 + \frac{\lambda}{3+2\lambda}. \tag{A.41}$$

is a necessary condition for expectations Λ^{HHH} to be consistent with SP-PE. ||

STEP 4: COMPARISON OF EXISTENCE CONDITIONS.
With $\lambda > 0$, the condition (A.34) for expectations Λ^{LLH} to be consistent with SP-PE is less restrictive than both the corresponding condition (A.37) for expectations Λ^{LHH} and the corresponding (A.41) for expectations Λ^{HHH}. Thus, whenever Λ^{LHH} and Λ^{HHH} are consistent with SP-PE, then also Λ^{LLL} is consistent with SP-PE. ||

STEP 5: NEITHER Λ^{LHH} NOR Λ^{HHH} IS CONSISTENT WITH SP-PPE.
The buyer's expected utility under expectations Λ^{LHH} and Λ^{HHH} is

$$EU(\Lambda^{LHH}) = v_L - \bar{p} - Q_0(1+\lambda)v_L + [Q_H(1-\lambda(1-Q_H)) - \lambda Q_L(1-Q_H)](v_H - v_L) \tag{A.42}$$

and

$$EU(\Lambda^{HHH}) = v_L - \bar{p} - Q_0(1+\lambda)v_L + [1-(1+\lambda)(1-Q_H)](v_H - v_L), \tag{A.43}$$

respectively. Comparison of (25), (A.42), and (A.43) reveals that $EU(\Lambda^{LLH}) \geq \max\{EU(\Lambda^{LHH}), EU(\Lambda^{HHH})\}$ whenever all three sets of expectations are consistent with subsequently rational behavior. Thus, from STEP 4 it follows that neither Λ^{LHH} nor Λ^{HHH} is consistent with SP-PPE. || □

Proof of Proposition 5. In general, the desired result is established in analogy to the proofs of Propositions 1 and 4. Next to Λ_B^{LL}, Λ_B^{LH}, and Λ_S^{LL} as defined in Proposition 5, define $\Lambda_B^{HH} = ((v_H, c_H, \hat{p}_L^{HH}), (v_H, c_H, \bar{p}))$, $\Lambda_S^{HH} = ((v_H, c_H, \hat{p}_0^{HH}), (v_H, c_H, \hat{p}_L^{HH}))$, and $\Lambda_S^{LH} = ((v_L, c_L, \hat{p}_0^{LH}), (v_H, c_H, \hat{p}_L^{LH}))$.

(i) For $E = B$, the default outcome will never be a worthless service. Therefore, when we make references to earlier established results, set $Q_0 = 0$ and ignore all derivations for the case of a worthless default outcome.

Regarding Λ_B^{LL}, following along the lines of the proof of Proposition 4, the renegotiated trade price $\hat{p}_H^{LL}$ and the buyer's expected utility $EU(\Lambda^{LL})$ correspond to (20) and (22), respectively.

Regarding Λ_B^{LH}, following along the lines of STEP 1 in the proof of Proposition 4, the buyer's expected utility $EU(\Lambda^{LH})$ and the condition for Λ_B^{LH} to be consistent with SP-PE correspond to (25) and (A.34), respectively.

Regarding Λ_B^{HH}, following along the lines of STEP 2 in the proof of Proposition 4, the renegotiated trade price $\hat{p}_L^{HH}$, the buyer's expected utility $EU(\Lambda^{HH})$, and the condition for Λ_B^{HH} to be consistent with SP-PE correspond to (A.35), (A.42), and (A.37), respectively.

Finally, similar to STEP 4 and STEP 5 of Proposition 4, the following can be shown: first, the buyer's expected utility is higher under Λ_B^{LH} than under Λ_B^{LL} and Λ_B^{HH}; second, Λ_B^{LH} is consistent with SP-PE whenever Λ_B^{HH} is consistent with SP-PE; third, the buyer's expected utility is higher under Λ_B^{LL} than under Λ_B^{HH}.

(ii) For $E = S$, the default outcome will never be a high-value/high-cost service. Therefore, when we make references to earlier established results, set $Q_H = 0$ and ignore all derivations for the case of a high-value/high-cost default outcome.

Regarding Λ_S^{LL}, following along the lines of the proof of Proposition 4, the renegotiated trade price $\hat{p}_0^{LL}$ and the buyer's expected utility $EU(\Lambda^{LL})$ correspond to (21) and (22), respectively.

Regarding Λ_S^{LH}, following along the lines of STEP 2 in the proof of Proposition 4, the renegotiated trade prices $\hat{p}_L^{LH}$ and $\hat{p}_0^{LH}$ and the buyer's expected utility $EU(\Lambda^{LH})$ correspond to (A.35), (A.36), and (A.42), respectively.

Regarding Λ_S^{HH}, following along the lines of STEP 3 in the proof of Proposition 4, the renegotiated trade prices $\hat{p}_L^{HH}$ and $\hat{p}_0^{HH}$ and the buyer's expected utility $EU(\Lambda^{HH})$ correspond to (A.38), (A.39), and (A.43), respectively.

Finally, it can be shown that the buyer's expected utility is higher under Λ_S^{LL} than under Λ_S^{LH} and Λ_S^{HH}. □

Proof of Proposition 6. The statement follows from the seller making a take-it-or-leave-it contract offer to the buyer at the initial date 0, together with Propositions 1, 2, 4, and 5. □

Proof of Proposition 7. The buyer employment contract with large and medium acceptance set is analyzed in the main text. We will first analyze the three remaining contracts and show that these are dominated. Thereafter, we will compare the two buyer employment contracts.

Suppose the seller offers a *sales contract*. The material efficient good is traded ex post if $\lambda < 3\tilde{\lambda}(I)$, which is always the case under Assumption 3. The buyer's expected utility is

$$EU(I|\lambda^{LLL}) = v_L(I) - \bar{p} - \frac{1}{3}(1+\lambda)v_L(I) + \frac{3-2\lambda}{9+3\lambda}[v_H(I) - v_L(I)] - \psi I. \tag{A.44}$$

Thus, $I = 1$ if and only if

$$\psi \leq \frac{3+\lambda-\lambda^2}{9+3\lambda}\psi^{FB} + \frac{3-2\lambda}{9+3\lambda}\hat{\psi}. \tag{A.45}$$

The sales contract is dominated by the buyer employment contract with large acceptance set if it leads to lower investment incentives because it triggers losses. The investment incentives provided by the sales contract are lower than the investment incentives under the buyer employment contract with full acceptance set if

$$\frac{\lambda}{1+\lambda}\psi^{FB} + \frac{1}{1+\lambda}\hat{\psi} \geq \frac{3+\lambda-\lambda^2}{9+3\lambda}\psi^{FB} + \frac{3-2\lambda}{9+3\lambda}\hat{\psi}$$
$$\iff \lambda(6+\lambda^2)\psi^{FB} + (6+2\lambda+2\lambda^2)\hat{\psi} \geq 0. \tag{A.46}$$

Next, suppose the seller offers a *seller employment contract with large acceptance set*. For this contract materially efficient renegotiation takes always place. The buyer's expected utility is

$$EU(I|\lambda_S^L) = -\lambda v_L(I) - \bar{p} - \psi I. \tag{A.47}$$

Undertaking the investment reduces the buyer's expected utility and thus he never invests for $\psi \geq 0$. This implies that the seller employment contract with large acceptance set is dominated by the buyer employment contract with large acceptance set. Both contracts eliminate any losses but only the latter creates positive investment incentives.

Finally, suppose the seller offers a *seller employment contract with medium acceptance set*. Again, materially efficient renegotiation always takes place. The buyer's expected utility is

$$EU(I|\lambda_S^{LL}) = v_L(I) - \bar{p} - \frac{2(1+\lambda)}{3}v_L(I) - \psi I. \tag{A.48}$$

The buyer undertakes the investment if and only if

$$\psi \leq \frac{1-2\lambda}{3}\psi^{FB}, \tag{A.49}$$

in which case the joint surplus amounts to

$$S_{S2}(1) = v_L(1) - c_L - \frac{2\lambda(1+\lambda)}{3(3+\lambda)}v_L(1) - \psi. \tag{A.50}$$

If $\psi > \psi^{FB}(1-2\lambda)/3$, then this contract is dominated by the buyer employment contract with large acceptance set. Next, we show that for $\psi \leq \psi^{FB}(1-2\lambda)/3$ it is dominated by the buyer employment contract with medium acceptance set. Obviously, $\psi_{B2} > \psi^{FB}(1-2\lambda)/3$. Thus, it remains to be shown that $S_{B2} \geq S_{S2}$, which is equivalent to

$$\frac{2\lambda(1+\lambda)}{3(3+\lambda)} v_L(1) \geq \frac{2\lambda}{3(3+2\lambda)} [v_H(1) - v_L(1)] \tag{A.51}$$

$$\iff 1 + \frac{(3+2\lambda)(1+\lambda)}{3+\lambda} \geq \frac{v_H(1)}{v_L(1)}. \tag{A.52}$$

The left-hand side is always weakly larger than 2 and the right-hand side is strictly smaller than 2 by Assumption 3(i).

Thus, the optimal contract is either the buyer employment contract with large acceptance set or with small acceptance set. When the investment decision is the same under both contracts, the large acceptance set is optimal because it does not lead to any sensations of losses. The question is which of the two contracts leads to the larger social surplus if $\psi \in (\psi^{FB}/3 + 2\hat{\psi}/3, \psi_{B2}]$. The medium acceptance set is preferred to the large acceptance set if and only if

$$v_L(1) - c_L - \frac{2\lambda}{9+6\lambda}[v_H(1) - v_L(1)] - \psi \geq v_L(0) - c_L. \tag{A.53}$$

Solving for λ yields (35); i.e., $\lambda \leq \hat{\lambda}(\psi)$. Straightforward calculations show that $\hat{\lambda}'(\psi) < 0$. This implies that if $\hat{\lambda}(\psi_{B2}) \geq \tilde{\lambda}(0)$, then—in the relevant range—the buyer employment contract with medium acceptance set is always preferred to the buyer employment contract with large acceptance set.

The statement of the proposition now follows directly from a comparison of the above finding with Observation 2. □

B. Remarks on Genericity

Proof of Lemma 1. Given contract $C = (E, \mathcal{A}, \bar{p})$, each state $\theta \in \Theta$ is associated with a unique default outcome $(v^D(\theta, C), c^D(\theta, C))$. With our focus on pure strategies, the buyer expects renegotiation in state θ to result in a particular outcome $(\hat{v}(\theta, C), \hat{c}(\theta, C))$ at price $\hat{p}(\theta, C)$.

Letting $\Lambda(C)$ denote the buyer' expectations consistent with equilibrium for a given contract $C = (E, \mathcal{A}, \bar{p})$, a first observation is that if renegotiation occurs in state $\theta \in \Theta$, then the seller's renegotiation offer makes the buyer just indifferent between the default outcome and the renegotiated outcome, i.e., $U(\hat{v}(\theta, C), \hat{p}(\theta, C)|\Lambda(C)) = U(v^D(\theta, C), \bar{p}|\Lambda(C))$. If the buyer was not indifferent, then either he would reject the seller's renegotiation offer or the seller could profitably deviate by offering the outcome $(\hat{v}(\theta, C), \hat{c}(\theta, C))$ at a slightly higher price which the buyer nevertheless would accept.

The above observation has two immediate implications. First, if the buyer expects renegotiation to lead to the same value to be implemented in two states with the same default outcome, then he has to expect the same price to be offered by the seller in renegotiation. Formally, if $\hat{v}(\theta', C) = \hat{v}(\theta'', C)$ for $\theta', \theta'' \in \Theta$ with $v^D(\theta', C) = v^D(\theta'', C)$, then $\hat{p}(\theta', C) = \hat{p}(\theta'', C)$.

Second, if the buyer expects renegotiation in two states with different default outcomes to result in the same outcome with either strictly higher or strictly lower value than the two default outcomes, then the buyer has to expect renegotiation involving higher differences in value to lead to a larger change in the trade price. Formally, if $\hat{v}(\theta', C) = \hat{v}(\theta'', C) = 0$ for $\theta', \theta'' \in \Theta$ with $v^D(\theta', C) = v_L$ and $v^D(\theta'', C) = v_H$ or $\hat{v}(\theta', C) = \hat{v}(\theta'', C) = v_H$ for $\theta', \theta'' \in \Theta$ with $v^D(\theta', C) = 0$ and $v^D(\theta'', C) = v_L$, then $\hat{p}(\theta', C) > \hat{p}(\theta'', C)$.

Armed with these observations, we can establish that the buyer's expectation in equilibrium about the outcome of renegotiation after state $\theta \in \Theta$ has been realized is fully determined by the default outcome $(v^D(\theta, C), c^D(\theta, C))$. For $k, j \in \{0, L, H\}$, define

$$\Theta_{\{k \to j\}} := \{\theta \in \Theta | v^D(\theta, C) = v_k, \hat{v}(\theta, C) = v_j\} \tag{B.1}$$

to be the set of states of the world that share the same default outcome under contract C and that the buyer expects to be identically renegotiated. Due to our focus on pure strategies, $\Theta_{\{k \to j'\}} \cap \Theta_{\{k \to j''\}} = \varnothing$ for $j' \neq j''$. Furthermore, define

$$Q_{\{k \to j\}} := \frac{|\Theta_{\{k \to j\}}|}{3}. \tag{B.2}$$

From the discussion above, for all $\theta \in \Theta_{\{k \to j\}}$ the buyer expects the seller to offer the same price $\hat{p}_{\{k \to j\}}$ in renegotiation, where $\hat{p}_{\{k \to k\}} = \bar{p}$.

Whenever $\Theta_{\{k \to j'\}} \neq \varnothing$ and $\Theta_{\{k \to j''\}} \neq \varnothing$, the buyer expects the seller to be indifferent between offering $v_{j'}$ at price $\hat{p}_{\{k \to j'\}}$ and offering $v_{j''}$ at price $\hat{p}_{\{k \to j''\}}$ if her default is to sell v_k at price $\bar{p}$. If this was not the case, i.e. if (w.l.o.g.) $\hat{p}_{\{k \to j'\}} - c_{j'} > \hat{p}_{\{k \to j''\}} - c_{j''}$, then for $\theta \in \Theta_{\{k \to j''\}}$ the seller could offer $v_{j'}$ at a price $\hat{p}_{\{k \to j'\}} - \varepsilon$ with $\varepsilon > 0$ sufficiently small, thereby making the buyer strictly prefer to obtain $v_{j'}$ at price $\hat{p}_{\{k \to j'\}} - \varepsilon$ while at the same time strictly increasing her profits. This indifference of the seller has the following implications for the buyer's expectations regarding prices:

$$\begin{aligned}
\Theta_{\{H \to H\}} \neq \varnothing, \Theta_{\{H \to L\}} \neq \varnothing \quad &\Rightarrow \quad \bar{p} - c_H = \hat{p}_{\{H \to L\}} - c_L \\
\Theta_{\{H \to H\}} \neq \varnothing, \Theta_{\{H \to 0\}} \neq \varnothing \quad &\Rightarrow \quad \bar{p} - c_H = \hat{p}_{\{H \to 0\}} \\
\Theta_{\{H \to L\}} \neq \varnothing, \Theta_{\{H \to 0\}} \neq \varnothing \quad &\Rightarrow \quad \hat{p}_{\{H \to L\}} - c_L = \hat{p}_{\{H \to 0\}} \\
\Theta_{\{L \to H\}} \neq \varnothing, \Theta_{\{L \to L\}} \neq \varnothing \quad &\Rightarrow \quad \hat{p}_{\{L \to H\}} - c_H = \bar{p} - c_L \\
\Theta_{\{L \to H\}} \neq \varnothing, \Theta_{\{L \to 0\}} \neq \varnothing \quad &\Rightarrow \quad \hat{p}_{\{L \to H\}} - c_H = \hat{p}_{\{L \to 0\}} \\
\Theta_{\{L \to L\}} \neq \varnothing, \Theta_{\{L \to 0\}} \neq \varnothing \quad &\Rightarrow \quad \bar{p} - c_L = \hat{p}_{\{L \to 0\}} \\
\Theta_{\{0 \to H\}} \neq \varnothing, \Theta_{\{0 \to L\}} \neq \varnothing \quad &\Rightarrow \quad \hat{p}_{\{0 \to H\}} - c_H = \hat{p}_{\{0 \to L\}} - c_L \\
\Theta_{\{0 \to H\}} \neq \varnothing, \Theta_{\{0 \to 0\}} \neq \varnothing \quad &\Rightarrow \quad \hat{p}_{\{0 \to H\}} - c_H = \bar{p} \\
\Theta_{\{0 \to L\}} \neq \varnothing, \Theta_{\{0 \to 0\}} \neq \varnothing \quad &\Rightarrow \quad \hat{p}_{\{0 \to L\}} - c_L = \bar{p}
\end{aligned}$$

At the same time, in equilibrium we have $U(v_{j'}, \hat{p}_{\{k \to j'\}} | \Lambda(C)) = U(v_{k''}, \hat{p}_{\{k \to j''\}} | \Lambda(C))$, i.e., the buyer expects to be indifferent between obtaining $v_{j'}$ at price $\hat{p}_{\{k \to j'\}}$ and obtaining $v_{j''}$ at price $\hat{p}_{\{k\to j'\}}$ if the default is to obtain v_k at price $\bar{p}$. It can be shown that this latter indifference of the buyer is characterized by the zeros of a polynomial in λ of finite order, and thus, with λ being drawn from the interval $(0, 1]$, generically does *not* hold. With the procedure being the same for all relevant cases, we demonstrate the result only for two example cases.

CASE 1: Suppose that $\Theta_{\{H\to H\}} \neq \varnothing$, $\Theta_{\{H\to L\}} \neq \varnothing$, $\Theta_{\{L\to L\}} \neq \varnothing$, $\Theta_{\{0\to 0\}} \neq \varnothing$, and $\Theta_{\{H\to 0\}} = \Theta_{\{L\to H\}} = \Theta_{\{L\to 0\}} = \Theta_{\{0\to H\}} = \Theta_{\{0\to L\}} = \varnothing$. Regarding the relevant price expectations we have $\hat{p}_{\{H\to H\}} = \hat{p}_{\{L\to L\}} = \hat{p}_{\{0\to 0\}} = \bar{p}$ and $\hat{p}_{\{H\to L\}} = \bar{p} - (c_H - c_L)$. Moreover, we have that $U(v_L, \hat{p}_{\{H\to L\}}|\Lambda(C)) = v_L - [\bar{p} - (c_H - c_L)] - \lambda Q_{\{H\to H\}}(v_H - v_L)$ equals $U(v_H, \bar{p}|\Lambda(C)) = v_H - \bar{p} - \lambda Q_{\{H\to L\}}[\bar{p} - (\bar{p} - (c_H - c_L))]$, or equivalently,

$$(c_H - c_L) - (v_H - v_L) = \lambda\{Q_{\{H\to H\}}(v_H - v_L) - Q_{\{H\to L\}}(c_H - c_L)\}. \tag{B.3}$$

If at all, (B.3) holds for at most one value of λ and thus generically is not satisfied.

CASE 2: Suppose that $\Theta_{\{H\to L\}} \neq \varnothing$, $\Theta_{\{H\to 0\}} \neq \varnothing$, $\Theta_{\{L\to L\}} \neq \varnothing$, $\Theta_{\{L\to 0\}} \neq \varnothing$, $\Theta_{\{H\to H\}} = \varnothing$, and $\Theta_{\{L\to H\}}$, $\Theta_{\{0\to H\}}$, $\Theta_{\{0\to L\}}$, $\Theta_{\{0\to 0\}}$ arbitrarily specified. Regarding the relevant price expectations we have $\hat{p}_{\{H\to 0\}} = \hat{p}_{\{H\to L\}} - c_L < \hat{p}_{\{H\to L\}} < \bar{p}$, $\hat{p}_{\{L\to 0\}} = \bar{p} - c_L < \bar{p} = \hat{p}_{\{L\to L\}}$, and $\hat{p}_{\{L\to H\}}, \hat{p}_{\{0\to H\}}, \hat{p}_{\{0\to L\}}, \hat{p}_{\{0\to 0\}} \geq \bar{p}$. Remember, from the discussion above, we know that $\hat{p}_{\{H\to 0\}} < \hat{p}_{\{L\to 0\}}$. Suppose that $\hat{p}_{\{H\to L\}} > \hat{p}_{\{L\to 0\}}$. In equilibrium, we have that $U(v_L, \hat{p}_{\{H\to L\}}|\Lambda(C)) = v_L - \hat{p}_{\{H\to L\}} - \lambda(Q_{\{L\to H\}} + Q_{\{0\to H\}})(v_H - v_L) - \lambda Q_{\{H\to 0\}}(\hat{p}_{\{H\to L\}} - \hat{p}_{\{H\to 0\}}) - \lambda Q_{\{L\to 0\}}(\hat{p}_{\{H\to L\}} - \hat{p}_{\{L\to 0\}})$ equals $U(v_H, \bar{p}|\Lambda(C)) = v_H - \bar{p} - \lambda Q_{\{H\to 0\}}(\bar{p} - \hat{p}_{\{H\to L\}}) - \lambda Q_{\{L\to 0\}}(\bar{p} - \hat{p}_{\{L\to 0\}}) - \lambda Q_{\{H\to L\}}(\bar{p} - \hat{p}_{\{H\to L\}})$ such that

$$\hat{p}_{\{H\to L\}} = \bar{p} - \frac{1 + \lambda(Q_{\{L\to H\}} + Q_{\{0\to H\}})}{1 + \lambda(Q_{\{H\to 0\}} + Q_{\{L\to 0\}} + Q_{\{H\to L\}})}(v_H - v_L), \tag{B.4}$$

and in consequence,

$$\hat{p}_{\{H\to 0\}} = \hat{p}_{\{H\to L\}} - c_L = \bar{p} - c_L - \frac{1 + \lambda(Q_{\{L\to H\}} + Q_{\{0\to H\}})}{1 + \lambda(Q_{\{H\to 0\}} + Q_{\{L\to 0\}} + Q_{\{H\to L\}})}(v_H - v_L), \tag{B.5}$$

Given these beliefs are feasible in the sense that $\hat{p}_{\{H\to 0\}} < \hat{p}_{\{L\to 0\}} < \hat{p}_{\{H\to L\}}$, then $U(0, \hat{p}_{\{H\to 0\}}|\Lambda(C)) = -\hat{p}_{\{H\to 0\}} - \lambda(Q_{\{H\to L\}} + Q_{\{L\to L\}} + Q_{\{0\to L\}})v_L - \lambda(Q_{\{L\to H\}} + Q_{\{0\to H\}})v_H$ equals $U(v_H, \bar{p}|\Lambda(C)) = v_H - \bar{p} - \lambda Q_{\{H\to 0\}}(\bar{p} - \hat{p}_{\{H\to 0\}}) - \lambda Q_{\{H\to L\}}(\bar{p} - \hat{p}_{\{H\to L\}}) - \lambda Q_{\{L\to 0\}}(\bar{p} - \hat{p}_{\{L\to 0\}})$, which is equivalent to

$$\begin{aligned}
&(v_H - c_L) + \lambda(Q_{\{H\to 0\}} + Q_{\{L\to 0\}} + Q_{\{H\to L\}})(v_H - c_L) = \\
&\qquad [1 + \lambda(Q_{\{L\to H\}} + Q_{\{0\to H\}})][1 + \lambda(Q_{\{H\to 0\}} + Q_{\{H\to L\}})](v_H - v_L) \\
&\quad - \lambda[1 + \lambda(Q_{\{H\to 0\}} + Q_{\{L\to 0\}} + Q_{\{H\to L\}})]\{(Q_{\{H\to L\}} + Q_{\{L\to L\}} + Q_{\{0\to L\}})v_L \\
&\qquad\qquad + (Q_{\{L\to H\}} + Q_{\{0\to H\}})v_H - (Q_{\{H\to 0\}} + Q_{\{L\to 0\}})c_L\}.
\end{aligned} \tag{B.6}$$

If at all, (B.6) holds for at most two values of λ and thus generically is not satisfied.

□

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