PROPERTY AND LIABILITY RULES IN THE LIGHT OF BARGAINING UNDER ASYMMETRIC INFORMATION

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1 Introduction

My thesis examines the efficiency and welfare implications of property rules and liability rules as legal mechanisms for protecting entitlements in situations of bargaining under asymmetric information.

Property rules require the consent of the entitlement holder for any transfer, while liability rules allow non-consensual transfers subject to compensation. The choice between these two types of rules has been extensively debated in the law and economics literature, following the seminal framework of Calabresi and Melamed (1972). According to Calabresi and Melamed (1972), liability rules are better when transaction costs are high and prevent bargaining, while property rules are better when transaction costs are low (Ayres and Goldbart 2003; Cooter and Ulen 2012; Posner 2014). However, Kaplow and Shavell (1995, 1996) challenge this view. They argue that liability rules always improve welfare by allowing efficient takings, regardless of transaction costs. They doubt that property rules can facilitate trade enough to outweigh the benefit of liability rules (Kaplow and Shavell 1995).

The debate continues but most of the existing literature assumes that the parties have symmetric or complete information about each other's valuations. This assumption is often unrealistic, especially in complex and dynamic environments. The main contribution of this thesis is to relax the symmetry assumption and analyze how asymmetric information affects the performance of property rules and liability rules in terms of efficiency. Asymmetric information is a key source of transaction costs. It not only makes transactions costly, but also changes the bargaining behavior of the parties. For example, a seller with private information may overstate the value of the entitlement, while a buyer with private information may understate it. This can lead to inefficient trade, or no trade at all. My thesis analyzes whether the effect of asymmetric information on bargaining and efficiency differs between property and liability rules, and which factors determine the optimal rule in situations of asymmetric information and bargaining.

Importantly, my thesis assumes that under a liability rule the court awards the owner his true valuation as compensation if someone takes his entitlement. Such a “variable” liability rule makes the owner indifferent between keeping the entitlement and being compensated for it. By contrast, liability rules are usually assumed to be “fixed”, i.e. damages are set in advance or according to a market value. Here, the owner is not indifferent between keeping the entitlement and being compensated for it. A fixed rule may be better for bargaining, but real-world liability rules are usually variable. For example, in the US, liability for torts follows the make-whole principle, extends to consequential damages, and covers even unforeseeable harm rooted in the plaintiff's conditions (American Law Institute 2010, §§ 2, 4, 6, 7). Contract damages include the value of performance and any other loss caused by the breach, which depends on the plaintiff's particular situation (American Law Institute 1981, § 347). Equally, the German civil code states in section 249 with regards to the extent of compensation of damages:

„(1) A person who is liable in damages is to restore the position that would exist if the circumstance obliging them to pay damages had not occurred."

My thesis models the law based on its actual content, not its "presumable" ideal form or judicial shortcomings. Chapter 2.1 discusses this assumption in more detail.

Property and liability rules are important concepts in many legal fields, such as torts, contracts, intellectual property, and antitrust law. In contract law, they correspond to the remedies of specific performance and expectation damages. Chapter 4 focuses on the field of contracts and these remedies. The difference between the two remedies got media attention when Elon Musk, the owner of Tesla and SpaceX, announced his plan to buy Twitter in October 2022, but later changed his mind. Twitter threatened to sue him for breach of contract (see Bloomberg article by Levine, 2022). Hence, the topic is classical but remains to be highly relevant.

In order to examine the efficiency and welfare implications of property rules and liability rules in situations of bargaining under asymmetric information my thesis combines theory and empirics. It covers one-sided asymmetric information as well as two-sided asymmetric information. The thesis consists of three chapters. Each is based on a separate paper. It starts with a game-theoretic approach and models the interaction between the owner of an entitlement and the potential taker as a bargaining game with one-sided asymmetric information, the owner's valuation being private information (chapter 2). This is followed by an analysis with two-sided asymmetric information, the owner's and the taker's valuation being private information (chapter 3). This is combined with an analysis of a laboratory experiment with two-sided asymmetric information (chapter 4). Chapter 5 derives an overall conclusion putting the results from each chapter into relation.

2 Property and liability rules under one-sided asymmetric information[1]

2.1 Introduction

Liability rules allow the unilateral taking of an entitlement for compensation while property rules require the consent of the owner. Property rules thus force the use of contract to reallocate a protected resource. Calabresi and Melamed (1972) famously recommend liability rules when transaction costs are sufficiently high and prevent bargaining. Conversely, it has been called "one of the most basic tenets of law and economics scholarship" to prefer property rules when transaction costs are low (Ayres and Goldbart 2003, p. 123; Cooter and Ulen 2012, p. 100; Posner 2014).

Kaplow and Shavell (1995, 1996) have challenged the orthodox view.[2] They observe that, irrespective of the level of transaction costs, liability rules always add a welfare-enhancing option, the opportunity to take when it is efficient. While they recognize that property rules could somewhat facilitate efficient trade, they consider it unlikely that this advantage fully offsets the benefit of liability rules from efficient takings (Kaplow and Shavell 1995, p. 224). In this paper, we take Kaplow's and Shavell's conjecture head on by analyzing the effect of property and liability rules on bargaining. For asymmetric information—an important source of transaction costs—we show property rules to be more efficient than liability rules if the owner's valuation is private information. While liability rules have the expected benefit of substituting for a failed bargain, they also hamper reaching a consensus. Endogenizing transaction costs sheds new light on the race between property and liability rules.

Whether an entitlement should be reallocated from its owner to another party depends on the respective valuations. In our model, the owner's valuation is private information. If the parties fail to agree on a voluntary transfer, enforcing the owner's right under a property or liability rule is costly. We analyze the two polar cases of giving all bargaining power to either the uninformed other party (screening game) or the informed owner (signaling game). In the screening game, the efficiency advantage of property rules is less pronounced because the bargaining power of the potential "taker" restricts the owner's ability to benefit from her information advantage. For a small set of parameter values, liability rules surpass property rules, but even in the screening game the property rule prevails for extensive parameter regions. The results for the

[1] This chapter is based on a paper *"Ask, don't just take: Property rules are more efficient than liability rules under asymmetric information"* written in collaboration with Prof. Dr. Andreas Engert (unpublished working paper).

[2] See also Ayres (2005, ch. 9) and Ayres and Talley (1995a, 1995b); Ayres and Goldbart (2003).

signaling game are unequivocal. Vesting the informed party with full bargaining power accomplishes the first best under a property rule. Liability rules, by contrast, often entail a strictly positive probability of bargaining failure and inefficient unilateral taking.

Our results indicate that a liability rule's option to "just take" impedes the exchange of information in bargaining. The owner lacks an incentive to disclose his private information: if he did, the taker could capture the gains from trade by appropriating the entitlement and paying damages. Property rules force the taker to seek the owner's consent. This allows the owner to extract a share of the surplus, providing an incentive for truthful disclosure. By contrast, the option to take under a liability rule shifts bargaining power to the taker. Only the information asymmetry prevents the taker from capturing all the gains from a transfer.

One can have divergent intuitions about whether the informed or the uninformed party should have greater bargaining power. On the one hand, empowering the informed party gives it a greater share in the surplus and thus incentivizes it to use its private information. On the other hand, vesting more control in its opponent can force the informed party to share its information. In line with the second intuition, Ayres and Talley (1995a, 1995b) claim that a liability rule compels the owner to reveal a high valuation by offering to pay the taker for respecting the entitlement. The opposite finding of the present paper comes from the critical assumption that, after a unilateral taking, the court awards the owner his true valuation as compensation.[3] Such a "variable" liability rule continues to give the other party an option to take, but without knowing the strike price. Receiving his actual valuation as damages makes the owner indifferent between keeping the entitlement and being compensated for it. As a result, revealing his valuation only hurts the owner by informing the taker about the value of her outside option. By contrast, proponents of liability rules assume damages are set in advance and are commonly known by both parties. Under such a "fixed" liability rule, the owner is no longer indifferent between keeping the entitlement and being compensated for it. If his valuation exceeds the strike price, he will seek to pay the taker for not exercising the option. In the taxonomy of the bargaining literature, a variable liability rule makes the owner's valuation a "common value" while it remains a "private value" of the owner under a fixed liability rule.

This thesis thus extends the literature by investigating how a variable—not fixed—liability rule changes bargaining over the allocation of an entitlement. Although a fixed liability rule may provide better bargaining incentives, real-world liability rules tend to be variable. For instance,

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[3] To vary a common phrase, we assume the owner's valuation to be "unobservable but verifiable." A straightforward objection is that the court's knowledge of the owner's private information allows the parties to devise a contractual mechanism that induces truthful disclosure by the owner already at the bargaining stage. Basically, the owner would agree to pay a large penalty if the court later found his reported valuation to exceed the true one; with a stiff enough penalty, actual litigation could be kept to a minimum. Lavie and Tabbach (2020) study a mechanism along these lines for settlement bargaining. We ignore such mechanisms because they seem to be rarely used, if at all. Explaining their absence (e.g., with risk or rent-seeking costs) requires a different paper.

in the US liability for torts follows the make-whole principle, extends to consequential damages, and covers even unforeseeable harm rooted in the plaintiff's conditions (American Law Institute 2010, §§ 2, 4, 6, 7). Damages for contract breaches comprise the value of performance as well as "any other loss, including incidental or consequential loss, caused by the breach," which again reflects the plaintiff's particular circumstances (American Law Institute 1981, § 347). The foreseeability doctrine only excludes losses that were not a "probable result of the breach" (American Law Institute 1981, § 351); many jurisdictions outside the US do not even recognize such a limitation. The only real-world correspondence of a fixed liability rule is liquidated damages where the parties stipulate a compensation amount in advance (American Law Institute 1981, § 356).

Of course, existing liability rules could be misconceived. One might argue that property rules should have to compete against the optimal alternative, a fixed liability rule, not existing law. However, the law may well have efficiency reasons for sticking to variable liability rules: assessing the actual loss suffered by the plaintiff in a given case can be a cost-efficient strategy to ensure that expected liability equals expected harm. Setting a fixed compensation in advance necessitates defining case classes or compensation formulas based on observable characteristics. Determining the appropriate parameters for such a general scheme requires expertise about the distribution of valuations across possible cases. Moreover, the theorized advantages of fixed liability rules hinge in owners' and takers' knowledge of the compensation schedule. Only anticipating the court-imposed price will induce them to reveal their potentially higher or lower valuations. The compensation formula thus needs to be common knowledge. In light of these demands, the advantage of fixed liability rules could prove elusive except when the parties themselves have set liquidated damages.

A second important assumption of our model besides variable damages is that administering the rule involves cost. Assessing damages replaces an agreed-upon transfer with a transaction designed by the court. If bargaining is costly, then so must be invoking the court as an arbiter (see Macneil 1982 for contract remedies). The respective costs reflect the time, effort, and expense that the court and the parties devote to determining damages, including through evidence collection and for settlement bargaining to avoid even higher litigation costs.[4] While conflict costs burden the liability rule, the race between the property and liability protection of entitlements turns on more than a trivial tradeoff between these costs and allocative efficiency. The liability rule often loses on both counts.

4 Litigation is expensive; negotiating a settlement in the shadow of a court judgment is cheaper but not free. Insurance data for personal injury liability of Texan firms revealed a cost-to-net-payment quota of 75%, including for cases before filing suit (Hersch and Viscusi 2007). National experts have estimated the litigation expenses for a complex contract breach case over €5 million profit loss at 52% of claim value in England, 13% in Japan, and 4% in Germany (Hodges, Vogenauer, and Tulibacka 2011).

The rest of this chapter is structured as follows. Section 2.2 considers the related literature. Sections 2.3 and 2.4 present and analyze the signaling and screening games, respectively. Section 2.5 attributes the differences in welfare outcomes to conflict costs and allocative inefficiencies; it also looks at the distributive effects of liability and property protection. Section 2.6 concludes.

2.2 Related literature

The debate over property and liability rules begins with the seminal contribution of Calabresi and Melamed (1972; for overviews, see Porat 2017; Rizzolli 2008). The traditional view has attributed different virtues to the two modes of entitlement protection: property rules are "market-encouraging" because they require mutual consent for the transfer of an entitlement, whereas liability rules are said to be "market-mimicking" because they enable transactions that would have occurred in a frictionless market (Calabresi and Melamed 1972; Haddock, McChesney, and Spiegel 1990; Craswell 1993; Cooter and Ulen 2012). The present paper provides analytical support for this original view, opposing the more recent claim that liability rules are generally superior to property rules. Kaplow and Shavell (1995, 1996) have made this latter argument in its most simple and straightforward form. They frame the issue as a race between the two types of entitlement protection. The liability rule has a head start because it permits an efficient allocation even if transaction costs prevent voluntary transfers. The property rule never quite catches up: As transaction costs decline and bargaining becomes available, the Coase theorem neutralizes any difference between the two rules. The best the property rule can do is to tie with the liability rule.[5] Against this line of reasoning, the main contribution of our paper is to reassert and spell out the original intuition that property rules facilitate market exchange to a greater degree than do liability rules. For the case of private information about the owner's valuation, we show that transaction costs are not exogenous to the choice of entitlement protection. A property rule can reduce transaction costs beyond what a liability rule accomplishes, thus producing better overall welfare outcomes.

It deserves note that the choice between property and liability rules has direct application in contract law, where the specific performance remedy represents a property rule and expectation damages a liability rule (Porat 2017; Kronman 1978). Interestingly, however, the debate over efficient breach (Shavell 1980, 1984; Schwartz and Edlin 2003; Miceli 2004; Eisenberg 2005; Schwartz and Scott 2008) has largely avoided to engage with the Calabresi-Melamed framework. A likely reason is that the traditional view to prefer property rules when bargaining is possible would suggest to rely on specific performance between contract parties that, by definition, have shown themselves capable of contracting (Ayres and Goldbart 2003, p. 128). By contrast, the standard argument in favor of "efficient breach"—and hence expectation damages as the sole remedy—has been to avoid the cost and risk of having to negotiate around performance if the contract has become inefficient (Kronman 1978; Shavell 1984, 2006; but see Schwartz 1979). In this context, our contribution picks up on the observation of Eisenberg

[5] Importantly, Kaplow and Shavell (1995, 1996a) fully recognize that asymmetric information can give property rules an advantage. They clearly mark their reasoning as only suggestive and a "conjecture." Their own analysis of transaction costs under the competing rules yields no clear-cut result because they assume a fixed liability rule.

(2005) that efficient breach becomes difficult if a promisor is uncertain about the value of performance to the promisee. In this setting, having to renegotiate the contract is not a useless burden but a way to elicit information about the continuing efficiency of performance. Our results suggest that specific performance, by forcing the promisor to seek the promisee's consent for non-performance, encourages information exchange between the parties.

The existing literature has not ignored the effects of entitlement protection on the cost of reaching voluntary agreement. In fact, important contributions have arrived at the opposite conclusion that a liability rule performs better than a property rule at reducing transaction costs and eliciting private information (Ayres and Talley 1995a, 1995b; Ayres and Balkin 1996, pp. 736–41; Ayres 2005, ch. 9 and 10).[6] This directly contradicts our findings. The reason lies in a critical assumption: Proponents of liability rules suppose that damages consist in a fixed amount that is common knowledge between the parties. For them, the liability rule amounts to a call option with a set strike price. Such a fixed liability rule incentivizes the owner to reveal a high valuation by offering a side-payment to a potential taker; this extra incentive is lacking under a property rule that always assures the owner the value of his entitlement.[7] By contrast, our analysis assumes a variable liability rule under which the court assesses the actual loss suffered by the owner from a unilateral taking; damages amount to the owner's true valuation that, during bargaining, had been his private information.[8] We have motivated this modeling choice in the introduction of this chapter. Pursuing its implications for the relative efficiency of property and liability rule protection distinguishes the present paper from these prior contributions.

Other related work abstracts from bargaining and instead focuses on the unilateral decision to take or respect the entitlement. Here, too, variable liability rules—where damages reflect the other party's actual loss—prove to be inferior to their fixed counterparts (Liu and Avraham 2012; Avraham and Liu 2012).[9] Several studies have investigated the welfare implications of more general classes of unilateral options at fixed strike prices (for various combinations of fixed and bilateral liability rules, see Avraham 2004 and Ayres and Goldbart 2003; for repeated mutual takings as auctions, Ayres and Balkin 1996; see, generally, Ayres 2005). Insofar as this literature abstracts from bargaining, property rules are no serious contenders for efficiency. An apparent exception is Avraham and Liu (2012) who compare specific performance in contract law with fixed and variable expectation damages. At first sight, their results align with ours in

[6] See also Kaplow and Shavell (1996, pp. 735–36, 785).

[7] Although Johnston (1995) considers a property rule, his findings resemble those of Ayres, Talley, Balkin, and Goldbart: He assumes an uncertain initial allocation of the entitlement with a commonly known probability distribution. This effectively corresponds to a fixed liability rule. Croson and Johnston (2000) confirm in an experiment that such a split entitlement facilitates bargaining.

[8] A "tailoring" liability rule in the language of Ayres and Talley (1995a, pp. 1065–72).

[9] In an extension, Avraham and Liu (2012) consider bargaining but without asymmetric information by assuming that, at this stage, pre-trial discovery has already revealed the owner's (buyer's) valuation.

that they find specific performance to be superior to variable expectation damages. A key difference, however, is that the promisee in Avraham's and Liu's model can enforce specific performance only in exchange for paying the contract price. Thus, their specific performance remedy effectively amounts to a put-option-type fixed liability rule where the owner—instead of the "taker"—has a choice between keeping the entitlement and selling it to the taker at a preset price.[10] Therefore, their comparison, unlike ours, is in fact not between a property and a liability rule.[11] Overall, the crucial difference of the present paper from the options literature consists in analyzing bargaining under a variable liability rule.[12] This assumption reinstates the property rule's claim to efficiency.

The variable liability rule introduces an information asymmetry: the parties bargain in the shadow of an impending judgment while only one of them—the owner—knows how the court will decide. The setup resembles that in settlement bargaining, which has been studied extensively (Bebchuk 1984; Reinganum and Wilde 1986; Schweizer 1989; Daughety and Reinganum 1994, 1995; Schwartz and Wickelgren 2009; Farmer and Pecorino 2013; for overviews Daughety and Reinganum 2012, 2014). There is, however, a critical difference: negotiating over a settlement has the sole purpose of avoiding costly litigation. Both parties know that trade is efficient and disagree only about the distribution of gains. Conversely, bargaining in our model is not just about saving conflict costs but also about allocating the entitlement efficiently. The uninformed party is uncertain whether an agreement range exists. In the taxonomy of Ausubel, Cramton and Deneckere (2002), there is a "gap" between valuation distributions in settlement bargaining; ours, by contrast, is a "no gap" case. The literature about settlement bargaining, therefore, does not carry over to bargaining over entitlements under different protection rules.

10 Different from the put options contemplated in the property-law literature, the promisee's (owner's) choice in Avraham and Liu (2012) arises only after the promisor (taker) has indicated that she would prefer to breach the promise (take the entitlement). In the classic property-law taxonomy, put-option liability rules are known as "rule 5," see Avraham (2004, p. 272), attributing their discovery to Krier and Schwab (1995).

11 A recent article by Schmitz (2022) compares specific performance with an "at-will contract" that allows the promisor to cancel the contractual exchange; this effectively amounts to a fixed liability rule where the promisor can breach ("take") at the cost of losing the contract price. The novel twist is that the promisor learns her own performance cost (valuation) only with a certain probability. Schmitz finds the fixed liability rule to be superior for low probabilities of an informed promisor but not for higher probabilities.

12 Avraham (2004, n. 13) argues that a well-designed option scheme constitutes a second-best mechanism, implying that bargaining under any rule cannot achieve a better outcome than the option design; see also Schmitz (2022, pp. 2573–75). However, this only helps if fixed-price options are feasible, contrary to our assumption.

2.3 Signaling game

2.3.1 Model

Our model concerns the “holder” or “owner” of an entitlement (“he”) and a potential “taker” (“she”). The owner’s valuation v of the entitlement is private information; the taker’s valuation w is common knowledge. Both valuations are drawn independently from a uniform distribution over the interval $[0, H]$ with $H > 0$. In the signaling model, it is for the owner to make a demand x. If the taker accepts, the owner’s payoff is $\Pi_O = x$ whereas the taker receives $\Pi_T = w - x$. If the demand is rejected, continuation again hinges on the available remedy.

Under a *liability rule*, the taker can choose to take unilaterally. If she does, the owner can enforce a claim for monetary damages. The court observes v and orders the taker to pay v as expectation damages to the owner. However, litigation—or settlement bargaining to avoid it—impose expected conflict costs ϕ on each party. Unilateral taking thus results in payoffs $\Pi_O = v - \phi$ for the owner and $\Pi_T = w - v - \phi$ for the taker.[13] If the taker abstains from appropriating the entitlement, no conflict arises. This results in payoffs of $\Pi_O = v$ and $\Pi_T = 0$.[14] Figure 1 shows the game tree (without nature’s first moves of choosing v and w).

[13] We assume that the owner always seeks damages if the taker takes his right, incurring cost ϕ. If $v < \phi$, the holder may still derive additional utility from holding the taker to account, or she might seek to preserve a reputation for defending her rights. We could as well assume $v \in [L, H]$ with $L > \phi$ but wanted to save notation.

[14] One could challenge the no-conflict assumption. Respecting a right may not be trivial as the parties can disagree over the scope of the owner’s entitlement. For instance, a dispute can arise over whether a patent covers a particular technological process or—in a contractual setting—whether the promisor’s performance meets the contractual specification. In a more complicated version of our model, we assumed conflict cost ψ for each party if there is no agreement and the taker chooses to respect the entitlement. With $\phi > \psi$, we obtained essentially the same results as in the present simpler model. The more complex version is available on request.

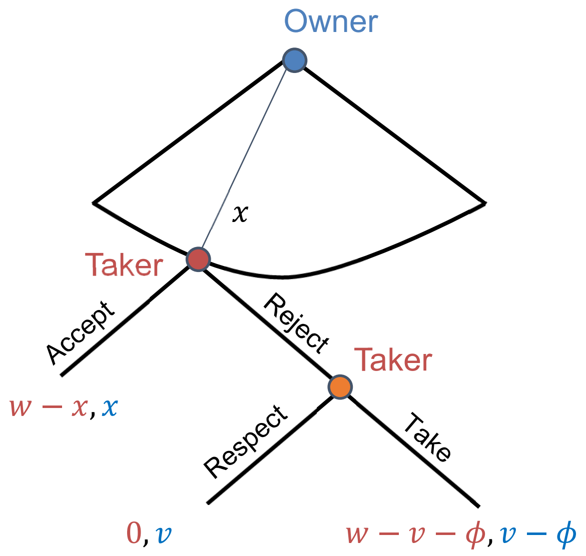

Figure 1: Signaling game with liability rule

With a *property rule* as the remedy, if the parties fail to reach agreement the owner keeps the entitlement. As under the liability rule, forcing the taker to respect the entitlement imposes no conflict cost.[15] Payoffs are $\Pi_O = v$ and $\Pi_T = 0$. The signaling game is summarized in Figure 2.

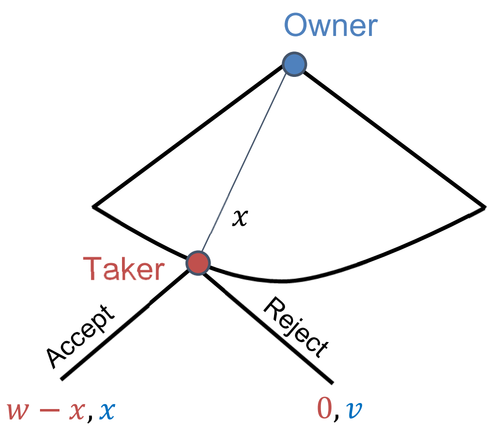

Figure 2: Signaling game with property rule

[15] For the more complicated analysis with conflict costs also under the property rule see the preceding footnote.

Before examining the equilibria and welfare consequences under the property and liability rules, we fix the first best as a reference. Under first-best behavior, the taker never takes the entitlement even under a liability rule because a voluntary transfer is always cheaper than incurring conflict costs ϕ. The total first-best payoff for both parties then obviously is

$$\Pi_{FB} = \begin{cases} w & v \leq w \\ v & v > w \end{cases}$$

The expected value in v then is

$$\mathrm{E}_v(\Pi_{FB}) = \frac{w^2}{H} + \left(1 - \frac{w}{H}\right)\left(\frac{w + H}{2}\right)$$

2.3.2 Equilibria

In the signaling game, the owner has both complete information and all the bargaining power. Under a property rule, the taker accepts all offers $x \leq w$. The owner demands the highest acceptable price $x = w$ if this makes him better off than the payoff v from keeping the entitlement. This allows him to capture all available surplus, leading to full separation:

Proposition 1. Equilibrium of the signaling game under the property rule

> An owner with $v \leq w$ demands $x = w$, which the taker accepts. If the owner's valuation is higher, $v > w$, he makes an unacceptable offer $x > w$ that the taker rejects.

By contrast, equilibrium play under a liability rule is more complicated.

Proposition 2. Equilibrium of the signaling game under the liability rule

Define cutoffs $\bar{v} = 2\phi \ln 2$ and $\bar{\bar{v}} = 2w - 2\phi - H$.

(I) For low taker valuations $w \leq 2\phi$, there is a semi-separating equilibrium in pure strategies:

Owners with $v \leq w$ demand $x = w$, which takers accept.

Owners with $v > w$ demand $x > w$; takers reject and respect the entitlement.

(II) For lower intermediate taker valuations with $2\phi < w \leq \bar{v} + \phi$, there is a semi-separating equilibrium with mixed taker strategies:

Owners with $v \leq w - \phi$ demand $x = v + \phi$, which takers accepts with probability $p(x) = e^{\frac{\phi - x}{2\phi}}$; otherwise, they reject and take the entitlement.

Owners with $v > w - \phi$ demand $x > w$; takers reject and respect the entitlement.

(III) For higher intermediate taker valuations with $\bar{v} + \phi < w \leq \frac{H + \bar{v}}{2} + \phi$, there is a semi-separating equilibrium with mixed taker strategies:

Owners with $v \leq \bar{v}$ demand $x = v + \phi$, which takers accept with probability $p(x) = e^{\frac{\phi - x}{2\phi}}$; otherwise, they reject and take the entitlement.

Owners with $v > \bar{v}$ demand $x > w$; takers reject and respect the entitlement.

(IV) For high taker valuations with $\frac{H + \bar{v}}{2} + \phi < w \leq H$, there is a semi-separating equilibrium with mixed taker strategies:

Owners with $v \leq \bar{\bar{v}}$ demand $x = v + \phi$, which takers accept with probability $p(x) = e^{\frac{\phi - x}{2\phi}}$; otherwise, they reject and take the entitlement.

Owners with $v > \bar{\bar{v}}$ demand $x > w$; takers reject and respect the entitlement with probability $\pi = 2e^{-\frac{2w - 2\phi - H}{2\phi}}$; otherwise they reject and take the entitlement.

Here and in the following, all proofs are relegated to the appendix. For a small range of low taker valuations ($w \leq 2\phi$), we find a pure strategy equilibrium that equals the one under the property rule in Proposition 1. This equilibrium is driven by conflict costs, which prevent the taker from seizing the entitlement. With a higher taker valuation, the equilibria deviate from the one under the property rule. The owner no longer can claim all the surplus from trade due to the taker's option to appropriate the entitlement unilaterally. The resulting equilibria involve mixed strategies by the taker. All three equilibria share the common feature that owners separate in two groups: The lower-valuation owners make the fully revealing demand $x = v + \phi$; takers randomize between accepting and rejecting followed by taking ("reject-take" for short). Higher-valuation owners make demands that no taker accepts. The equilibria differ in cutoffs between the two owner groups as well as in how takers respond to inacceptable demands.

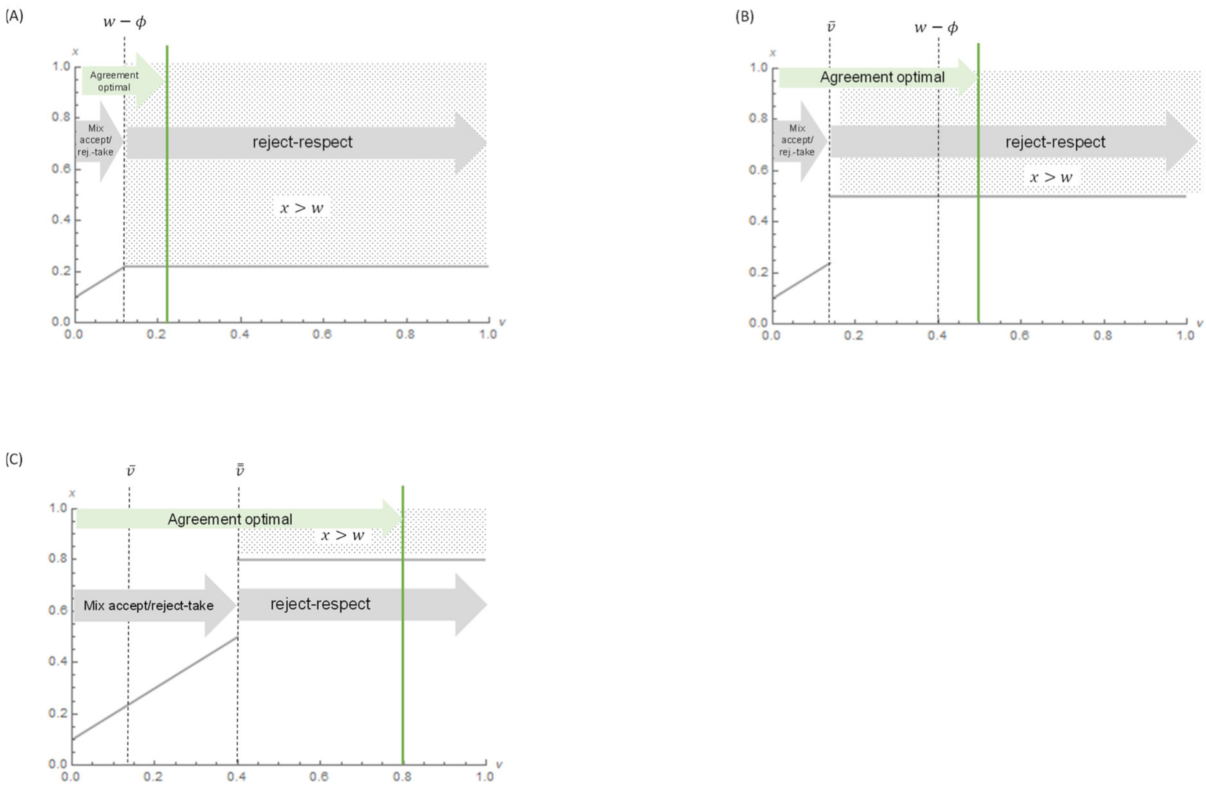

Figure 3: Equilibrium owner demands in signaling game under liability rule

Owner demands x as a function of owner's valuation v with $H = 1,\ \phi = 0.1$ under the liability rule. The dotted area represents inacceptable demands $x > w$. Pane (A) exemplifies case (II) from Proposition 2 with $w = 0.22$, pane (B) reflects case (III) with $w = 0.5$, and pane (C) case (IV) with $w = 0.8$.

Figure 3 summarizes the interesting cases (II)–(IV) from Proposition 2. To grasp the intuition behind the equilibrium, start by considering pane (A) for "lower intermediate" taker valuations, reflecting Proposition 2 (II). Takers reject demands $x > w$ and subsequently respect the entitlement ("reject-respect" for short) because owners making such high demands are from the higher-valuation group. To induce owners from the lower-valuation group with $v \leq w - \phi$ to make revealing demands $x = v + \phi$, takers randomize between accept and reject-take. The acceptance probability must prevent the owner from mimicking, firstly, a higher type within the low-valuation (separating) group and, secondly, a type from the high-valuation (pooling) group. The first constraint requires that a higher demand is associated with a lower probability of acceptance, as $p(x)$ in Proposition 2 provides. For the second constraint to be met, the acceptance probability cannot fall below a certain threshold. The cutoff $\bar{v} = 2\phi \ln 2$ reflects this limitation—it is the highest owner valuation for which randomization with acceptance probability $p(x)$ can induce separating demands, given the second constraint.

The threshold $\bar{v}$ is not yet binding in case (II) of Proposition 2 because it is preempted by another constraint, namely that for the taker to randomize between accept and reject-breach;

the demand $x = v + \phi$ must generate a higher payoff than rejecting the offer and respecting the entitlement. The latter constraint yields the cutoff $w - \phi$ in case (II). In case (III), $\bar{v}$ becomes binding. Owners with higher valuations no longer separate. Instead, they make inacceptable demands. Interestingly, this implies that certain demands are not made at all in equilibrium, as Figure 3 pane (B) shows.[16] Because taker valuations in case (III) are still at an "intermediate" level, takers respond with reject-respect.

With the high taker valuations of case (IV), a pure reject-respect response to an inacceptable demand as in case (III) is no longer in equilibrium: If it still were that all owners above $\bar{v}$ made an inacceptable demand, the taker would respond reject-take rather than reject-respect. But such a pure response would make it profitable for owners with valuations in the lower range of $]\bar{v}, H]$ to differentiate themselves by off-equilibrium demands between separating and inacceptable ones, that is, $\bar{v} + \phi < x \leq \frac{H+\bar{v}}{2} + \phi$. Takers would rather accept such a demand ($\Pi_T = w - x$) than reject-take (with $\Pi_T = w - \frac{H+\bar{v}}{2} - \phi$, given equilibrium play). The equilibrium with a pure reject-take response would unravel.

There is, however, also a viable equilibrium with a mixed taker strategy between reject-respect and reject-take as stated in case (IV). Randomizing between respecting and appropriating the entitlement impairs the owner's payoff from inacceptable demands and thereby loosens the constraint for separating demands; this allows case (IV) to extend the range of separating equilibria beyond $\bar{v}$. The randomization probability π indirectly determines the new owner valuation threshold $\bar{\bar{v}}$ for separating demands. $\bar{\bar{v}}$ and hence π need to ensure that the taker is indifferent between respecting and appropriating the entitlement when facing an inacceptable demand.

16 In the proof, we use the "intuitive" and the "divine" criterion to determine whether the equilibrium is robust to off-equilibrium demands.

2.3.3 Welfare

In the signaling model, the property rule is unambiguously superior from a welfare perspective. It always leads to efficient agreements whereas, with a liability rule, the parties' ability to conclude efficient agreements depends on the taker's valuation. For higher valuations, there is a strictly positive probability under the liability rule that the parties forego efficient trading opportunities. The following Proposition 3 states this result.

Proposition 3. Welfare comparison of the property and liability rules in the signaling game

(I) For low taker valuations $w \leq 2\phi$, property and liability rules are equally efficient.

(II) For high taker valuations $w > 2\phi$, property rules are more efficient.

Figure 4 illustrates the findings from Proposition 3. The curves represent the parties' total expected payoff as a function of the taker's valuation w under each rule. The upper line represents first-best total expected payoff and also the property rule. The different subsections within the figure represent the different equilibria shown in Proposition 2. In a setting of low taker's valuations ($w \leq 2\phi$), the parties behave equally under both rules, implying the same welfare outcome. With $2\phi < w \leq \frac{H+\bar{v}}{2} + \phi$ (Proposition 2 (II and III)), the liability rule produces two types of welfare losses: The taker does not always accept low demands but rejects with a certain probability and then takes the entitlement; this causes conflict costs. In addition, the taker respects the entitlement of owners with $w - \phi < v \leq w$ although a transfer would be efficient.

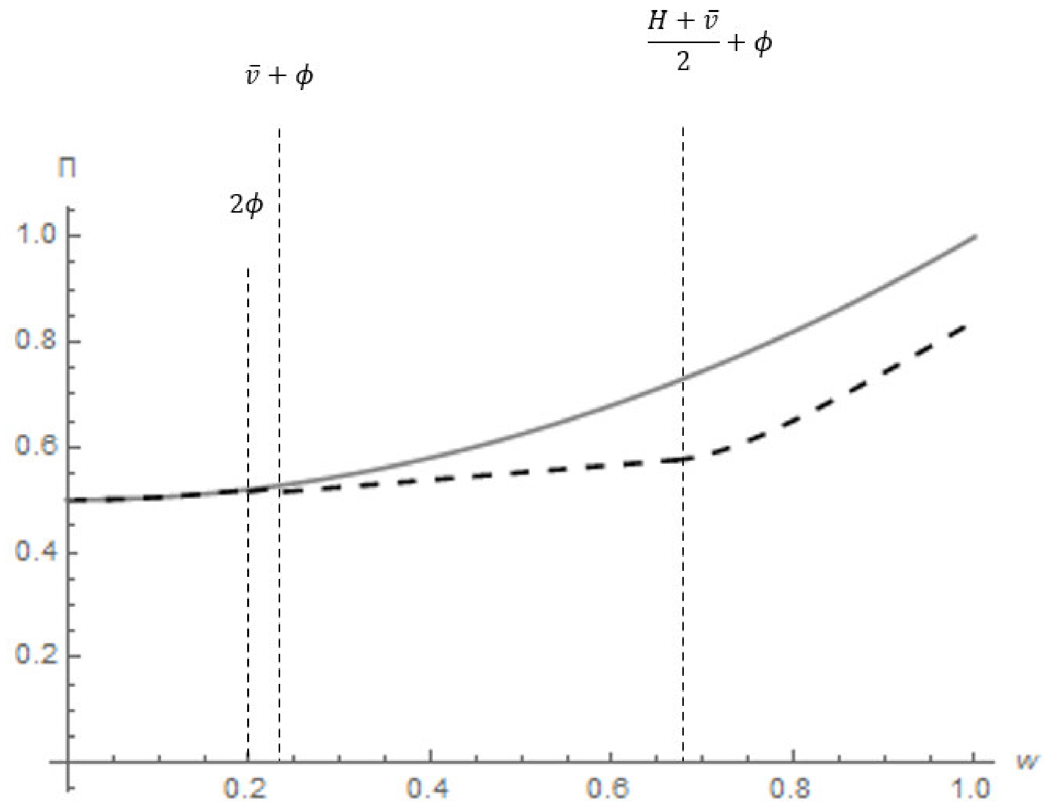

Figure 4: Total expected payoff in signaling game

Total expected payoffs Π as a function of taker's valuation w with $H = 1$, and $\phi = 0.1$. The gray line represents the property rule, which is also the first best, the dashed line the liability rule.

2.4 Screening game

2.4.1 Model

In the screening model, the taker makes a take-it-or-leave-it offer to buy the entitlement at price x. If the owner accepts, he receives a payoff $\Pi_O = x$; the taker's payoff is $\Pi_T = w - x$. If the owner rejects, continuation of the game again depends on the available remedy.

With *a* liability rule*,* the taker can choose to respect the entitlement, implying a payoff $\Pi_T = 0$ for her and a payoff to the owner of $\Pi_O = v$. If the taker appropriates the entitlement, she gets $\Pi_T = w - v - \phi$ and the owner $\Pi_O = v - \phi$. As in the signaling model, we assume that the owner always sues when his right is usurped. Figure 5 shows the game tree under a liability rule without nature's choice of v and w from $[0, H]$.

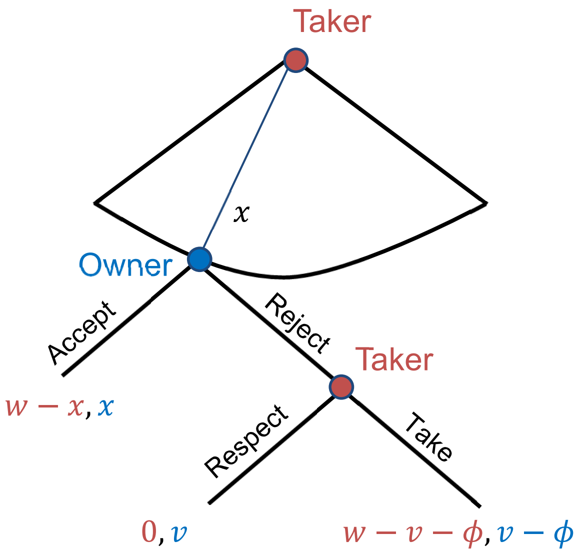

Figure 5: Screening game with liability rule

Under a *property rule*, the taker has to respect the entitlement if no agreement is made. Payoffs then are $\Pi_O = v$ and $\Pi_T = 0$.The game tree in Figure 6 presents the simpler situation under a property rule.

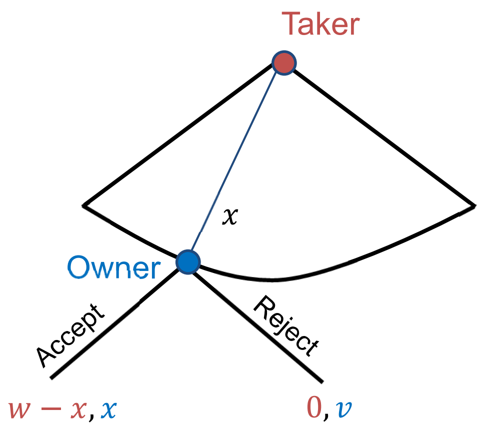

Figure 6: Screening game with a property rule

The first-best payoffs correspond to those under the signaling game in subsection 2.3.

2.4.2 Equilibria

Under the property rule, the taker's problem corresponds to that of a price-setting monopsonist with no ability to price discriminate. In making an offer, she trades off the opportunity to strike a deal with a higher-valuation owner against overpaying a low-valuation owner. Her payoff-maximizing offer is $x = \frac{w}{2}$, implying that efficient agreements with owners in the range $\frac{w}{2} < v \leq w$ are foregone. The following Proposition 4 states this equilibrium:

Proposition 4. Equilibrium of the screening game under the property rule

The taker offers $x = \frac{w}{2}$ and owners with $v \leq x$ accept.

Again, the analysis is more complicated for the liability rule. Proposition 5 specifies the resulting equilibrium:

Proposition 5. Equilibrium of the screening game under the liability rule

(I) For high conflict costs $H \leq H^I = \left(4 + 4\sqrt{2}\right)\phi$:

Takers with $w \leq w^{\bar{T}\dot{N}} = \frac{2}{9}\left(3H + 8\phi - \sqrt{\phi(3H + 10\phi)}\right)$ offer $x = \frac{w}{2}$ and owners with $v \leq \frac{w}{2}$ accept; if rejected, the taker respects the entitlement.

Takers with $w^{\bar{T}\dot{N}} < w \leq w^T = \frac{H}{2} + 2\phi$ offer $x = 2w - H - 3\phi$ and owners with $v \leq 2w - H - 2\phi$ accept; if rejected, the taker appropriates the entitlement.

Takers with $w > w^T$ offer $x = \phi$ and owners with $v \leq 2\phi$ accept; if rejected, the taker appropriates the entitlement.

(II) For low conflict costs $H > H^I$:

Takers with $w \leq w^{\dot{T}\dot{N}} = 2H - \sqrt{2}\sqrt{H^2 - 2H\phi + 4\phi^2}$ offer $x = \frac{w}{2}$ and owners with $v \leq \frac{w}{2}$ accept; if rejected, the taker respects the entitlement.

Takers with $w > w^{\dot{T}\dot{N}}$ offer $x = \phi$ and owners with $v \leq 2\phi$ accept; if rejected, the taker appropriates the entitlement.

The two value ranges of H capture the level of conflict costs relative to the distribution of the taker's and the owner's valuation. "Low H" thus means "high conflict costs." Because we have normalized the distributions of w and v to an interval from zero to H, one should not read H as the maximum value of the entitlement. Rather, it captures the distribution in valuations.

Figure 7 illustrates the equilibrium from Proposition 5. One main insight is that outcomes differ between property and liability protection only for higher taker valuations. Depending on conflict costs, the taker respects the entitlement for a broad range of valuations when her offer is rejected because expected damages plus conflict costs ϕ exceed the benefits from taking. In this range, the seller seeks to acquire the entitlement, mostly by offering the optimal monopsonist price $x = \frac{w}{2}$, just as she would under a property rule.

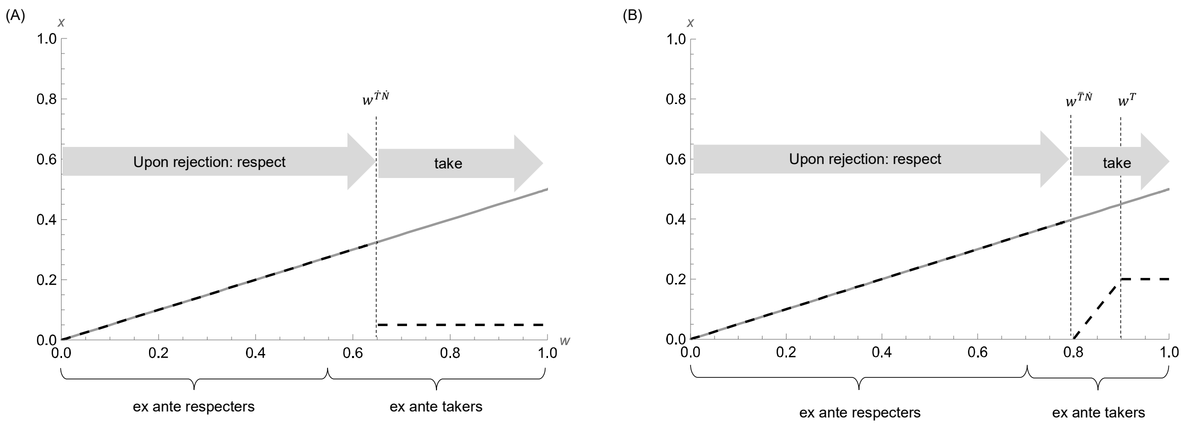

Figure 7: Equilibrium taker offers in screening game under liability rule

Equilibrium taker offers x as a function of taker's valuation w with $H = 1$. The gray lines depict taker offers under the property rule, the dashed lines under the liability rule. Pane (A) shows case (II) of Proposition 5 with low conflict costs ($\phi = 0.05$), pane (B) case (I) with high conflict costs ($\phi = 0.20$)). "Ex ante respecters" are takers who would have respected the entitlement under a liability rule in the absence of bargaining.

The opportunity to buy out lower-valuation owners also raises the taker's threshold for taking the entitlement after rejection because the remaining owners have a larger valuation v on average, which they can claim as damages if their right is taken. Bargaining produces information for the taker even if it breaks down, as the following remark states.

Remark 1

> Under liability protection, bargaining leads more takers to respect the entitlement: All three threshold values w^T, $w^{\bar{T}\dot{N}}$, and $w^{\dot{T}\dot{N}}$ for the taker respecting the entitlement after rejection exceed the taker valuation threshold $\frac{H}{2} + \phi$ above which the taker would appropriate the entitlement in the absence of bargaining.

For valuations greater than w^T, $w^{\bar{T}\dot{N}}$, and $w^{\dot{T}\dot{N}}$, respectively, takers are committed to appropriate the entitlement if no agreement is reached. They continue to screen, but only for owners with valuations low enough to warrant buying them out and avoiding conflict cost ϕ from an unconsented taking. Usually, takers offer $x = \phi$ to screen out such owners (Figure 7, pane (A)), which owners with $v \leq 2\phi$ accept. Yet sometimes an additional constraint arises: For takers with $w \leq w^T = \frac{H}{2} + 2\phi$, offering the full ϕ would raise the expected liability by so much that it would become optimal for the taker to respect, rather than take, upon rejection. This would make owners less willing to accept. Takers therefore restrict their offers to preserve the owners' pure belief in her commitment to take (Figure 7, pane (B) for $w^{\bar{T}\dot{N}} < w \leq w^T$).

2.4.3 Welfare

Figure 7 suggests that bargaining succeeds more often with property than with liability protection. Takers always offer $x = \frac{w}{2}$ under a property rule. Under a liability rule, while lower-valuation takers make the same offer $x = \frac{w}{2}$, takers with high valuations make rather unattractive offers.

The welfare consequences also depend on the response to bargaining failure. In this regard, a property rule has the disadvantage of preventing takers from appropriating the entitlement even if their valuation is very high. The following proposition shows that the benefits of property protection usually outweigh this shortcoming.

Proposition 6. Welfare comparison of the property and liability rules in the screening game

(I) For high conflict costs with $H \leq H^{I} = (4 + 4\sqrt{2})\phi$:

For $w \leq w^{\bar{T}\dot{N}} = \frac{2}{9}\left(3H + 8\phi - \sqrt{\phi(3H + 10\phi)}\right)$, both rules are equally efficient;

for $w > w^{\bar{T}\dot{N}}$, the property rule is more efficient.

(II) For intermediate conflict costs with $H^{I} < H \leq H^{II} = (8 + 4\sqrt{2})\phi$:

For $w \leq w^{\dot{T}\dot{N}} = 2H - \sqrt{2}\sqrt{H^2 - 2H\phi + 4\phi^2}$, both rules are equally efficient;

for $w > w^{\dot{T}\dot{N}}$, the property rule is more efficient.

(III) For low conflict costs with $H > H^{II}$:

For $w \leq w^{\dot{T}\dot{N}}$, both rules are equally efficient;

for $w^{\dot{T}\dot{N}} < w \leq w_{PRLR} = \frac{4}{3}H - \frac{2}{3}\sqrt{H^2 - 12H\phi + 24\phi^2}$, the property rule is more efficient;

for $w > \frac{4}{3}H - \frac{2}{3}\sqrt{H^2 - 12H\phi + 24\phi^2}$, the liability rule is more efficient.

The liability rule prevails only in case (III) of Proposition 6, for very low conflict costs ($H > H^{II}$), and even there only for certain taker valuations ($w > w_{PRLR}$). For higher conflict costs with $H \leq H^{II}$, the two types of entitlement protection are either equivalent or the property rule is more efficient.

Figure 8 illustrates the findings from Proposition 6. The curves represent the parties' total expected payoffs as a function of the taker's valuation w for the different cases of Proposition 6. As a reference, the upmost thin line shows the first-best total expected payoff from subsection 2.4.1.

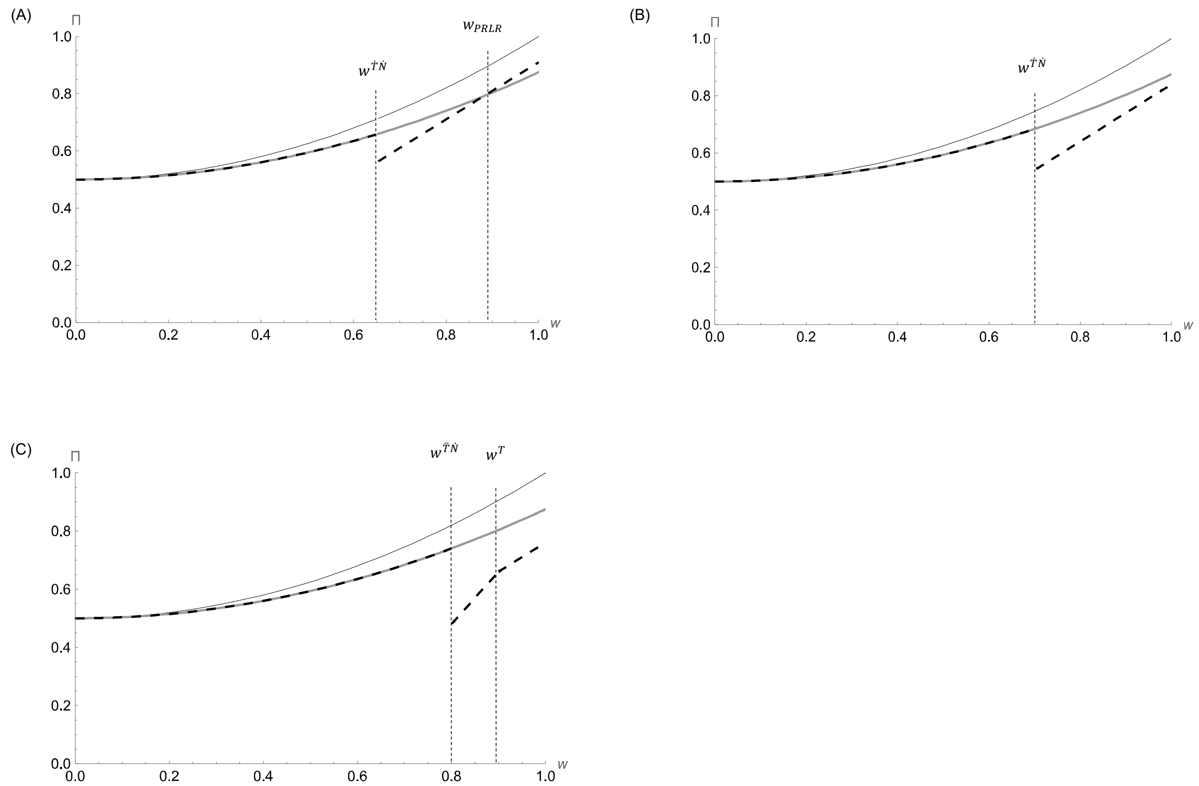

Figure 8: Total payoffs in screening game

Total payoffs Π as a function of taker's valuation w with $H = 1$. The upper gray line is the first best, the lower gray and dashed lines the property rule and the liability rule, respectively. Pane (A) shows case (III) of Proposition 6 with low conflict costs ($\phi = 0.05$), pane (B) case (II) with intermediate conflict costs ($\phi = 0.1$), and pane (C) case (I) with high conflict costs ($\phi = 0.2$).

2.5 Decomposing welfare and distribution effects

2.5.1 Welfare effects

Our analysis suggests that property rules enhance welfare compared to liability rules most of the time if the owner's valuation is private information. In this section we dissect the difference in the total expected payoff into allocative inefficiencies and conflict costs. An allocative inefficiency occurs if the owner keeps the entitlement although the taker's valuation is greater or, vice versa, if the taker obtains the entitlement despite a higher valuation by the owner.

For the signaling game, Figure 9 shows the welfare loss caused by the liability rule compared to the first best in terms of conflict costs (orange lines) and allocative inefficiencies (blue lines). The property rule always achieves the first best. Its superiority results not only from conflict cost savings but also from greater allocative efficiency; the property rule helps the parties to allocate resources better by eliciting private information. Pane (D) also illustrates that high conflict costs function as a sanction that can enforce respecting the entitlement eventually turning a liability rule into a property rule.

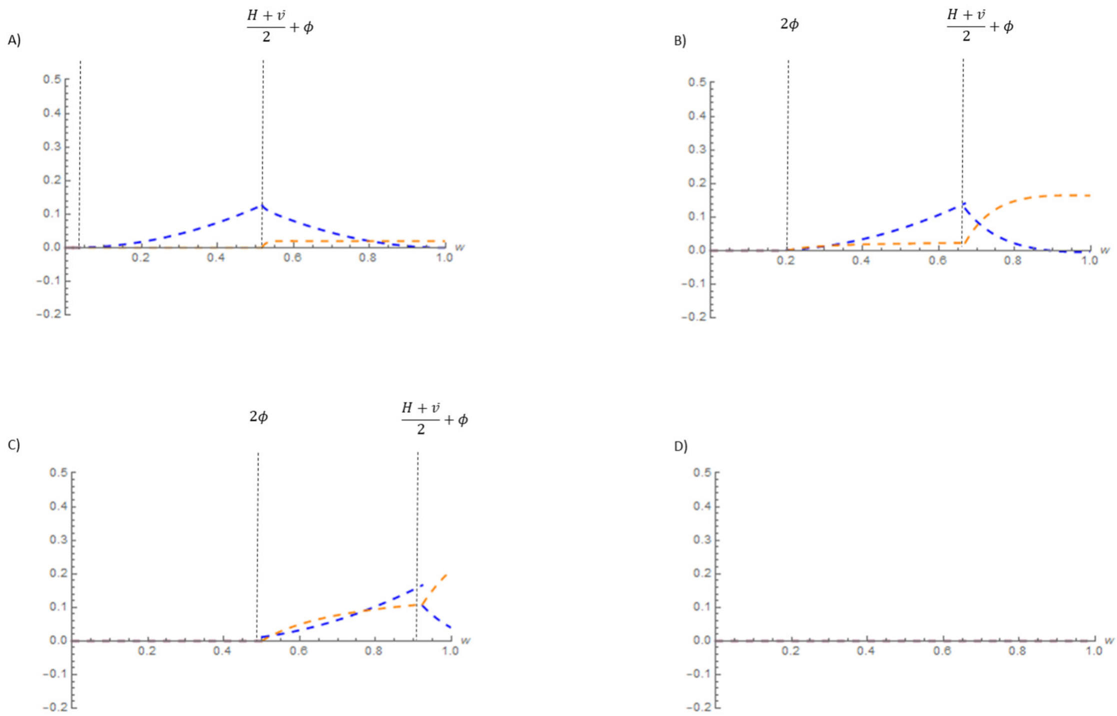

Figure 9: Welfare loss from liability rule in signaling game

Welfare loss from the liability rule as a function of the taker's valuation w with $H = 1$ in the signaling game decomposed into conflict costs (orange lines) and allocative inefficiency (blue lines). Panes (A)–(D) present increasing conflict costs ϕ of 0.01, 0.1, 0.25, and 0.65.

For the screening game, the picture is different. Here, both rules produce welfare losses in many cases. In Figure 10, inefficiencies caused by the property rule appear as straight, those from the liability rule as dashed lines. Conflict costs are represented by orange, allocative inefficiencies by blue lines. The liability rule now surpasses the property rule in terms of allocative efficiency. Yet the conflict costs it causes still make it inferior overall to the property rule in most cases.

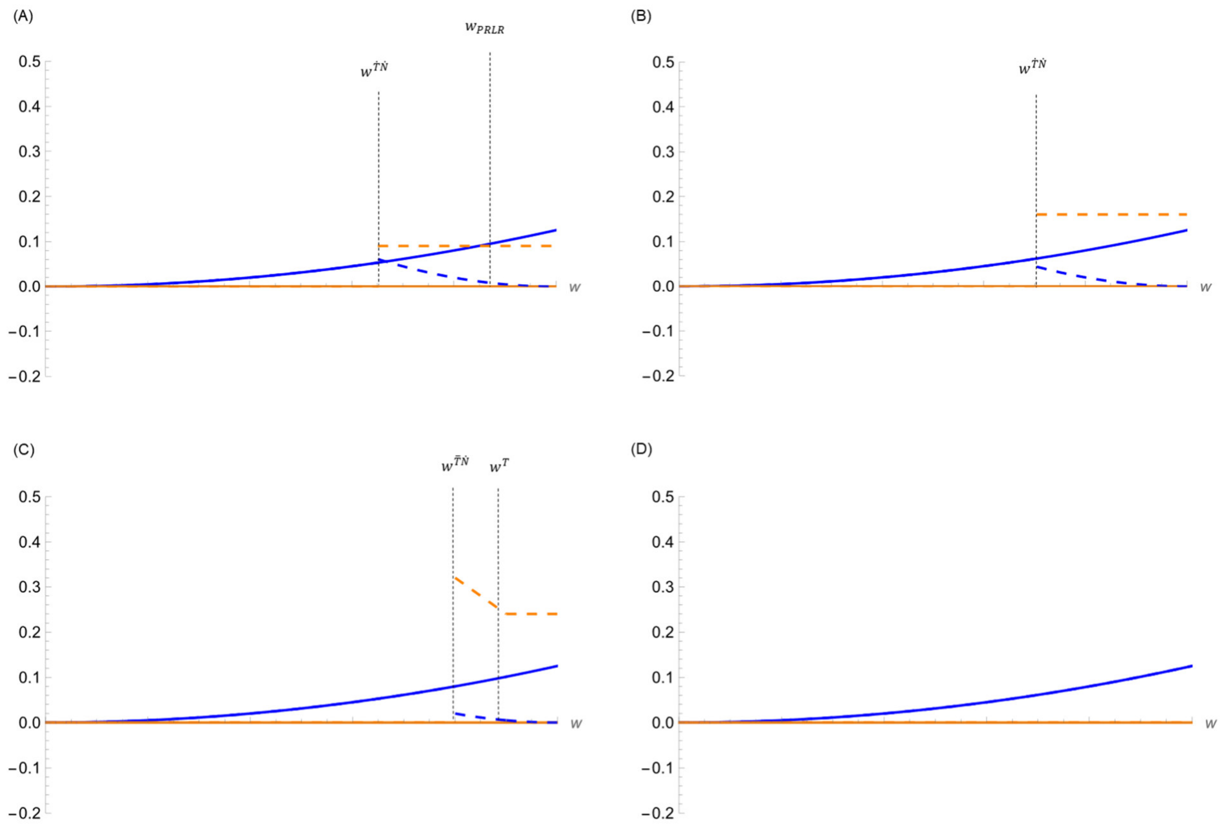

Figure 10: Welfare loss from property and liability rule in screening game

Welfare losses as a function of the taker's valuation w with $H = 1$ in the screening game decomposed into conflict costs (orange lines) and allocative inefficiencies (blue lines) for the property rule (straight lines) and the liability rule (dashed lines). Panes (A)–(D) present increasing conflict costs ϕ of 0.05, 0.1, 0.2, and 0.65.

2.5.2 Distribution effects

Besides efficiency, the choice between property and liability protection of entitlements can also affect the wealth distribution between the parties. Figure 11 and Figure 12 show the distributive outcomes for the owner (gray straight line) and the taker (black dashed line). The lines represent the difference in expected payoffs from the two rules, specifically from the property rule minus those under the liability rule. Figure 11 relates to the signaling game, Figure 12 to the screening game. As one would expect, the property rule invariably favors the owner. The owner's distributive advantage from the property rule tends to be more pronounced when facing a taker with a higher valuation. The distributive effect is mitigated in the screening game where the bargaining protocol favors the taker. Again, if conflict costs are sufficiently high the difference between property and liability rule disappears (Figure 11, pane (D)).

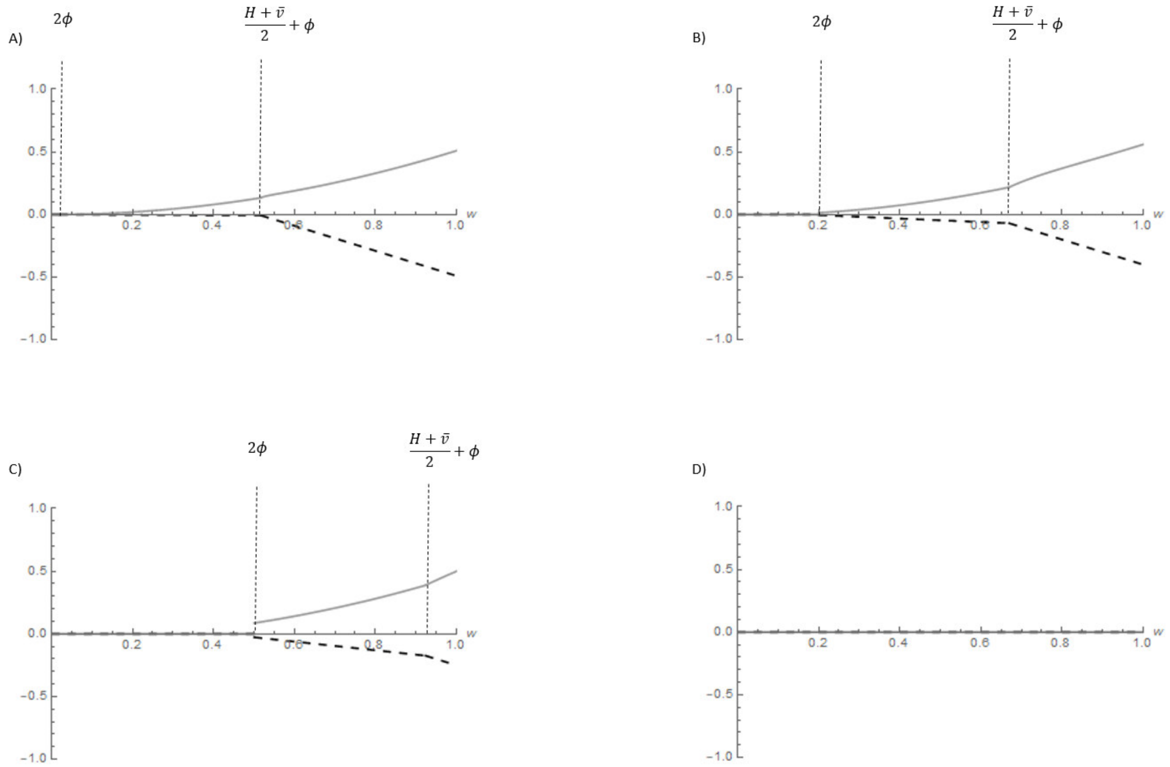

Figure 11: Distributive effects in signaling game

Distributive effects as a function of the taker's valuation w with $H = 1$ in the signaling game for the owner (gray straight lines) and the taker (black dashed lines). The lines show the payoff difference from the property rule minus the liability rule. Panes (A)–(D) present increasing conflict costs ϕ of 0.01, 0.1, 0.25, and 0.65.

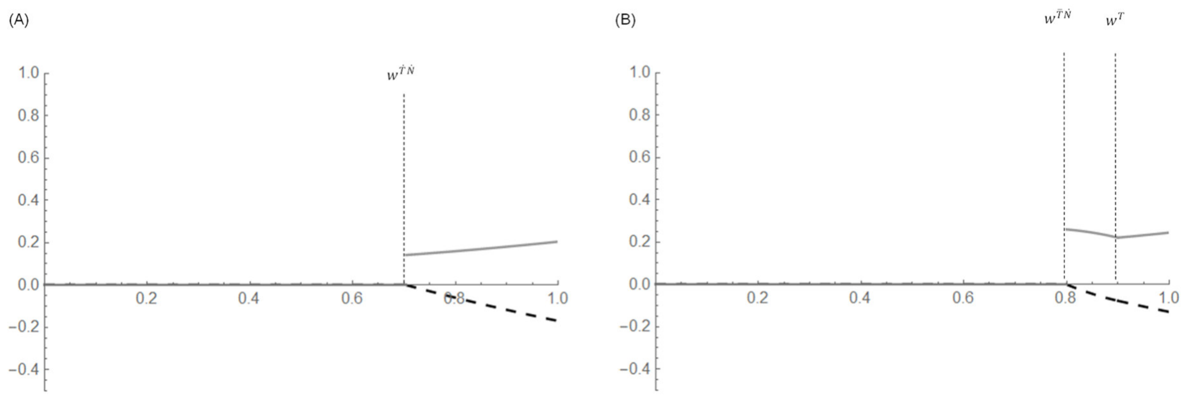

Figure 12: Distributive effects in screening game

Distributive effects as a function of the taker's valuation w with $H = 1$ in the screening game for the owner (gray straight lines) and the taker (black dashed lines). The lines show payoff difference from the property rule minus the liability rule. Pane (A) presents low conflict costs ($\phi = 0.1$) and pane (B) high conflict costs ($\phi = 0.2$).

2.6 Conclusion

Incomplete information increases transaction costs. This makes the property rule less attractive because it requires an agreement for an efficient transfer of a resource. Indeed, in the screening model of the present paper the liability rule shows an advantage in the efficient allocation of an entitlement despite private information about the valuation of the current owner. By allowing unilateral takings, the liability rule enables the taker to correct the shortcomings of the bargaining, at least in part. This effect is most needed in the screening game because it is least conducive to overcoming the information asymmetry by giving all bargaining power to the uninformed party. Yet it would be unrealistic to assume that a forced transfer is costless. Once administering liability entails a positive cost, the additional burden reverses the total welfare effect of the liability rule even in the screening game in most cases and gives the property rule the upper hand. The superiority of the property rule becomes complete in the signaling game that gives all bargaining power to the informed party and thus encourages the revelation of information.

Given the general character of Calabresi's and Melamed's framework, this result has important implications in a wide range of settings. The longstanding debate over contract remedies has already been mentioned. Of course, in each field other considerations will bear on the choice of entitlement protection. An example is how the distributional consequences of ex post bargaining under the different rules affect ex ante investment incentives. Other caveats relate to limitations in the assumptions: We have examined only the extreme cases of giving all bargaining power to either the owner or the taker. Also, real-world situations often involve information asymmetries about the valuation not only of the owner but also that of the taker. Exploring these complications is addressed in the following chapters.

3 Property and liability rules under two-sided asymmetric information[17]

3.1 Introduction

One of the key questions in the field of law pertains to how entitlements should be protected. This paper examines the impact of two-sided asymmetric information on efficiency with property and liability protection of entitlements.

Property rules grant rightsholders or owners (in the following: “owner”) the power to prevent others from infringing the entitlement. In contrast, liability rules give owners only the right to seek compensation if their entitlements are infringed upon by someone else (in the following: “taker”). In other words, the taker can enforce the transfer of the entitlement through taking without consent in exchange for paying damages. To illustrate this, let's consider patent law. A property rule in this context would enable a patent owner to take legal action, such as seeking an injunction, when someone infringes upon their patent. In contract law, specific performance serves as an example of a property rule, allowing the buyer to not only sue for damages if the seller fails to fulfill their obligations but also to insist that the seller actually performs the contract.

Different legal jurisdictions have different approaches to protecting entitlements. Generally, common law jurisdictions tend to favor liability rules, while civil law countries tend to prefer property rules. The conventional law and economics view recommends property rules if transaction costs are low and liability rules if transaction costs are high (Cooter and Ulen 2012, p. 100) as liability rules allow for unilateral takings of entitlements when parties fail to trade under a property rule.

For two-sided asymmetric information, an important source of transaction costs as famously shown by Myerson and Satterthwaite (1983), this paper challenges the conventional belief that liability rules are ideal by revealing inherent inefficiencies.

In a previous study (Engert and Hofmann, 2024), we examined the performance of property rules and liability rules under one-sided asymmetric information, where only the owner's valuation remained private. The results showed that the property rule is efficient when the informed owner makes the take-it-or-leave-it offer. In contrast, the liability rule hinders efficient outcomes by limiting the owner's bargaining power. When the taker makes the offer, the liability rule allows for efficient unilateral takings but undermines efficient agreements compared to the property rule.

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[17] This chapter is based on my paper *“Bargaining in the shadow of the law: Property versus liability protection under two-sided asymmetric information”* (Unpublished working paper).

Building on this, the current paper addresses the realistic scenario of two-sided asymmetric information, where both the owner's and the taker's valuations are private. Having one-sided asymmetric information put a focus on the bargaining hindering effect of liability rules and as a result came to a clear result recommending property rules for such scenarios. The analysis of this current paper reveals that two-sided asymmetric information complicates the efficiency of the rules in a nuanced manner and thereby fills an important gap. It shows that liability rules one the one hand help to overcome failed transfers under the property rule and on the other hand entail negative side-effects, as it results in inefficient takings and less effective bargaining. The model demonstrates that neither approach clearly dominates, as the outcomes depend on specific values and the distribution of types. The superiority of the liability rule arises as the transfer of entitlements becomes more clearly welfare enhancing on average. Conversely, the property rule gains a clearer advantage in situations where there is greater uncertainty surrounding the welfare-enhancing nature of the transfer. The property rule allows the parties to reveal information about their type through exchange offers, thereby promoting efficient outcomes. In such cases, the property rule leads to more efficient results.

In the presented model, either the taker or the owner makes a take-it-or-leave-it offer. If the opposing party declines the offer, the liability rule provides an alternative mechanism for transferring the entitlement. In this case, the taker unilaterally seizes the entitlement and compensates the owner. The amount of compensation is equivalent to the owner's valuation of the entitlement. It is important to note that the model assumes the court possesses knowledge of the true value of the owner's valuation and awards damages accordingly. This assumption aligns with the prevailing standard in the literature on bargaining settlements (see Daughety and Reinganum, 2012 p. 388) as well as with established norms and practices within the realm of law (see, e.g., American Law Institute 1981, §§ 347–354; 2010, §§ 26–31; see also discussion in introduction and Section 2.1).

The rest of the chapter is structured as follows. In section 3.2, we discuss the related literature. Section 3.3 contains the design of the model and its analysis. Section 3.4 concludes.

3.2 Related literature

The seminal article by Calabresi and Melamed (1972) on property and liability rules has given rise to a vast amount literature (see the survey by Rizzolli 2008). Few have analyzed the impact of asymmetric information.

Ayres and Talley (1995a, 1995b), Ayres and Goldbart (2003), and Ayres (2005) contend that a liability rule facilitates the disclosure of private information and thereby bargaining. They argue that a liability rule incentivizes the owner to disclose a particularly high valuation and offer the taker a payment to abstain from taking. But as they point out, this effect only exists if courts do not tailor damages to the owner's valuation (Ayres and Talley 1995a, pp. 1065–1069). It requires compensation to be a fixed amount known to the parties at the bargaining stage. Kaplow and Shavell (1996, p. 737) note that having such fixed amount reduces the asymmetry of information. Kaplow and Shavell (1995, 1996) portray the comparison of property and liability rules as a race. The liability has a head start if transaction costs prevent bargaining and both rules lead to the same outcome with zero transaction costs; as predicted by Coase theorem. Kaplow and Shavell (1995) suspect the property rule to catch up but not overtake the liability rule between those polar cases. The liability rules add a welfare-enhancing option, the opportunity to take when it is efficient. In Kaplow and Shavell (1996, p. 737) they declare that which rule is superior with imperfect bargaining is indeterminate because *"imperfect bargaining involves subtle and complex elements*" and bargaining may not be equally successful under both rules.

This analysis deviates from this literature, as mentioned in the outset, in that we assume damages to be tailored to the owner's valuation. This conforms to the law as it stands. In addition, it seems difficult for the law to adopt a rule which decrees a compensation amount both parties know at the bargaining stage.

In essence, Johnston (1995) shows a similar effect to Ayres, Talley, and Goldfarb discussed above. He shows that introducing uncertainty over the allocation of an entitlement under a property rule facilitates bargaining. Croson and Johnston (2000) find positive evidence in an experiment. Receiving the entitlement only with a known probability puts an owner in the same position as having an entitlement but receiving damages below his valuation. This causes high valuing types to make an offer. But as before, we see the difficulty that this requires the parties to know the probability of the court attributing the entitlement to either one of them.

This paper is closely linked to the literature on settlement bargaining as it models negotiation under incomplete information in the shadow of an expected ruling by a court (see Bebchuk 1984; Reinganum and Wilde 1986; Daughety and Reinganum 1994, 1995; Schwartz and Wickelgren 2009; Farmer and Pecorino 2013; Rapoport, Daniel, and Seale 2008; Schrag 1999; Schweizer 1989; for overviews Daughety and Reinganum 2012, 2014). The difference is that the literature on settlement bargaining focuses on the defendant paying the plaintiff to avoid litigation. Any agreement is efficient. The complexity is about how to share the gains. In contrast, in our setting it is not clear whether the parties should trade at all. There is “no gap” between the owners’ and the takers’ valuations as Ausubel, Cramton and Deneckere (2002) differentiate different “bargaining setups”. Thus, the literature about settlement bargaining does not speak to “how to protect entitlement”.

In the realm of contract law expectation damages, a liability rule, are argued to be superior to specific performance, a property rule, because they would prevent inefficient performance without the necessity to renegotiate (Kronman 1978; Shavell 1984, 2006; see generally for the debate over efficient breach: Schwartz and Edlin 2003; Miceli 2004; Eisenberg 2005; Schwartz and Scott 2008, Hofmann 2021). Eisenberg (2005) noted that efficient breach is impeded by uncertainty about the promisees valuation. This corresponds to our finding that liability rules do not always lead to takings where it would be efficient due to the asymmetry of information.

Avraham and Liu (2012) and Liu and Avraham (2012) compare expectation damages in its tailored and untailored form to specific performance under incomplete information with a special focus. They assess the effect of the buyer’s option not to sue if his valuation turns out to take a low value rendering it not beneficial to bring the seller to court. In contrast, in our analysis the owner always goes to court if the taker takes the entitlement.

Our topic needs to be distinguished from the literature on contract remedies and information disclosure at the contracting stage (Bebchuk and Shavell 1991; Ayres and Gertner 1989; Adler 1999; Ben-Shahar and Bernstein 2000). Those studies concern how contract remedies cause the parties to disclose information in the light that in the future the contract is potentially breached. In contrast, our analysis is about entitlement protection and information disclosure without the existence of an earlier contracting stage.

3.3 Model

The simple model captures the effects of two-sided asymmetric information on the two main decisions: What offer or demand to make and with regards to the taker whether to take if the parties did not agree on a transfer of the entitlement.

The model concerns the “owner” of an entitlement (“he”) and a potential “taker” (“she”). The taker can be of two types, a low taker and a high taker, $w \in \{\underline{w}, \overline{w}\}$ where $\delta = \Pr(w = \underline{w})$ for $\delta \in (0,1)$.

The owner can be of three types: $v \in \{\underline{v}, v_c, \overline{v}\}$ with $\alpha = \Pr(v = \overline{v})$, $\beta = \Pr(v = v_c)$ while $\alpha, \beta \in (0,1)$ and $\alpha + \beta < 1$.

Both, the owner’s (v) and the taker’s (w) valuation of the entitlement is private information, while the distribution is common knowledge. The valuations of types are related follows: The high taker’s valuation lies between the intermediate owner and the high owner while the low taker’s valuation lies between the low owner’ and the intermediate owner’s valuation.[18]

$$\underline{v} < \underline{w} < v_c < \overline{w} < \overline{v}$$

[18] To understand the rationale behind the chosen design, we must consider the following factors. The model design must fulfill three requirements in order to effectively capture the impact of two-sided asymmetric information on bargaining between the owner and the taker under both rules.
First, the model needs to include an owner type whose valuation is lower than of at least two taker types. This enables potential trading between the owner and taker.
If there is only one taker type with a valuation higher than the owner's valuation, the owner can simply make a take-it-or-leave-it offer without considering other types. In this case, the asymmetry of information regarding the taker's valuation would have no effect on the owner's decision-making. The model meets this requirement as the owner type $\underline{v}$ can efficiently trade with the two taker types $\overline{w}$ and $\underline{w}$.
Secondly, a similar requirement applies to the taker types. The model needs to include a taker type with a valuation higher than those of at least two owner types. Takers with only one owner type to trade with would simply make a take-it-or-leave-it offer equal to the owner’s valuation to capture all the surplus. Only a taker who can potentially trade with two types of owners would be influence by the asymmetry of information regarding the owner’s valuation when deciding on an offer. The model includes such a taker with $\overline{w} > v_c > \underline{v}$.
Thirdly, the model needs to incorporate an owner type with a higher valuation than the type of taker just described in the second requirement, i.e. taker type $(\overline{w})$ who can potentially trade with at least two owner types. Otherwise, this type of taker $(\overline{w})$ would always choose to take the entitlement, as it guarantees the complete surplus without the need for making an offer. Consequently, under the liability rule, the presence of two-sided asymmetric information would have no impact on the taker's decision regarding the offer. The model fulfills this requirement by introducing the owner type $\overline{v}$ as $\overline{v} > \overline{w}$.

The following figure illustrates that relationship graphically.

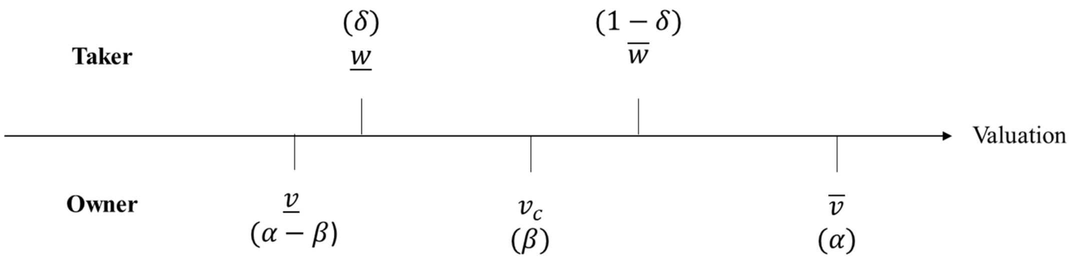


Figure 13: Relationship between types' valuations and their probability in brackets

The paper assesses the two extreme bargaining scenarios: one in which the taker makes a take-it-or-leave-it offer to purchase the entitlement at price x and the other in which the owner presents a take-it-or-leave-it demand to sell the entitlement at price y. By analyzing, these polar cases, we gain insight into the challenges and strategies faced by both owner and taker when making proposals. Furthermore, this analysis enables us to draw inferences about bargaining situations where both parties have the ability to make proposals, thus sharing a more balanced bargaining power.

In both scenarios, if the parties find an agreement the taker receives a payoff $\Pi_T = w - x$ or $\Pi_T = w - y$; the owner's payoff is $\Pi_O = x$ or $\Pi_O = y$ respectively. If the parties fail to reach an agreement, continuation of the game hinges on the available remedy.

As depicted in Panes A and B of Figure 14 if the parties fail to reach an agreement under a property rule as the remedy the owner enforces his right and prevents the taker from infringing. As a result, payoffs amount to $\Pi_O = v$ and $\Pi_T = 0$.

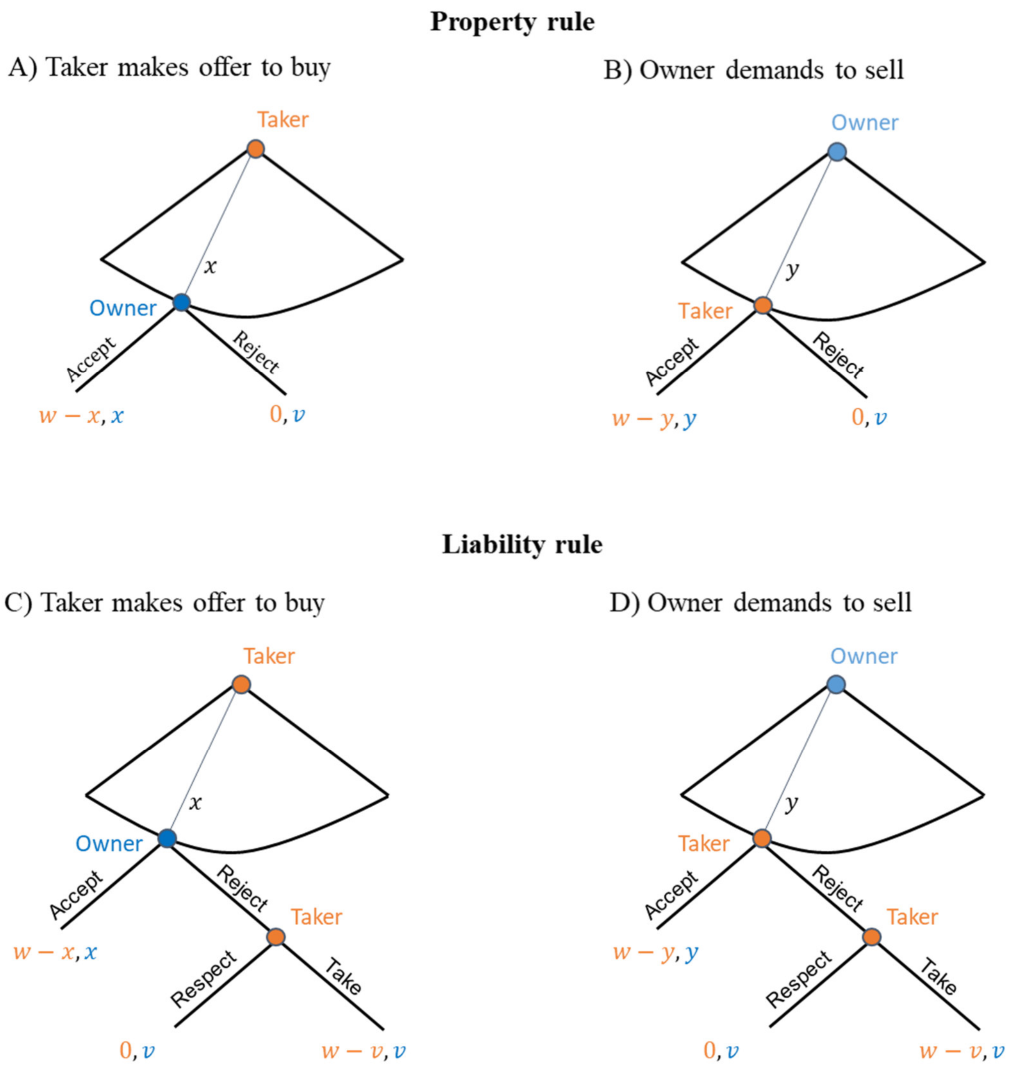


Figure 14: Game tree of the bargaining game under both rules

Under a liability rule, the taker has the option to unilaterally take the entitlement if the owner rejects her offer (Figure 14 Pane C) or if she rejected the owner's offer (Figure 14 Pane D). In such cases, the owner can enforce a claim for monetary damages. The court observes v and orders the taker to p

ay v as expectation damages to the owner. It is important to note that the model assumes that the taker is unable to change her decision about respecting the entitlement and the parties to renegotiate during the trial after the owner's valuation is revealed. This assumption corresponds to cases where the damage caused by the taking cannot be undone or is no longer feasible due to the time that has passed since the taking occurred.

In the model we focus on pure strategies. In addition, we make the following assumptions:

1. *Both parties prefer to achieve an agreement over "respect" and "take" if it yields the same payoff.*

This assumption simply solves the indifference in the way to avoid asymptotic offers.

2. *The owner prefers "respect" over "take" if both options yield the same payoff.*

This assumption not only solves the indifference but also influences the equilibrium outcome under the liability rule. To see the impact, consider the alternative scenario where the owner prefers "take" over "respect". In such scenario, low-valuing owners would have an incentive to reveal their type and to prompt the taker to take their entitlement instead of respecting it.

The assumption bases on three considerations. Firstly, engaging in litigation after the taking incurs costs. As the model does not account for litigation costs explicitly, we justify our assumption by assuming these costs to be infinitesimally small. Secondly, compensating the owner without resorting to legal proceedings implies transaction costs. By considering these transaction costs to be infinitesimally small, we support the preference for "respect". Lastly, while our model provides full compensation to the owner, in the real world, there is a significant risk of undercompensation. (see overview by Hofmann 2021, part 5. outlining the various reasons that can lead to undercompensation).

3.3.1 Benchmark: First best outcome

We begin by defining the first best outcome as the benchmark for equilibrium analysis and welfare assessment.

The first best outcome is reached provided that a transfer takes place if and only if the taker has a higher valuation than the owner. Consequently, in the first best outcome, the high taker acquires the entitlement solely from the low and intermediate owner, while the low taker acquires the entitlement solely from the low owner. The method through which the transfer occurs, be it an agreement or unilateral taking, is irrelevant.

Figure 15 illustrates the relationship between the valuations of the different types and identifies the specific transfers that transpire between them.

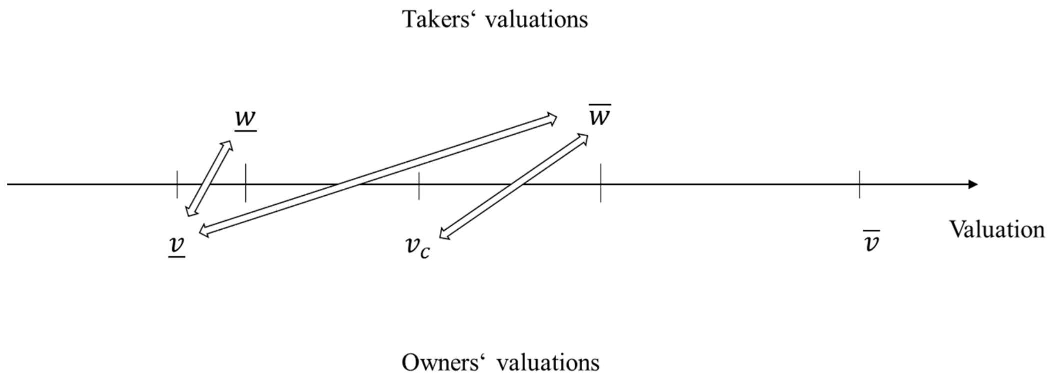


Figure 15: Illustration of transfers in first best outcome.

The arrows indicate between which types a transfer occurs.

Based on the first best equilibrium we determine the expected welfare in the first best.[19]

$$\mathrm{E}(\Pi_{FB}) = \alpha\overline{v} + \delta(1-\alpha-\beta)\underline{w} + \delta\beta v_c + (1-\delta)(1-\alpha)\overline{w}$$

[19] See Appedix for deduction of first best.

3.3.2 Taker makes take-it-or-leave-it offer

3.3.2.1 Equilibria

First, consider the property rule (Figure 14 Pane A). The taker making a take-it-or-leave-it offer puts her in the same position as a monopsonist. The equilibria are outlined in the following propositions. The proofs are relegated to the Appendix.

Proposition 1. Equilibria under the property rule if taker offers

(I) For $(1-\alpha-\beta)(\overline{w}-\underline{v}) > (1-\alpha)(\overline{w}-v_c)$, taker pooling and owner semi-separating equilibrium:

Both takers offer $x=\underline{v}$. The low owner accepts. Intermediate and high owners reject.

(II) For $(1-\alpha-\beta)(\overline{w}-\underline{v}) \leq (1-\alpha)(\overline{w}-v_c)$, taker separating and owner semi-separating equilibrium:

The low taker offers $x=\underline{v}$. The low owner accepts. Intermediate and high owners reject.

The high taker offers $x=v_c$. The low and intermediate owners accept. The high owner rejects.

In both cases, the low taker enters into a contract with the low owner at the lowest possible price, corresponding to the low owner's valuation. Due to the higher valuations of the other owner types, the low taker cannot engage in contracts with them. Consequently, the presence of these higher-valuing owner types does not influence the offering behavior of the low taker.

On the other hand, the high taker faces a more complex situation, as she must strike a delicate balance between offering an adequate price without offering too little, which could lead to a breakdown in bargaining. The high taker has two options: offering a high price equivalent to the intermediate owner's valuation and contracting with both the low and intermediate owners or offering a low price equivalent to the low owner's valuation but only contracting with the low owner. The decision hinges on the specific valuations of the low and intermediate owners and the relative proportions of each owner type.

The analysis reveals that under the property rule, the presence of the high owner has no impact on either the bargaining process or the outcome. It is impossible to reach an agreement between the high owner and either taker. Therefore, both takers make offers as if the high owner does not exist.

The equilibrium for the liability rule (Figure 14 Pane C) is as follows:

Proposition 2. Equilibrium under the liability rule if taker offers

(I) For $\alpha\overline{v} + \beta v_c \geq (\alpha + \beta)\overline{w}$ and $(1 - \alpha - \beta)(\overline{w} - \underline{v}) > (1 - \alpha)(\overline{w} - v_c)$, taker pooling and owner semi-separating equilibrium:

Both takers offer $x = \underline{v}$. The low owner accepts. Intermediate and high owners reject. The takers respect the entitlement.

(II) For $(1 - \alpha - \beta)(v_c - \underline{v}) \leq \alpha(\overline{v} - \overline{w})$ and $(1 - \alpha - \beta)(\overline{w} - \underline{v}) \leq (1 - \alpha)(\overline{w} - v_c)$, taker offer separating and owner semi-separating equilibrium:

The low taker offers $x = \underline{v}$. The low owner accepts while intermediate and high owners reject. The taker respects the entitlement upon rejection.

The high taker offers $x = v_c$ and respects upon rejection. The low and intermediate owners accept while the high owner rejects. The takers respect the entitlement.

(III) For $\alpha\overline{v} + \beta v_c < (\alpha + \beta)\overline{w}$ and $(1 - \alpha - \beta)(v_c - \underline{v}) > \alpha(\overline{v} - \overline{w})$, taker decision separating and owner semi-separating equilibrium:

Both types of takers offer $x = \underline{v}$. The low owner accepts while intermediate and high owners reject. The low taker respects and the high taker takes the entitlement.

Initially, we observe that the behavior of the low taker remains consistent under both the liability rule and the property rule. She contracts solely with the low owner, and no transfer occurs between her and the other two types. However, the situation differs for the high taker. While her behavior aligns with that under the property rule in certain scenarios, there are instances, specifically case (III), where she unilaterally takes the entitlement if the owner rejects her offer. The various cases under both rules are depicted in Figure 16.

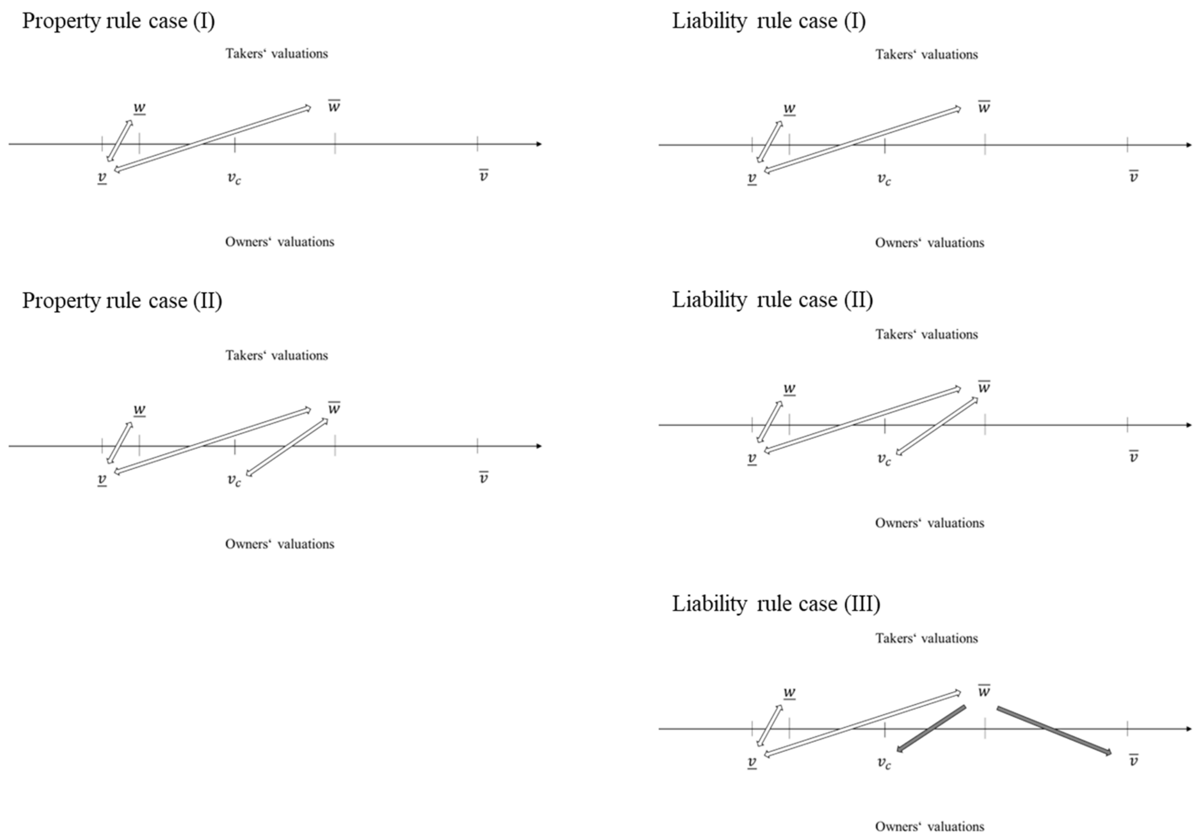


Figure 16: Overview of transfers if taker makes offer

The white arrows indicate where mutual trade occurs. The grey arrows show where the taker takes.

Figure 16 illustrates that both the property rule and the liability rule achieve the first best outcome in case (II). Trading occurs when feasible, and no inefficient transfers take place. In case (I) under both rules, the high taker does not receive the entitlement from the intermediate owner, despite it being efficient. In case (III) under the liability rule, this inefficiency is mitigated by the high taker unilaterally taking the entitlement. However, this comes at the cost of also taking from the high owner. The subsequent section examines how these dynamics affect overall welfare.

3.3.2.2 Welfare

We start straight with the proposition:

Proposition 3. Welfare comparison if taker offers

(I) For $\alpha\overline{v} + \beta v_c \geq (\alpha + \beta)\overline{w}$ and $(1 - \alpha - \beta)(\overline{w} - \underline{v}) > (1 - \alpha)(\overline{w} - v_c)$, both rules lead to the same outcome and imply a welfare loss.

(II) For $(1 - \alpha - \beta)(v_c - \underline{v}) \leq \alpha(\overline{v} - \overline{w})$ and $(1 - \alpha - \beta)(\overline{w} - \underline{v}) \leq (1 - \alpha)(\overline{w} - v_c)$, both rules achieve the first best outcome and are thus equally efficient

(III) For $\alpha\overline{v} + \beta v_c < (\alpha + \beta)\overline{w}$ and $(1 - \alpha - \beta)(v_c - \underline{v}) > \alpha(\overline{v} - \overline{w})$:

(a) The property rule achieves the first best outcome and is more efficient if $(1 - \alpha - \beta)(\overline{w} - \underline{v}) \leq (1 - \alpha)(\overline{w} - v_c)$.

(b) Otherwise, both remedies imply a welfare loss, and the liability rule is more efficient.

The proposition demonstrates that neither the property rule nor the liability rule universally dominates in terms of overall welfare. The optimal rule depends on the distribution of owner types, determining which rule yields more efficient outcomes. Specifically, in the parameter space defining case I and case II, both the property and liability rules result in the same outcome. This convergence arises due to the influence of high owner types. When these types are highly prevalent, either through a large share or high absolute values, the taker is prevented to exercise the option to take unilaterally.

However, in case III, which represents the intersection of the liability rule equilibrium case III with either the property rule equilibrium case I or case II, the two rules lead to distinct welfare outcomes. Here, the high taker takes advantage of the option to unilaterally take. This divergence highlights the welfare implications of case III under both the property rule and the liability rule.

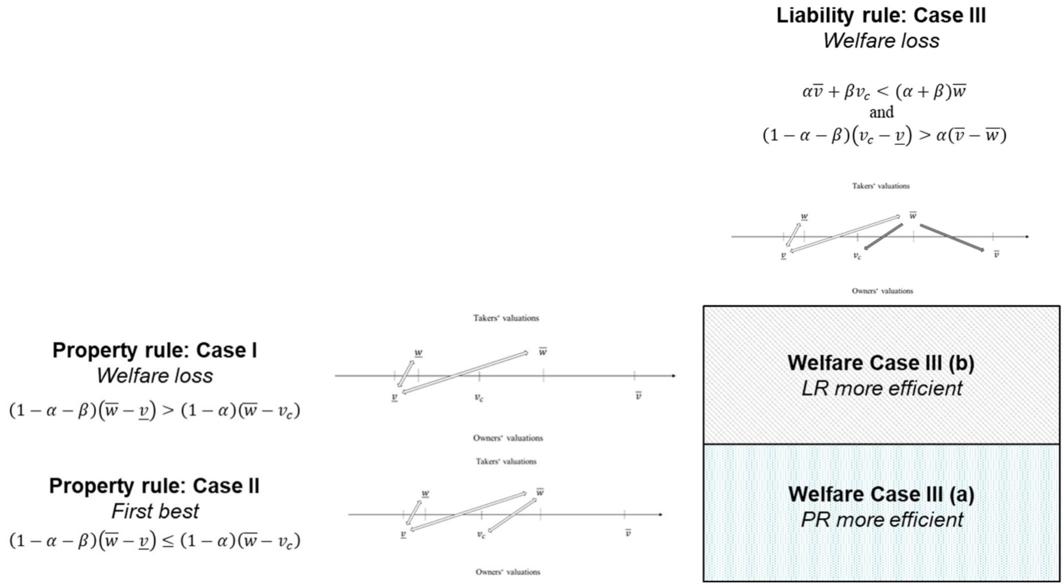


Figure 17: Decomposing welfare case (III) if taker makes offer

Relationship of welfare case (III) to the equilibria under the property and the liability rule.

Considering Figure 17, it is important to recall that in case (III) of the liability rule equilibrium, both taker types and the low owner type engage in an agreement, while the high taker takes from the intermediate and high owner type. This outcome offers the advantage of facilitating a transfer from the intermediate owner to the high taker, which is hindered in case (I) under both remedies. However, a downside is that the high taker inefficiently appropriates the entitlement of the high owner type under the liability rule. It is crucial to highlight that the high taker internalizes these costs, and thus case (III) of the liability rule applies only if the benefits outweigh the inefficiency of the taker seizing the high owner's entitlement.

While these enforced transfers may appear purely efficient, they do have a negative side effect. The high taker obtains a higher payoff in case (III) of the liability rule compared to case (I) of the property rule. As a result, the high taker is less inclined to make a high offer that would entail contracting with the low and intermediate owner without taking from the high owner, achieving the first best outcome. Consequently, the first best outcome is more frequently reached under the property rule.

Figure 18 illustrates this relationship by considering the proportion of taker and owner types, providing a graphical representation of the effects.

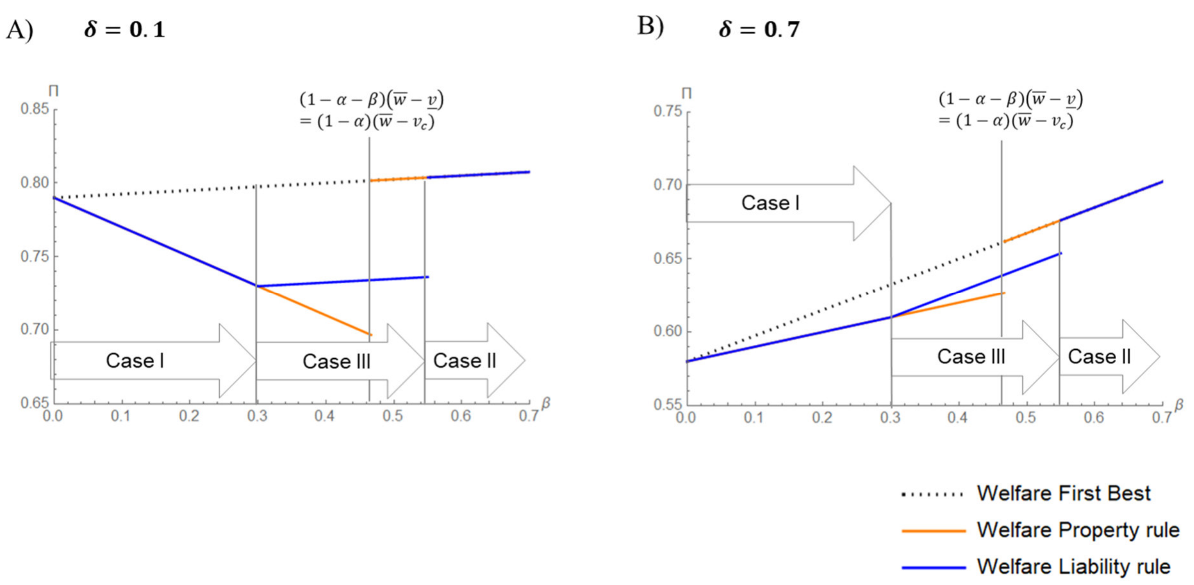


Figure 18: Total payoffs if taker makes offer

Total payoffs Π as a function of proportion of intermediate types β with $\overline{v} = 1$; $v_c = 0.5$; $\overline{w} = 0.75$; $\alpha = 0.3$; $\underline{w} = 0.25$; $\underline{v} = 0$. The two Panes vary with respect to the proportion of high and low takers specified by δ.

Pane A and Pane B display a similar pattern. Starting from the left, as the proportion of medium owner types increases, the distribution of types becomes more balanced, leading to increased uncertainty. Consequently, the welfare loss under both rules increases. At the first cutoff point, the high taker begins utilizing the option to take, resulting in inefficient takings from the high owner type. The liability rule demonstrates superior efficiency as the transfer of entitlements overall gets more efficient. As the proportion of medium owners further increases, the distribution becomes concentrated in the center. At the second cutoff point, the trade-facilitating effect of the property rule becomes evident. These trades are more efficient than the unilateral takings observed under the liability rule, as transfers occur without the negative side effect of inefficient takings from high owner types. Beyond the third cutoff point, the taker refrains from exercising the option to take and acts equally as under the property rule.

The two panes differ in terms of the proportion of low and high takers. Comparing them reveals that the impact of the increase in medium owners is more pronounced when there are many high takers (Pane A).

3.3.3 Owner makes take-it-or-leave-it demand

3.3.3.1 Equilibria

We begin by establishing the equilibria. Under the property rule, the owner's take-it-or-leave-it demand (Figure 14 Pane C) resembles a monopolist unable to engage in price discrimination. Two types of equilibria emerge, differing solely in the action taken by the low owner.

Proposition 4. Equilibrium under the property rule if owner demands

(I) For $\underline{w} \geq (1-\delta)\overline{w} + \delta\underline{v}$, there is a fully separating equilibrium in pure strategies:

High owner demands $y \geq \overline{v}$, which both types of takers reject and respect the entitlement.

Intermediate owner demands $y = \overline{w}$, which the high taker accepts, and the low taker rejects followed by respecting the entitlement.

Low owner demands $y = \underline{w}$ and both types of takers accept.

(II) For $\underline{w} < (1-\delta)\overline{w} + \delta\underline{v}$, there is a semi-separating equilibrium in pure strategies:

High owner demands $y \geq \overline{v}$, which both types of takers reject and respect the entitlement.

Intermediate and low owner demands $y = \overline{w}$, which the high taker accepts, and the low taker rejects followed by respecting the entitlement.

The rationale is straightforward: The high owner's valuation exceeds those of both takers, precluding any transfer. The intermediate owner can only sell to the high taker, capturing the entire surplus by demanding a price equal to the high taker's valuation. Only the low owner has the potential to sell to both takers. Whether the low owner chooses to sell to both or exclusively to the high taker hinges on the trade-off between charging a higher price and selling to the high taker alone or charging a lower price and accommodating both takers.

Proposition 5. Equilibrium under the liability rule if owner demands

(I) For $\overline{w} \leq \frac{\beta v_c + \alpha\overline{v}}{\beta+\alpha}$, there is a semi-separating equilibrium:

High and intermediate owners make a pooling demand $y \geq \overline{v}$ which both types of takers reject followed by respecting the entitlement.

The low owner makes a separating demand $y = \underline{v}$ which both types of takers accept.

(II) For $\overline{w} > \frac{\beta v_c + \alpha\overline{v}}{\beta+\alpha}$, there is a semi-separating equilibrium:

High and intermediate owners make a pooling demand $y \geq \overline{v}$. The high taker rejects and takes the entitlement. The low taker rejects and respects the entitlement.

The low owner makes a separating demand $y = \underline{v}$ which both types of takers accept.

The equilibrium under the liability rule (Figure 14 Pane D) is shaped by the shift in bargaining power to the taker, enabled by her unilateral option to take. In this equilibrium, the intermediate owner refrains from revealing his type, driven by two key observations. Firstly, if the intermediate owner were to demand a price exceeding his valuation, thereby revealing his type, the taker would prefer to take unilaterally. Secondly, if the taker were to accept a demand made by the intermediate owner, the low owner would prefer to mimic the intermediate owner's strategy, making unilateral taking even more attractive to the taker.

The equilibrium exhibits two distinct cases, distinguished by the response of the high taker to the semi-pooling demand $y \geq \overline{v}$. In case (I), when the high taker's valuation is low relative to the owner's expected valuation, she chooses to respect the entitlement. Conversely, in case (II), when the high taker's valuation exceeds the owner's expected valuation, she opts to take unilaterally.

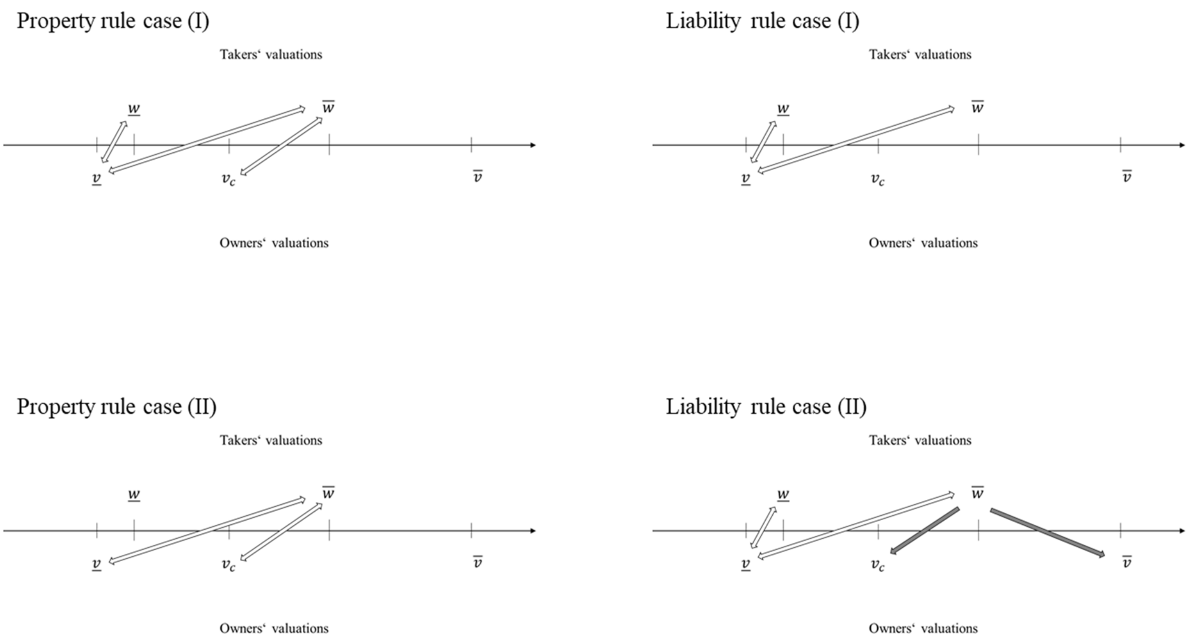


Figure 19: Overview of transfers if owner demands

The white arrows indicate where mutual trade occurs. The grey arrows show where the taker takes.

Figure 19 provides a summary of the equilibrium outcomes, contrasting the differing crucial relationships between the types under the two rules.

Under the property rule, the crucial relationship lies between the low owner and the low taker, with the efficient transfer occurring only in case (I). On the other hand, under the liability rule, the decision of the high taker to either respect or take takes center stage. However, while case (I) under the property rule results in the first best outcome, neither case under the liability rule achieves this ideal. The reasons for inefficiency differ: in case (I), it stems from the missed trade between the intermediate owner and the high taker, whereas in case (II), it arises from the inefficient transfer from the high owner to the high taker. The subsequent section delves into the analysis of the overall welfare implications.

3.3.3.2 Welfare

The property rule demonstrates its superiority from a welfare perspective by leading to the same outcome as the first best in Proposition 4 case I. This unambiguous advantage is stated in Proposition 6 case I. However, in the area of Proposition 4 case II, the comparison becomes less clear and depends on the valuations of different owner and taker types and their proportions. This is reflected by Proposition 6 case II and III.

Proposition 6. Welfare comparison if owner demands

(I) For $\underline{w} \geq (1-\delta)\overline{w} + \delta\underline{v}$, property rules reach the first best outcome and are more efficient.

(II) For $\underline{w} < (1-\delta)\overline{w} + \delta\underline{v}$ and $\overline{w} \leq \frac{\beta v_c + \alpha\overline{v}}{\beta+\alpha}$ property rules are more efficient if $(1-\delta)\beta(\overline{w} - v_c) > \delta(1-\alpha-\beta)(\underline{w} - \underline{v})$ and liability rules otherwise; in all those cases there is a welfare loss.

(III) For $\underline{w} < (1-\delta)\overline{w} + \delta\underline{v}$ and $\overline{w} > \frac{\beta v_c + \alpha\overline{v}}{\beta+\alpha}$ property rules are more efficient if $\alpha(1-\delta)(\overline{v} - \overline{w}) > \delta(1-\alpha-\beta)(\underline{w} - \underline{v})$ and liability rules otherwise; in all those cases there is a welfare loss.

The graphical representation of Proposition 6 provides an overview of how these cases relate to the equilibria determined for each rule and the factors driving the welfare comparison.

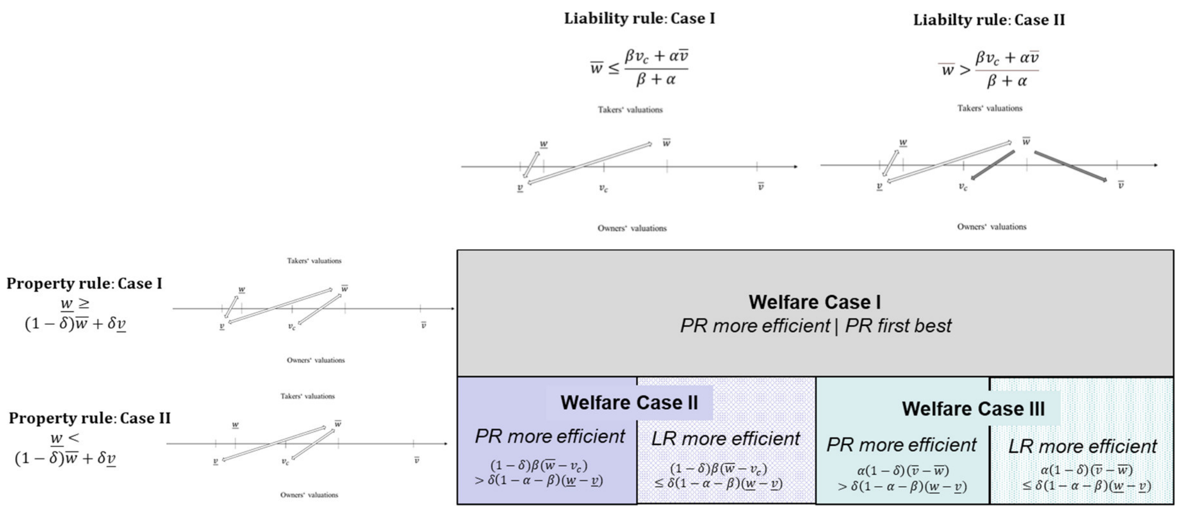


Figure 20: Decomposing welfare if owner demands

Relationship of welfare cases to the equilibria under the property and the liability rule.

The representation illustrates that only the property rule facilitates transactions in the center, where players have similar valuations, specifically between the higher taker and the medium owner. Conversely, the liability rule encourages transactions at lower valuations, particularly between low taker and low owner types. The welfare of these transactions may be compromised under the property rule if the proportion of low takers is not sufficient (Welfare Case II). As long as the proportion of low takers remains sufficient, the property rule attains the first best outcome and outperforms the liability rule (Welfare Case I).

While the liability rule restricts transactions in the center, it enables transfers between high takers and medium owners through unilateral taking. However, this advantage comes at the cost of inefficient takings from the high owner type. In scenarios where the weight is not on the low taker (Welfare Case III), the welfare comparison between the property and liability rule hinges on whether the inefficient takings outweigh the welfare loss under the property rule resulting from missed transfers between low takers and low owners. This reflects the overall benefit of transferring the entitlement on average, without the ability to differentiate between owner types. As a general finding, we can deduce that the higher the average efficiency of transfers, the smaller the welfare loss under the liability rule.

Figure 21 graphically depicts this finding: a comparison of the four panes reveals that as the proportion of high owner types increases (from pane A to pane D), and therefore the average efficiency of transfers decreases, the property rule maintains a clear advantage.

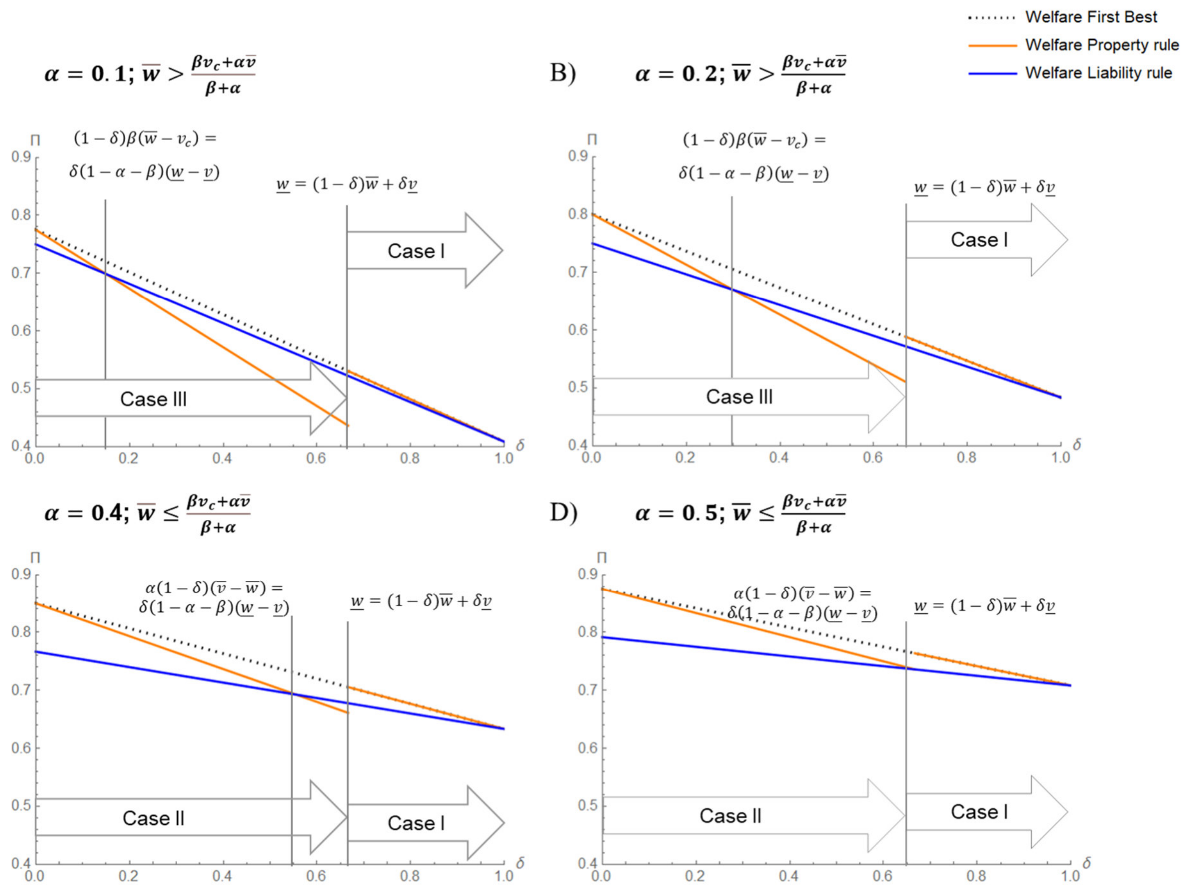


Figure 21: Total payoffs if owner demands

Total payoffs Π as a function of proportion of low takers δ with $\overline{v} = 1$; $v_c = 0.5$; $\overline{w} = 0.75$; $\beta = 1/3$; $\underline{w} = 0.25$; $\underline{v} = 0$. The panes vary with respect to the proportion of high owner types α and indirectly proportion of low owner types $(1 - \alpha - \beta)$.

Regarding the proportion of high and low takers, each pane demonstrates that with fewer low takers, the property rule initially holds a welfare advantage. However, as the proportion of high takers increases, this advantage diminishes. Depending on the distribution of owner types, the liability rule takes the lead until the proportion of low takers reaches a threshold where the property rule equilibrium changes, and the property rule achieves the first best outcome.

Comparing the panes reveals that the smaller the number of low owner types (pane A to D), the more pronounced the welfare loss, and the steeper the curve, as the proportion of low takers increases. This reflects the fact that with fewer low owner types but more high owner types, fewer opportunities for transfers exist. Importantly, this effect is particularly amplified under the property rule due to the absence of transfers of the entitlement from the low owner type to the low taker. The absence of these transfers has a greater impact on the welfare loss when there are more low owner types. As a result, the welfare lines of the property rule and liability rule intersect at an earlier point.

3.4 Conclusion

The presence of two-sided asymmetric information hinders the achievement of efficient transfers between parties. In contrast to our previous study on one-sided asymmetric information (Engert and Hofmann, 2024), where we established the efficiency of the property rule when the owner makes the take-it-or-leave-it offer, neither the property rule nor the liability rule attains the first best outcome under two-sided asymmetric information.

Figure 22 provides a comprehensive overview of the outcomes associated with each rule based on who makes the take-it-or-leave-it offer.

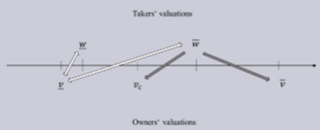
	Taker offer		Owner demand	
A) First Best 	**Property rule:** Case (II)	**Liability rule:** Case (II)	**Property rule:** Case (I)	-
B) Missed transfers in the center 	**Property rule:** Case (I)	**Liability rule:** Case (I)	-	**Liability rule:** Case (I)
C) Excessive Taking 	-	**Liability rule:** Case (III)	-	**Liability rule:** Case (II)
D) Missed transfers at lower end 	-	-	**Property rule:** Case (II)	-

Figure 22: Overview of outcomes under each remedy

The information asymmetry prevents efficient trade to occur in all cases under the property rule. The introduction of a liability rule provides the option to take without consent and pay damages. It leads to enforced transfers where the parties would fail to trade under the property rule. However, these enforced transfers are not limited to cases where they are welfare enhancing but can be inefficient, and bargaining is less effective compared to the property rule.

The dominance of either effect depends on the distribution of player types. The analysis reveals that the clearer a transfer of the entitlement is welfare enhancing on average, i.e. high proportion of low owner types, the more likely is the liability rule to outperform the property rule. Conversely, when there is greater uncertainty regarding the welfare-enhancing nature of a transfer, the trade fostering effect of the property rule becomes more relevant. This effect allows the parties to exchange offers that convey information about their type, facilitating the revelation of whether the transfer is efficient.

The analysis is limited in that it applies extreme bargaining scenarios. This has the advantage to provide clear results. With two-sided asymmetric information other bargaining protocols, like a sealed bid auction, lead to an extensive number of equilibria (see Leininger et al. 1989). In a co-authored related paper, we take an experimental approach to compare bargaining under property and liability rules with a more open bargaining protocol (Engert et al. 2024). This is covered in the next chapter.

4 Bargaining experiment with two-sided asymmetric information[20]

4.1 Introduction

Should a seller be allowed to back out of an agreed deal if she is willing to pay off the buyer? The “efficient breach hypothesis” answers this question in the affirmative (Birmingham 1970, 284–286; Barton 1972). Proponents invoke the general insight of Calabresi and Melamed (1972) that transaction costs can prevent consensual trade and that allowing the unilateral taking of entitlements against compensation can correct such bargaining failure. Applied to contract remedies, this means that a seller should be empowered to “take” the buyer’s right by breaching the contract. The buyer should have no right to enforce the seller’s obligation in kind (“specific performance”) as long as he is fully compensated by the seller (see, e.g., Shavell 1980; Shavell 1984; Schwartz and Edlin 2003; Miceli 2004; Schwartz and Scott 2008). Holding the seller liable for the buyer’s expectation damages ensures that she breaches the contract only if the cost of performance exceeds the benefits to the buyer—hence “efficient” breach.

While the argument for efficient breach is consistent, it assumes that the parties cannot renegotiate the contract to avoid inefficient performance and, importantly, that these bargaining imperfections are exogenous to the choice of remedy for contract breach. But what if the available remedy itself causes renegotiation to fail? Inspired by Eisenberg’s (2005) remark that the optimal remedy should promote the exchange of information, we ask two questions: First, which remedy better promotes bargaining and the parties’ joint decision to execute or liquidate the contract? Second, how does a possible difference between remedies in fostering bargaining and information exchange affect welfare outcomes for the parties?

In this paper, we examine these questions in a laboratory experiment. We reproduce a standard efficient breach situation: After the contract has been concluded, the cost of performance rises above the price. This implies that the seller would prefer to renege on her promise and forego earning the agreed-upon price. To maximize joint welfare, the seller should be kept to her promise if and only if the increased performance cost does not exceed the buyer’s benefit. One way for the parties of determining this is to negotiate over an agreement to discharge the seller from her obligation in return for a side payment. The remedy for breach of contract defines the parties’ outside options in this renegotiation of the original contract: If they fail to reach an agreement, expectation damages (ED) allow the seller to breach the contract unilaterally in exchange for full monetary compensation of the buyer. By contrast, if the buyer is entitled to specific performance (SP), he can force the seller to perform the contract as promised.

[20] This chapter is based on a paper *“The inefficiency of efficient breach: An experiment on contract renegotiation under asymmetric information”* written in collaboration with Prof. Dr. Andreas Engert and Prof. Dr. Henrik Orzen (Unpublished working paper).

In the real world, if no agreement is reached, buyers have to enforce their entitlements against recalcitrant sellers under both remedies. SP requires a determination of the precise scope of the buyer's claim and monitoring of the seller's performance actions, including through litigation and the execution of court orders. ED poses similar difficulties if the seller chooses to perform; if she breaches the contract, the parties and possibly a court need to assess the value of performance to the buyer to set the quantum of damages. All of these instances involve a conflict between the parties that is likely to impose losses of time, effort, and expense. In our experimental setting, we therefore assume that failure to cancel the contractual exchange burdens the parties with a fixed amount of (expected) conflict costs.

Our experimental design concentrates on the individual incentives and strips away the contractual context. This is not to deny that normative preconceptions and preferences for either promise keeping or the freedom to breach a contract against compensation can play an important role as well (e.g., Wilkinson-Ryan 2015; Bar-Gill and Engel 2018; Mittlaender 2019; Mittlaender and Buskens 2019).[21] We argue, however, that there is a benefit in distinguishing different factors that can influence the optimal choice of remedy. The focus of this study is on the comparison of ED and SP remedies in the presence of (imperfect) bargaining opportunities.

The bargaining friction in our experiment arises from private information about, respectively, the seller's cost of performance and the buyer's valuation. We believe this to be a highly realistic assumption in many contract renegotiations. Yet a formal theoretical analysis of two-sided asymmetric information requires restrictive assumptions on the bargaining process and often defies a solution with a unique equilibrium. Our experimental approach enables us to sidestep both problems: We can allow our players to make and accept offers freely and simultaneously. The experimental results provide insights into how real-world human players would renegotiate a contract under two-sided asymmetric information.

Our hypothesis that the choice of remedy affects bargaining resonates with the broader theoretical literature on entitlement protection through property and liability rules. A general assertion is that property rules—SP in contracts—are "market-encouraging" and promote bargaining whereas liability rules—such as the ED remedy—are said to be "market-mimicking" (Calabresi and Melamed 1972; Haddock, McChesney, and Spiegel 1990; Craswell 1993). In a concurrent theoretical project to the present paper, two of the authors (Engert and Hofmann 2024 – chapter 2 of this thesis is based on that paper) show that property rules facilitate reaching agreement under one-sided asymmetric information. The intuition is that a property rule prevents a forced transfer of the entitlement—in the contractual context, a unilateral breach—and thereby

[21] These value judgements can differ across parties and transactions. Professional repeat players in large-scale transactions could be interested exclusively in financial gain while other parties may take losses for keeping their promises. More importantly, the law itself could shape the normative views of the parties (Bar-Gill and Fershtman 2004; Arlen and Kornhauser 2020). If this is the case, contract law can move people's moral views towards the remedy that also maximizes payoffs.

allows the owner to claim part of the gains from a reallocation of the resource. This creates an incentive to reveal private information to identify valuable trading opportunities. In an additional theoretical project, the author of this thesis (Hofmann 2024 – chapter 3 of this thesis is based on that paper) shows that this finding translates to two-sided asymmetric information. However, under two-sided asymmetric information this advantage of property rules does not generally outweigh the benefits associated with giving the taker the option to take unilaterally. It depends on the distribution of types, which rule is superior.

The present paper goes beyond these theoretical findings in an important way. The experiment permits us to implement a more realistic bargaining protocol than the take-it-or-leave-it rule used in the theoretical papers.

The experimental results indicate that the SP remedy—a property rule—has advantages in overcoming bargaining impediments from private information. We find SP to enhance the parties' ability to bargain and to make an optimal choice about performance. It produces more agreements on non-performance when it is efficient and prevents the seller from inefficiently not performing. In consequence, SP induces the parties to behave more efficiently overall. The conventional view may have missed a key advantage of specific performance as a remedy in contract law, as well as of property rules more generally.

The rest of the chapter is structured as follows. In section 4.2, we discuss the related literature. Section 4.3 describes the design of the experiment. Section 4.4 outlines the research questions and the predictions. Section 4.5 contains the results and Section 4.6 concludes.

4.2 Related literature and contribution

Our paper contributes to the debate about contract remedies and more broadly different modes of protection for legal entitlements. The idea of an "efficient breach of contract" has sparked a controversy over several decades. Our main contribution is to offer experimental insight into the efficiency implications of the two competing views. Such evidence is rather scarce in spite of the longstanding debate. In an observational study, Listokin (2005) finds that an unexpected SP award in a single case of merger litigation increased the combined stock market value of the two merging corporations. He views this as favorable for the efficiency of SP, contrary to the common law preference for ED. Indirect evidence comes from real-world choices of remedies. Eisenberg and Miller (2015) document that parties actively contract for SP especially in certain contract types such as employment contracts or merger agreements, opting out of the common law default rule of only ED. On the other hand, Lando and Rose (2004), Arbel (2015) and Anidjar, Katz, and Zamir (2020) all provide indications that SP are rarely enforced even in jurisdictions where it is available by default.

To the best of our knowledge, only two experimental studies so far examine the effect of different remedies on ex post bargaining.[22] Like our paper, Ayres (2005) considers negotiation under two-sided asymmetric information. The treatment relates to whether an entitlement is protected by a property rule (the equivalent of SP) or liability rule (corresponding to ED). Ayres hypothesizes the exact opposite of our claim, that liability protection facilitates bargaining. His experiment fails to deliver significant differences in welfare outcomes. A key difference is that Ayres (2005), following the theoretical analysis in Ayres and Talley (1995a, 1995b), adopts a special version of a liability rule: He assumes that damages do not depend on the valuation of the entitlement holder but consist in "liquidated damages", a fixed amount that is commonly known by the players. This simplifies bargaining under the liability rule because the "taker" knows her payoffs from her outside option of seizing the entitlement. By contrast, ED in our experiment reflect the buyer's actual valuation and remains private information except after a contract breach. We believe this assumption conforms more closely to the law because ED are meant to compensate the buyer for her true expectation interest. While awards can deviate from this benchmark, the buyer will often have more information about the quantum of damages assessed by a court.

Croson and Johnston (2000) consider only one-sided private information of the entitlement holder (buyer) about his valuation. Similar to Ayres (2005), they assume that the amount of damages under the liability rule are predetermined at the holder's average valuation. They choose parameters such that in equilibrium the entitlement is always taken in the absence of an agreement. Their prediction of a higher rate of agreements under the liability rule is "(almost)

[22] A borderline case is Depoorter and Tontrup (2012) discussed below.

significantly” ($p = 0.057$) borne out in the data. That owners are more willing to compromise under such a liability rule is unsurprising because they are almost certain to lose the entitlement, sometimes against insufficient compensation. In fact, Croson and Johnston are less interested in comparing liability and property rules than they are in the effect of uncertainty of entitlement assignment under a property rule.[23] Our study thus appears to be the first to pitch a property rule (SP) against a liability rule (ED) that compensates the buyer for the actual loss he has suffered.

Contract remedies influence not only ex post renegotiation and performance choice. The expected payoffs from the execution stage also feed back into parties’ ex ante decisions to form a contract and to invest in performance and reliance.[24] Sloof et al. (2003, 2006) find in experiments that both ED and SP induce buyers to invest excessively into their own valuation of the good. Sloof et al. (2006) also allow for ex post renegotiation with complete information. Since we cover only the ex post stage of contract renegotiation and performance decision, our results have no direct bearing on ex ante investment behavior. We can, however, contribute a piece of indirect evidence: While SP promotes more efficient ex post bargaining, the two competing remedies seem to produce the same expected payoffs for the seller. This alleviates the concern that the seller could overinvest ex ante to avoid a hold up by the buyer under SP, compared to ED.

Like the work reviewed so far, our interest is in the incentive effects of remedies under private information. Other research has concentrated on the role of normative and other non-standard preferences induced by the contractual commitment.[25] A growing literature looks into motivations for keeping contractual promises (see Charness and Dufwenberg, 2006; Vanberg 2008; Guiso, Sapienza and Zingales 2013; Eigen 2012; Stone and Stremitzer 2020; Mischkowski, Stone and Stremitzer 2019). Wilkinson-Ryan (2015) uses an incentivized, modified trust game to elicit the dollar amounts at which subjects are willing to renege on their promise. That people attach a monetary value to honoring their commitments casts doubt on the advantage of ED to permit unilateral breach when it is efficient. Other research suggests that because ED ensures compensation of the victim it encourages breach as compared to a situation without any remedy. Using a vignette method, Mittlaender (2019) shows that in a representative sample of the U.S. population the moral disapproval of breach strongly declines if the seller has to fully make up for the buyer’s loss; a sizable minority continues to condemn breach at least in certain

23 They find that uncertainty can foster bargaining. As Ayres (2005) observes, with a commonly known probability of entitlement allocation, a property rule with uncertain entitlement resembles a fixed-amount liability rule.

24 See, e.g., the observational evidence of Cookson (2018) that contract enforcement encourages specific investment and the experimental evidence in McCannon, Asaad and Wilson (2018) for enforcement and trust as complements in fostering contract formation and investments.

25 Wilkonson-Ryan, Hoffmann and Campbell (2023) document a (mistaken) *belief* among laypeople in the availability of specific performance as a remedy under U.S. contract law.

circumstances. In an experimental contract setting, Mittlaender and Buskens (2019) allow the buyer to retaliate when the seller breaches. They find that the availability of the ED remedy strongly and significantly reduces the incidence of retaliation.[26] Outside the contractual context, Bar-Gill and Engel (2018) vary the level of compensation for an involuntary taking of a legitimate entitlement and measure the reservation prices of the taker and owner for not taking the right. The results show a distribution of selfish and normative preferences across participants: For some, the "power to take" is worth less when it is more costly to exercise while for others it becomes more acceptable and hence more valuable with higher compensation; still others are unaffected. Bar-Gill and Engel conclude that normative preferences diverge and as such can impede efficient bargaining.

For the SP remedy, Depoorter and Tontrup (2012) demonstrate that a right to SP makes the buyer significantly more inclined to insist on performance and to resent a breach of contract even if he is fully compensated and non-performance is efficient. Notably, the manipulation consisted only in making the SP remedy explicit. Even in the control group without SP the buyer had the power to prevent the breach instead of collecting damages. Depoorter and Tontrup suggest that SP accentuate the norm of promise keeping or trigger a sense of entitlement in the buyer. The latter interpretation resembles an endowment effect and also the finding of Lewinsohn-Zamir (2013) that people in general prefer in-kind remedies over monetary compensation.

The present paper contributes to this literature by complementing it: Our bargaining game comes with no prior contractual, legal, or moral commitment. This allows us to study bargaining with payoffs similar to contract renegotiation but insulated from the normative preferences attached to contracts and earlier promises. Besides an analytical interest in disentangling these effects, our approach creates a benchmark for evaluating normative preferences. This is relevant for contract law because normative preferences can be heterogenous and inconsistent, which means that the law cannot just adopt and implement them. Conversely, normative preferences themselves seem to be prompted or formed by the law. Policy makers are called upon to make their own judgment. Expected monetary (non-normative) payoffs from the renegotiation game offer guidance for making this choice.

Lastly, we also contribute to the analysis of bargaining in general. Bargaining games with two-sided asymmetric information are notoriously hard to solve analytically.[27] When they yield an

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26 They also document that buyers were forgiving if the breach was efficient and/or served to avoid a loss to the seller (as opposed to obtaining an extra gain). Likewise, Bigoni et al. (2017) find that participants are more willing to renegotiate and to accept a side payment if a change of circumstances imposes a loss on the promisor compared to when the other party is seeking additional gain from a more profitable transaction. See also Wilkinson-Ryan and Baron (2009) and Wilkinson-Ryan and Hoffman (2010).

27 See generally Abramowicz (2020) who recommends computational approaches.

equilibrium solution in closed form, they rely on formal and often restrictive bargaining protocols like “take it or leave it” or the symmetric Chatterjee-Samuelson mechanism (Chatterjee and Samuelson 1983; see the applications to settlement bargaining in Friedman and Wittman 2007; Klerman, Lee and Liu 2018). The experimental method allows us to adopt a less structured bargaining procedure that more closely resembles real-world negotiations. Such an unstructured approach has been less popular but, as Camerer, Nave and Smitz (2019) argue, it can both inform future theorizing and test certain more general predictions derived from theoretical analysis. For instance, they use the revelation principle to predict that bargaining failure under two-sided asymmetric information becomes less frequent as the agreement range grows.[28] In a similar vein, we argue below that SP, compared to ED, enlarges the surplus from an agreement if performance of the contract has become inefficient. This leads us to hypothesize that SP enhances the chance of reaching agreement.

28 Babcock, Loewenstein and Wang (1995) and Ashenfelter et al. (1992) investigate the same question in an unstructured bargaining experiment.

4.3 Experimental design

4.3.1 Game structure

Our experiment is designed to capture the essence of a contract renegotiation between a seller ("she") and a buyer ("he") after an increase in the cost of performance—possibly an opportunity cost—has made the contractual exchange unattractive for the seller. The two treatments reflect the different consequences under either an SP or an ED remedy if the parties fail to agree on discharging the seller for a side payment. To eliminate contextual framing effects, we used abstract labels for the two player roles ("Person A" for seller and "Person B" for buyer). We nonetheless will refer to them as "seller" and "buyer" here to simplify the exposition. Our experimental design also seeks to avoid behavioral effects due to diverging perceptions of gain or loss domains. A seller who has to perform at a cost exceeding the contract price plausibly finds herself in a "loss" frame. Having to compensate the buyer under ED or paying him off under an agreement also appears like a negative outcome. For the buyer, the framing is less clear. Receiving specific performance, a side payment or monetary compensation could all be seen as a gain, but not obtaining the promised performance can also violate a sense of entitlement. To avoid confounding effects from such different frames, our experimental design seeks to put both parties reliably in the same frame as regards gains or losses.

A single game (round) in the experiment consists of up to five stages:

1. The seller and the buyer each receive an endowment of 10 "thalers" (our experimental currency unit).

2. The seller and the buyer each privately learn their "personal number". Numbers are integers between 0 and 100 drawn from a uniform distribution and, as will become apparent, represent the seller's performance cost and the buyer's valuation.

3. The seller and the buyer negotiate over sharing 100 thalers. For a period of two minutes, they can continuously send each other sharing proposals by setting a slider and hitting the "send" button. The other party can accept a current offer or make a counteroffer. There is no restriction on the number of offers. Both players can quit the negotiation at any time.

4. If the parties agree in stage 3, the game ends. The players receive the agreed shares and keep their endowments of 10 thalers. If there is no agreement, the players lose their endowments (signifying the costs of conflict from enforcement of ED or SP).

5. If the players have failed to agree in stage 3, their payoffs depend on the treatment: In the SP condition, the players each receive their personal numbers from stage 2. In the ED condition, the seller can choose to perform or to breach: With performance, players receive their personal numbers. With breach, the buyer receives his personal number

but the seller is paid 100 minus the buyer's personal number—which is still private information when the seller makes her choice.

Table 1 summarizes the payoffs. To see that our game replicates the payoff structure of an actual contract renegotiation, think of the buyer's personal number as his valuation v of the good to be delivered. For the seller, suppose that she has received an extra endowment of 100 thalers. If she performs the contract, her cost of doing so is c. One can now interpret her personal number as the initial endowment minus performance cost, $PN_A = 100 - c$. If she breaches the contract, she has to compensate the buyer, leaving her with the initial endowment minus the buyer's valuation, $100 - v$. This exactly mirrors the payoffs in our experimental game. To avoid confusion, we continue to present the experiment in the familiar terms of the seller's cost of performance and the buyer's valuation.

	Specific performance treatment	*Expectation damages treatment*
Agreement	Payoff seller: $10 + (100 - x)$ Payoff buyer: $10 + x$	Payoff seller: $10 + (100 - x)$ Payoff buyer: $10 + x$
Performance	Payoff seller: PN_A Payoff buyer: PN_B	Payoff seller: PN_A Payoff buyer: PN_B
Breach	n/a	Payoff seller: $100 - PN_B$ Payoff buyer: PN_B

Table 1: Payoffs by outcome and treatment.

x denotes the number of thalers the agreement assigns to the buyer out of the 100 thalers to be divided. PN_A is the seller's personal number, PN_B the buyer's.

The loss of the initial endowments of 10 thalers per party after a bargaining breakdown reflects the costs of conflict that occur in the contractual setting: Recall that renegotiation occurs only if the seller's performance cost has risen above the contract price so that the seller loses interest in the contract. If the parties cannot agree on cancelation, the buyer has to enforce whatever remedy the law provides. Ensuring that a recalcitrant seller performs as specified requires the buyer to closely monitor performance. It often also involves resolving disputes—through litigation or out of court—over contract interpretation and the quality of the good. Similar issues arise when the remedy is ED but the seller chooses to perform. If instead she breaches the contract, damages need to be assessed. This requires a determination of the contractual obligation and of the benefits the buyer would have derived from performance.

Overall, both continuation of the contract and breach are associated with conflict costs that the parties can save by releasing the seller from her obligation against a specified payment.

4.3.2 Procedures

The experiment was conducted at the University of Mannheim's mLab with a total of 168 student participants from various study areas, recruited via the ORSEE system (Greiner 2015). Eleven sessions were held, with 8 to 18 subjects per session and with no subject participating in more than one session. We used a random matching protocol with 17 statistically independent matching groups. Nine matching groups employed the SP regime, in the remaining eight matching groups negotiations were governed by ED. Each session consisted of 25 rounds which yields a total of 2,100 one-on-one bargaining games, 1,050 for each treatment. As we discuss below, for the analysis we discard the first five of the 25 rounds from each session. This leaves us with 1,680 bargaining encounters, 840 for each treatment.

At the beginning of a session, participants were randomly seated at private cubicles and given a set of instructions, which were then read aloud by the experimenter.[29] Payoffs were expressed in "thalers". In each period, players were randomly matched into pairs and were assigned either the role of "Person A" (seller) or that of "Person B" (buyer). Participants interacted solely through the computer interface and stayed anonymous. No other form of communication between subjects was allowed during the experiment. The software was programmed in VB.NET.[30]

At the end of a session, participants were paid based on their average payoff in a random selection of three rounds each in the role of Person A and Person B. Participants were informed about this procedure at the beginning of the session. Four thalers translated into one Euro, resulting in an average earning of 15.42 Euros for a session lasting less than one and a half hour.

4.4 Research questions

Whether the parties should agree to forego performance depends on the relation between the seller's performance cost, the buyer's valuation, and the conflict costs of enforcing SP or ED. For conflict costs of 10 thalers per player and the value ranges assumed in the experiment, Figure 23 depicts the efficient strategy combinations. In the light grey area, the seller's cost exceeds the buyer's valuation so that it is efficient to abolish the contractual obligation. Should the parties fail to agree, however, not performing the contract is the next best option. The preferred strategy without an agreement is indicated in parentheses: Agree (Breach). In the

[29] A translated version of the instructions can be found in Appendix A.
[30] Appendix B contains a screenshot of the interface.

white area, the buyer values performance more than it costs the seller but the conflict costs from forcing the seller still make it optimal to agree on non-performance—this is the Agree (Perform) region. Finally, in the dark grey zone the buyer's valuation is so large relative to the costs of performance and enforcement that the contract should be executed—the Non-Agree (Perform) region.

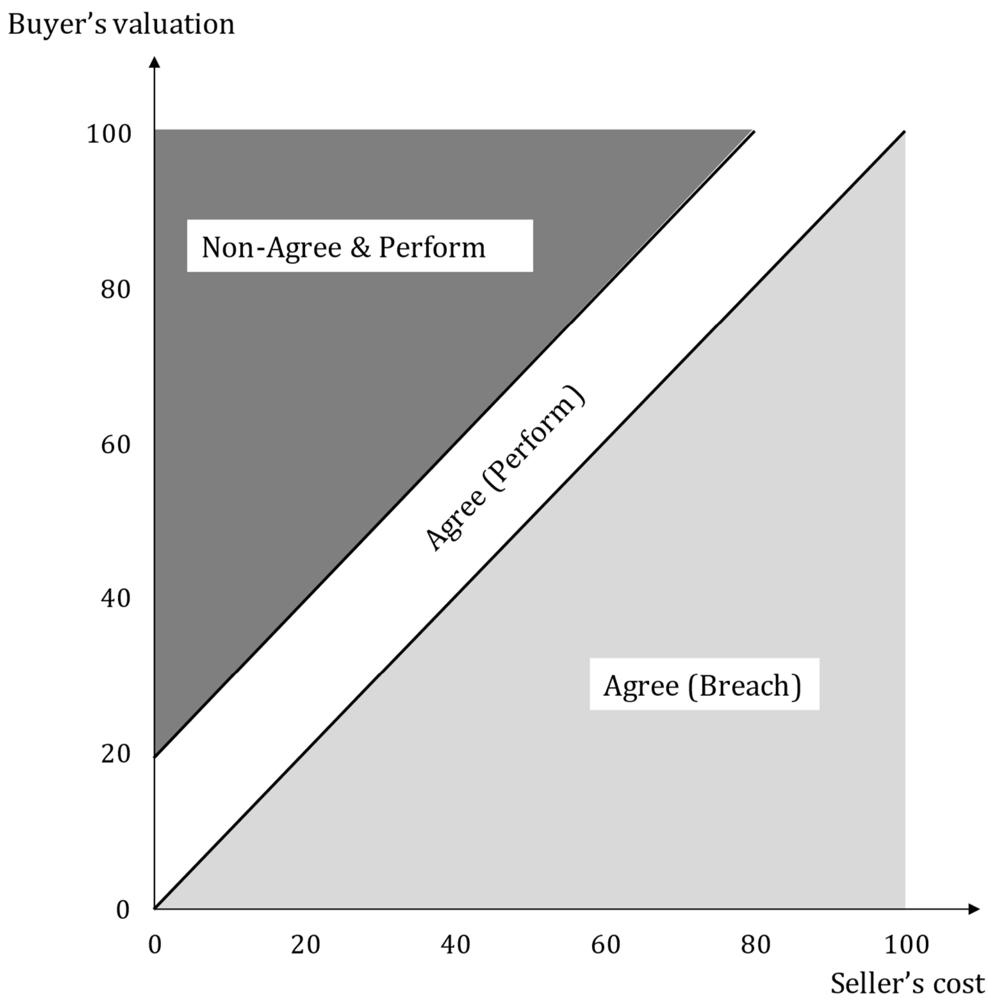

Figure 23: Efficient strategy combinations

A formal analysis of bargaining under two-sided asymmetric information requires restrictive assumptions on bargaining protocols and often leads to manyfold equilibria with no specific prediction. Therefore, we confine ourselves to offering an intuition why SP could facilitate the parties' ex post decision making over contract performance. We start by noting that ED has an advantage if one leaves aside contract renegotiation because the seller can unilaterally avoid inefficient performance. Given that in our setting the buyer's average valuation is 50, efficiency-oriented sellers with performance costs greater than 50 would breach.[31] The expected total

[31] Note that without renegotiation, the parties cannot avoid conflict costs.

payoff would be greater than under SP. On the other hand, if renegotiation were possible and took place under complete information, it would be plausible to expect the parties to reach the efficient outcome under either remedy. These two observations suggest that ED, if anything, lead to more efficient outcomes because they hold the potential to correct bargaining failures (the “head start” argument in favor of ED, see Kaplow and Shavell 1995, 1996).

This line of reasoning assumes that bargaining works equally well under both remedies. We explore the idea that SP may create stronger incentives for the parties to reach agreement because with SP this is the only way to avoid inefficient performance. Specifically, since ED give the seller the power to appropriate all renegotiation surplus by breaching the contract without the buyer’s consent, the buyer has—apart from conflict costs—no incentive to reveal a low valuation. Under a SP remedy, by contrast, the buyer may find it more attractive to explore the possibility of a mutually beneficial agreement opportunity together with the seller. The presence of conflict costs restores some of the incentive to reach a deal with ED. However, the surplus that only an agreement can produce remains smaller under ED compared to SP, as Figure 24 illustrates. Although specific performance widens the agreement range only when breach is efficient, this makes it easier and more attractive for the parties to discover an agreement opportunity. Our main claim, therefore, is that SP is more conducive to renegotiation than ED.

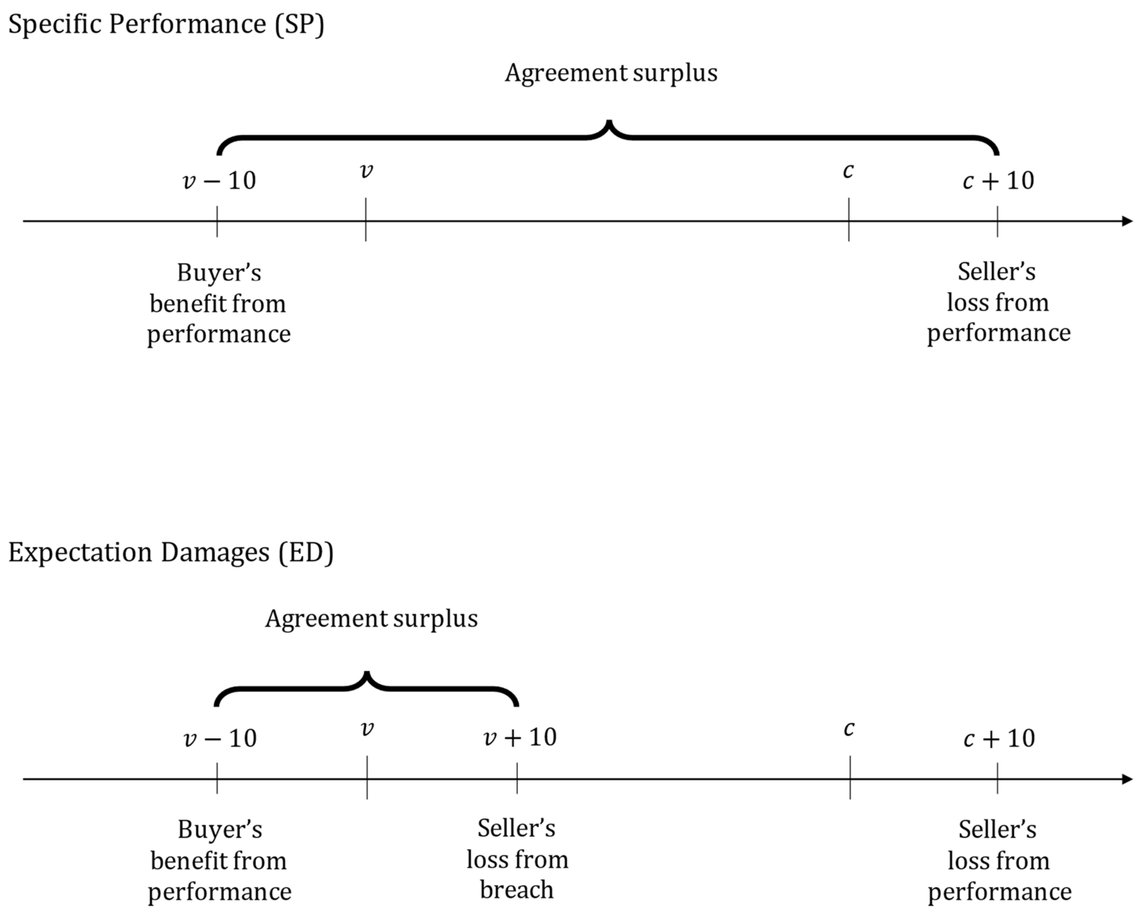

Figure 24: Available surplus from agreements under SP and ED

Buyer valuation: v; seller performance cost: c; conflict costs: 10 for each party

We start our inquiry by asking whether ED help the seller to avoid having to perform the contract when her costs exceed the benefit to the buyer, as the traditional efficient-breach analysis suggests. This is not obvious as in our setting with two-sided private information, the seller does not know the buyer's valuation.

Question 1: Do ED reduce performance when it is inefficient?

We then turn to our main claim, a potential advantage of SP in promoting efficient renegotiation of the contract.

Question 2: Does SP lead to more efficient agreements?

Assuming that the first two questions are answered in the affirmative, it is interesting which of the two effects prevails and, as a consequence, which of the two candidate remedies is more efficient.

Question 3: Do ED or SP lead to greater total expected payoffs for the parties?

Besides the efficiency consequences for the parties combined, the two competing remedies can have a differential impact on the welfare of the seller and buyer.

Question 4: How do ED and SP affect the individual expected payoffs of the parties and hence the wealth distribution?

Lastly, if ED and SP—as we suspect—affect renegotiation one would like to learn which changes in bargaining behavior cause these different outcomes. ED gives the seller an additional outside option if renegotiation breaks down. This suggests that ED make the seller less willing to compromise than SP.

Question 5: How willing to compromise are the seller and the buyer under ED and SP?

4.5 Results

4.5.1 Agreements over time

Before we turn to answering our main research questions, we look for a time trend in the behavior of subjects in the experiment. Figure 25 shows how frequently the negotiating parties strike agreements conditional on whether it is efficient to do so. The agreement rate fluctuates mostly between 70 and 80 percent. There is no discernible trend over time. It is not surprising that there are such imperfections in the negotiation outcomes: Identifying efficient agreements is a non-trivial collective undertaking that requires information from both parties but revealing individual private information carries the risk of substantially weakening one's bargaining position.

In contrast, *inefficient* agreements are easily averted in our setting if neither player accepts a deal that yields a lower payoff than the respective outside option. As Figure 25 shows, most participants quickly learn to subscribe to this principle during the initial phase of the experiment. However, a low rate of inefficient settlements remains. One explanation is that some subjects just value the cooperative nature of coming to an agreement and are willing to forgo a proportion of their payoff for that. While there are cases in the data that seem compatible with this idea, only few individuals strike unprofitable deals more than once. This suggests that the majority of inefficient settlements occur by mistake, possibly due to the switching of roles across rounds which may occasionally create a moment of confusion regarding the distribution of money under a proposed agreement. Because these outcomes are more prevalent at the beginning of the experiment, we exclude the first 5 periods from our analysis.

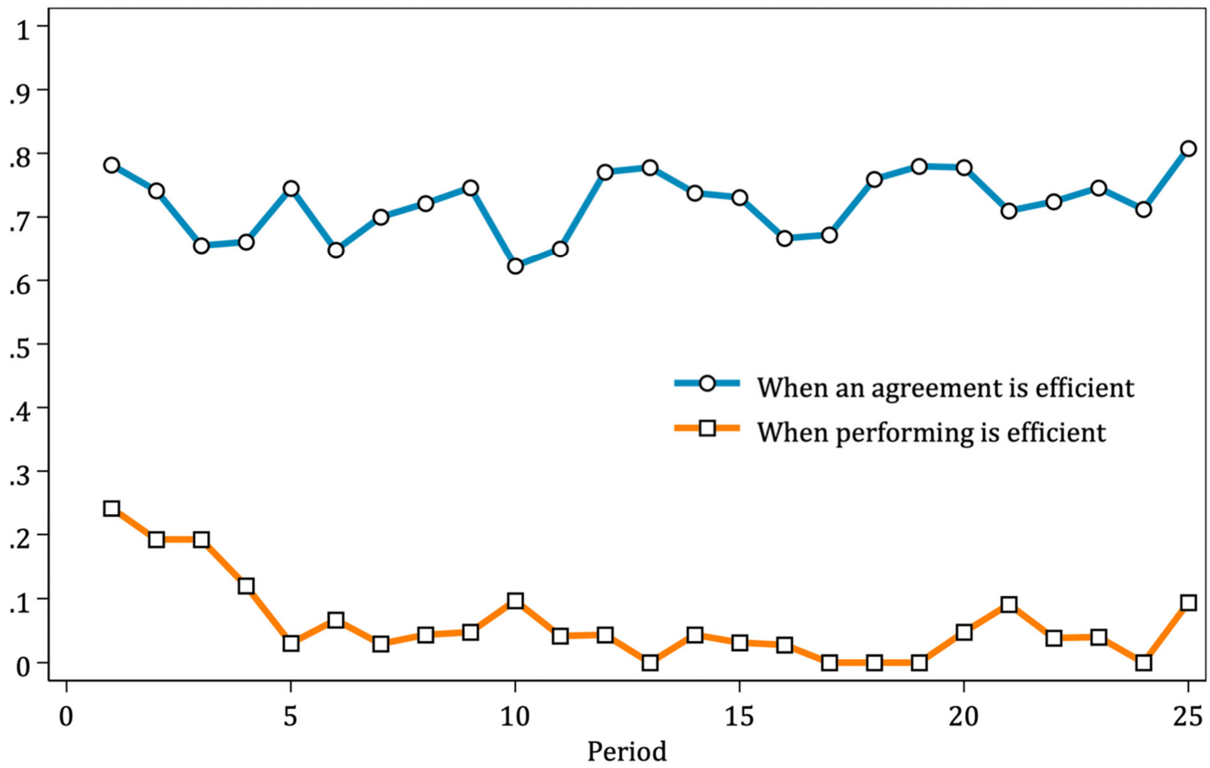

Figure 25: Share of pairings reaching an agreement

4.5.2 Efficiency analysis

The main part of our analysis will focus on instances where buyer value and seller cost make agreements optimal for the parties, starting with the Agree (Breach) parameter region and then turning to Agree (Perform). Subsequently, we will consider the Non-Agree & Perform case in which continuing to perform the contract maximizes the parties' joint surplus.

Agree (Breach): Efficient breach

In the Agree (Breach) region, the seller's cost of performance is so large that breaching the contract and compensating the buyer is preferable to performance even in the absence of an agreement. Here, ED has the best chance of surpassing SP. However, with incomplete information it remains an open question to what extent, first, the parties can avoid conflict cost and, second, sellers successfully identify the optimal choice, breach or performance.

Figure 26 provides an overview of the negotiating partners' actual earnings relative to the first best. That is, taking the outcome of an agreement as a reference point—normalized to zero—the figure shows average total earnings both conditional on no agreement being reached and overall. As the light blue bars indicate, negotiation failure is generally quite costly as one would expect due to conflict costs. However, there is a clear difference between the two remedies: While forced performance under the SP regime leads to very severe payoff reductions (−37.3), efficiency losses under ED are mitigated considerably (to –24.3) by sellers making use of their breach option. This treatment effect is highly significant (p-value < 0.001).[32] As illustrated in Figure 27, the frequency of inefficient performance drops from 10% of cases in the SP treatment to less than 7% in the ED treatment. In this sense the remedy of ED works as intended.

Result 1: Avoiding inefficient performance. *Under ED it is less likely that sellers end up performing when doing so is inefficient. This leads to substantial efficiency gains relative to SP if the parties are unable to reach an agreement.*

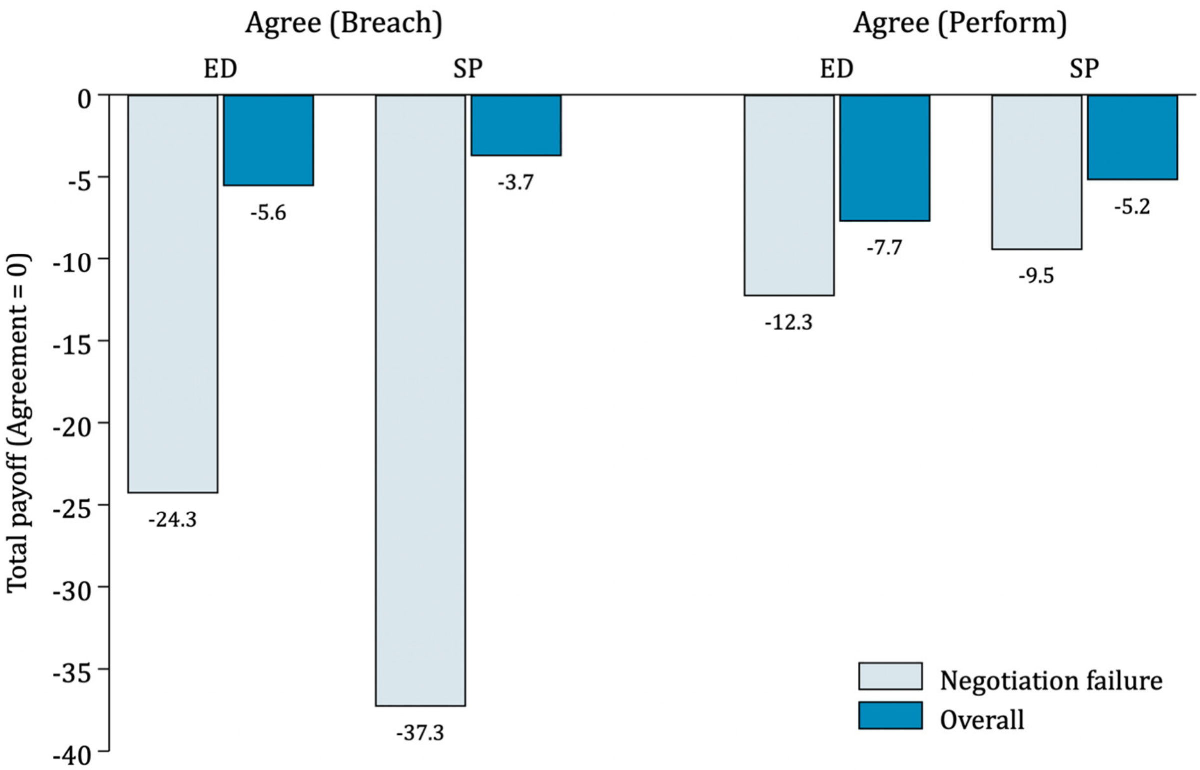

Figure 26: Average earnings when agreements are efficient

However, there is a flipside to this story. As is also evident from Figure 27, negotiation failure is substantially more common under ED (23% of cases) than under SP (10% of cases). The relevant statistical comparison yields a p-value < 0.001 for this difference. Thus, given the information problems in our setting, it is harder for subjects to come to an agreement with the

[32] For treatment comparisons we use nonparametric two-sided Fisher-Pitman permutation tests for independent samples based on the statistically independent matching groups, unless explicitly stated otherwise.

ED remedy than with SP. In Section 4.5.4, we will take a closer look at potential reasons for this.

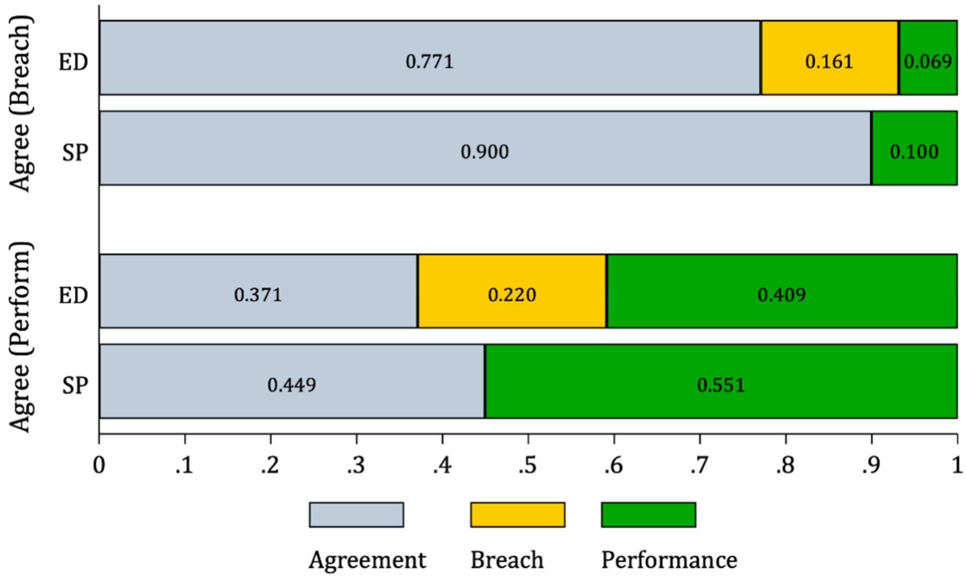

Figure 27: Outcomes when agreements are efficient

Overall, the second effect carries a little more weight. Relative to the efficiency benchmark of reaching an agreement subjects lose 5.6 thalers in the ED treatment but only 3.7 thalers under SP (see Figure 26). However, this difference is not significant at conventional levels (p-value = 0.153).

Agree (Perform): Avoiding conflict

In the Agree (Perform) parameter region, breach is inefficient. The optimal outcome nonetheless is to abolish the contractual promise consensually because retaining it entails conflict costs that would push parties' earnings into negative territory.

Consider again Figure 26 and Figure 27. Naturally, the payoff losses from negotiation failure are not as severe as in the Agree (Breach) region. This may explain why agreements are far less common (p-value < 0.001).[33] In fact, subjects attain the first best solution in fewer than 50% of the cases. As shown in Figure 27, agreement rates are again lower under ED than under SP. Furthermore, sellers often use the opportunity to breach the contract unilaterally, to their own detriment. As a result, total payoffs are lower in the ED treatment than in the SP treatment (p-value = 0.014).

[33] For statistical within-group comparisons we employ the two-sided Fisher-Pitman test for *paired* observations based on the statistically independent matching groups—again, unless explicitly stated otherwise.

Result 2: Bargaining efficiency. *Even though failure to settle is a common problem in both treatments, negotiations are significantly more likely to be successful under SP than under ED.*

The value of performance and expected earnings

To further explore the relative efficiency of the two remedies and how earnings develop as we move from one region of cost/value parameters to the other, we relate outcomes to the *value of performance*—the difference between the buyer's valuation and the seller's performance cost. The value of performance is negative in the efficient breach region whereas it is positive, albeit relatively small, in the Agree (Perform) region. Figure 28 shows expected total payoffs based on probabilities estimated in a multinomial logit regression of outcomes—agreement, breach, or performance—on the value of performance. The fitted probabilities of the model are multiplied with the respective total payoffs to calculate expected total payoffs.

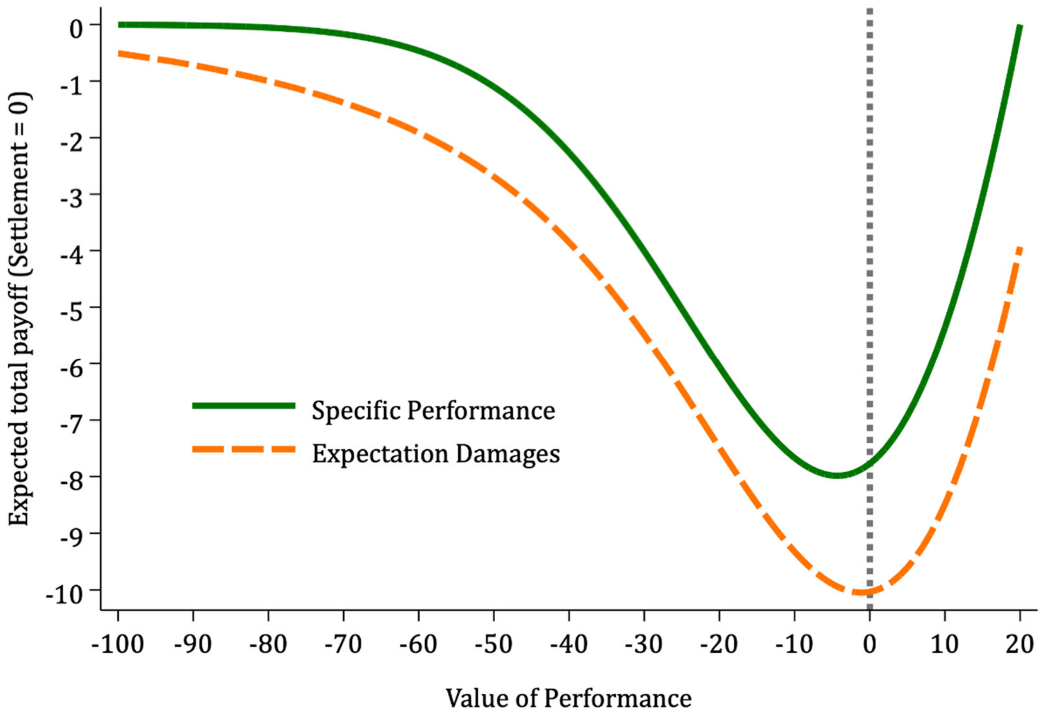

Figure 28: Expected earnings as a function of the value of performance

Consider first SP. The main drawback of this remedy is that it can force the seller to perform even if it is inefficient. The potential damage is most severe when the seller's cost is particularly high and, at the same time, the buyer's value is very low, i.e., when the value of performance is close to –100. However, as Figure 28 shows, the ill effects of overperformance in these situations are in fact negligible as the risk of negotiation failure turns out to be extremely small. Expected payoffs deteriorate only when the negative consequences of performing fall to lower levels. Now it becomes more common that the parties fail to agree. A low point in expected payoffs is reached when the value of performance comes close to zero. As the negative impact of the seller performing the contract is limited at this point, the low payoffs result from reduced agreement probabilities in combination with conflict costs. Once the value of performance turns positive, forced performance mitigates losses from conflict costs. At a value of 20, the expected total payoff in the SP treatment is zero by construction.

By comparison, ED generate lower overall earnings relative to SP, on average by approximately 2 thalers.[34] This means that switching from SP to ED increases the efficiency loss by 49% on average. For negative values of performance this is caused solely by lower agreement probabilities, since the ED regime is, as we have seen, more efficient in case of negotiation failure. For positive values of performance there is an additional second effect: Not only do the negotiators miss out on the first-best solution when they fail to agree, but ED introduce a new way of "getting it wrong" for the seller—breaching the contract instead of performing. As can be seen in Figure 27, this is not uncommon: Overall, the seller breaches the contract in 22% of cases and conditional on negotiation failure, the chance of a contract breach exceeds one third ($0.22/(0.22 + 0.409) \approx 0.35$). This explains the considerable and tenacious gap in expected payoffs between treatments that persists even as the value of performance approaches 20 where an agreement delivers the same total payoff as performance.

Non-Agree & Perform: Efficient performance

Finally, we briefly consider the least interesting Non-Agree & Perform region where the parties should continue to perform the contract since the value of performance outweighs conflict costs. Here, SP enjoys a natural advantage because it flatly prescribes the efficient outcome. As discussed in Subsection 4.5.1, subjects rarely agree on non-performance in this case. There are no noticeable treatment differences in this respect. As a consequence, the SP treatment mostly reproduces the randomly determined cost and value parameters. In contrast, the ED treatment affords the seller again an additional opportunity to "get it wrong" by breaching instead of performing the contract. In fact, sellers choose to breach in 4.3% of cases, bringing the rate of performance down from 97% to 91% (p-value = 0.046) and leading to a 16% drop in total payoffs (p-value = 0.008).

[34] The p-value from a two-sided Fisher Pitman test against the null hypothesis of no difference is 0.049. This result is also confirmed by an OLS regression of joint earnings on treatment in the efficient agreement region, controlling for the value of performance and using robust standard errors clustered on matching groups (p-value = 0.013).

Result 3: Total payoffs in ED vs. SP. *Overall, ED lead to lower total payoffs compared to SP. In the Agree (Breach) region, although outcomes are more efficient under ED when negotiations break down (Result 1), it is also more likely that they do break down (Result 2). As a result, ED carry no net advantage over SP in efficient breach scenarios. In the Agree (Perform) region, SP is more efficient than ED because, first, there are more (efficient) agreements (Result 2 again) and, second, there is a substantial risk of inefficient breach under ED. The latter effect also diminishes ED payoffs in the Non-Agree & Perform region.*

4.5.3 Distributive outcomes

How competing policies impact on the wealth distribution between affected parties is generally a relevant question. In the contractual context that we consider here, the distributive effects of performance choices can also have welfare implications. Remember that our experimental setup concerns a special contingency in the life of the contract, namely that the performance cost has risen above the price so that the contract value turns negative for the seller. So far, our analysis has focused on the remaining joint surplus ex post. However, an equally prominent concern in contract theory is whether the parties invest optimally in maximizing expected contract value ex ante. In this regard, a standard argument for efficient breach is that giving the buyer a veto right ex post enables him to extract a side payment in excess of the value of performance. Not performing thus carries an extra cost for the seller beyond internalizing the loss in buyer surplus. As a consequence, it is asserted, the seller would overinvest ex ante to avoid having to pay the buyer ex post for giving up a right to inefficient performance (cf. Shavell 1980).

The distributive consequences of ED and SP in our experiment suggest, however, that the choice of remedy does not noticeably change a seller's ex ante incentives. Indeed, 75% of the efficiency gain from SP accrues to the buyer.

Table 2 reports the results of a regression analysis of seller and buyer payoffs on potential determinants, including the remedy, the bargaining positions defined by the seller's cost of performance and the buyer's valuation, as well as demographic variables (columns 1 and 2). As one would expect, the parties outside options strongly influence ultimate outcomes. The buyer gains significantly from the treatment effect but there is no indication that this comes at the seller's expense.

Result 4: Seller and buyer payoffs. *Relative to ED, seller payoffs do not deteriorate under SP while buyer payoffs improve.*

In addition, Table 2 contains specifications that examine the interaction between the treatment variable and seller cost or buyer value (columns 3 and 4). We find that the seller's cost has a greater impact under SP than under ED: The seller suffers (benefits) more and the buyer benefits (suffers) more when the seller cost increases (decreases). The impact of the buyer's value, on the other hand, is *weaker* under SP than under ED.[35]

Why is this the case? Recall that buyers are not directly affected by the treatment since their outside option corresponds to their own value under both remedies, irrespective of whether the seller performs or breaches. However, removing the breach option in SP changes negotiation behavior and outcomes. Specifically, although seller costs and agreement propensities are positively correlated in both treatments, negotiations are more likely to succeed in SP than in ED when seller costs are high and her bargaining position is weak. The reason is that under ED the seller has unilateral breach as a viable alternative to accepting an unsatisfactory negotiation outcome. Without this alternative, high-cost sellers are more willing to compromise (as we will also see in more detail in the next subsection). Thus, some unilateral-breach payoffs, which are solely driven by damages, are effectively replaced by agreements, which also reflect seller costs. Furthermore, even without changes in the agreement rates, SP sellers always negotiate with their own cost parameter as the relevant disagreement point whereas some ED sellers see compensating the buyer as the relevant outside option. In consequence, the effect of buyer value on the seller's bargaining strategy could be greater under ED.

[35] The interaction effect is not statistically significant for the buyer, however.

	(1) Seller payoff	(2) Buyer payoff	(3) Seller payoff	(4) Buyer payoff
Specific Perf. (0/1)	0.729 (0.499)	2.085** (0.736)	0.054 (1.320)	–0.557 (1.415)
Seller cost	–0.531*** (0.017)	0.190*** (0.013)	–0.497*** (0.026)	0.158*** (0.016)
Buyer value	–0.274*** (0.017)	0.566*** (0.012)	–0.317*** (0.025)	0.572*** (0.018)
SP × Cost			–0.068** (0.030)	0.064*** (0.018)
SP × Value			0.083*** (0.026)	–0.012 (0.024)
Period	0.104*** (0.035)	0.011 (0.071)	0.103*** (0.033)	0.011 (0.071)
Year of study	0.180 (0.229)	–0.248 (0.263)	0.162 (0.238)	–0.241 (0.254)
Female (0/1)	–1.498* (0.712)	–0.216 (0.653)	–1.608** (0.715)	–0.193 (0.643)
Economics	0.697 (0.650)	0.375 (0.719)	0.558 (0.626)	0.337 (0.705)
N	1674	1666	1674	1666
F-test p-value	0.000	0.000	0.000	0.000
Adj. R^2	0.626	0.659	0.631	0.661

Table 2: Determinants of seller and buyer payoffs

*OLS regression. Significance at the 10%, 5%, 1% level is denoted by *, ** and *** respectively. Standard errors clustered for matching groups.*

4.5.4 Bargaining behavior

We have already seen that subjects are less likely to reach efficient agreements under ED than under SP. We will now examine underlying causes for this result and discuss bargaining behavior more generally.

We begin by considering how offers develop over time. Players enter the bargaining stage with the knowledge of their own cost or value, and the offers they submit must be viewed in the light of this. Taking the payoffs that would be obtained under seller performance as a benchmark, Figure 29 shows how much players ask for, on average, in excess of this benchmark when they submit offers over the course of the negotiations. As one would expect, there is a tendency for players to start with high demands, but to gradually lower these over time. Furthermore, there is a noticeable treatment effect. While buyer and seller behavior is virtually indistinguishable under SP, there is a clear difference in the bargaining strategies of buyers and sellers under ED: Sellers ask for more.

This is also reflected in players' *final offers*—the last offer made in a negotiation. In the SP treatment, sellers and buyers display very similar levels of aspiration: On average, they ask for an amount that would improve their position relative to the outside option by 14.7 thalers (sellers) and 14.5 thalers (buyers). It appears that ED encourage sellers to become more assertive and buyers to be more conciliatory in response: Their average final offers for the ED treatment are 17.0 and 13.9 thalers, respectively. This indicates a considerable gap in bargaining behavior between sellers and buyers under the ED regime (p-value = 0.023) that is not present under SP.

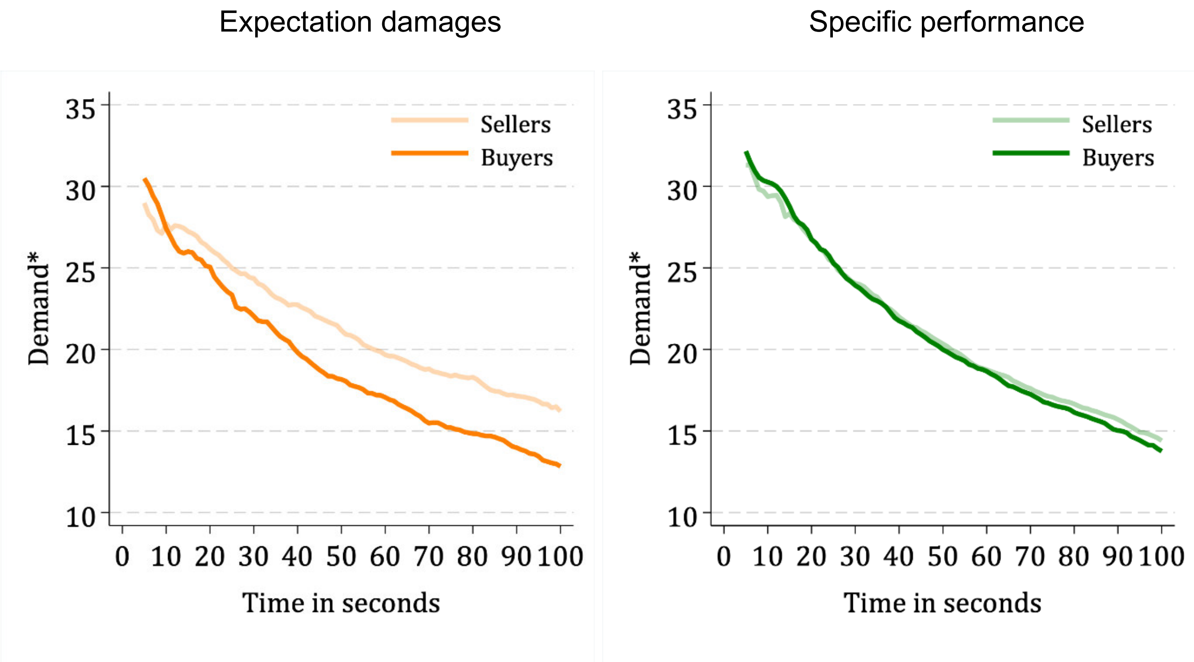

Figure 29: Buyer and seller demands over time

* A demand at time t is defined for a buyer as the payment he would receive if his own current offer was accepted by the seller minus his value, or—if at time t he has already accepted a seller offer himself—the payment from that offer minus his value. For a seller a demand is correspondingly defined as the seller's cost minus the payment she offers or has already accepted at time t.

Figure 30 provides further details on how demands depend on the outside option of the seller performing. It shows that both sellers and buyers naturally ask for larger shares of the pie in the negotiation stage as their outside option improves.[36] The relationship between the outside option and one's final offer is on the whole similar across roles and treatments, except that sellers in the ED treatment who would obtain low or moderate payoffs if they opted to perform subsequent to a negotiation failure make markedly higher demands.

[36] To use the same scale for both parties in Figure 30, the outside option for the seller on the horizontal axis should be read as $100 - c$.

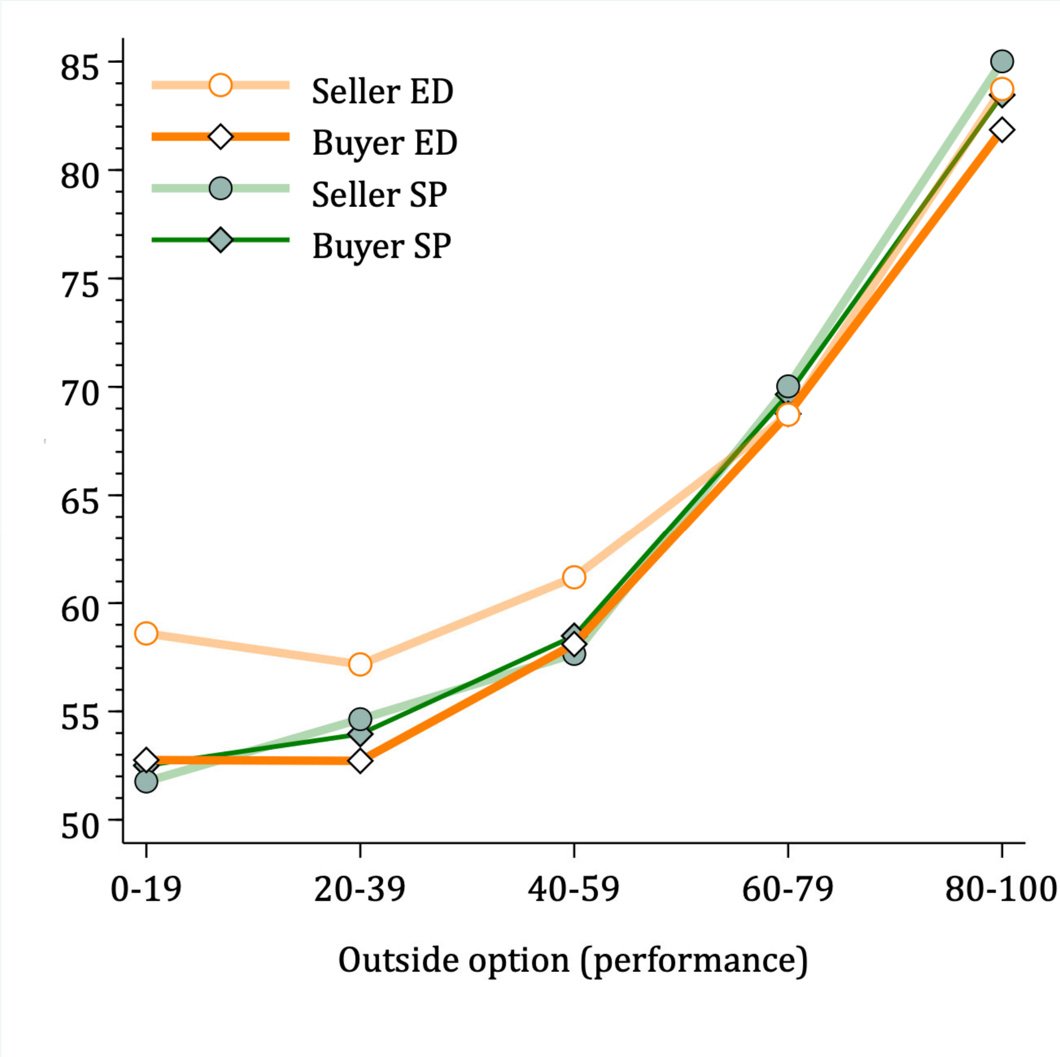

Figure 30: Final offers across roles and treatments

Mean own payoff from own final offer in relation to outside option[36]

Next, we ask whether the given remedy also impacts in some way on the success or failure of negotiations and how this differs between the Agree (Breach) and the Agree (Perform) regions.

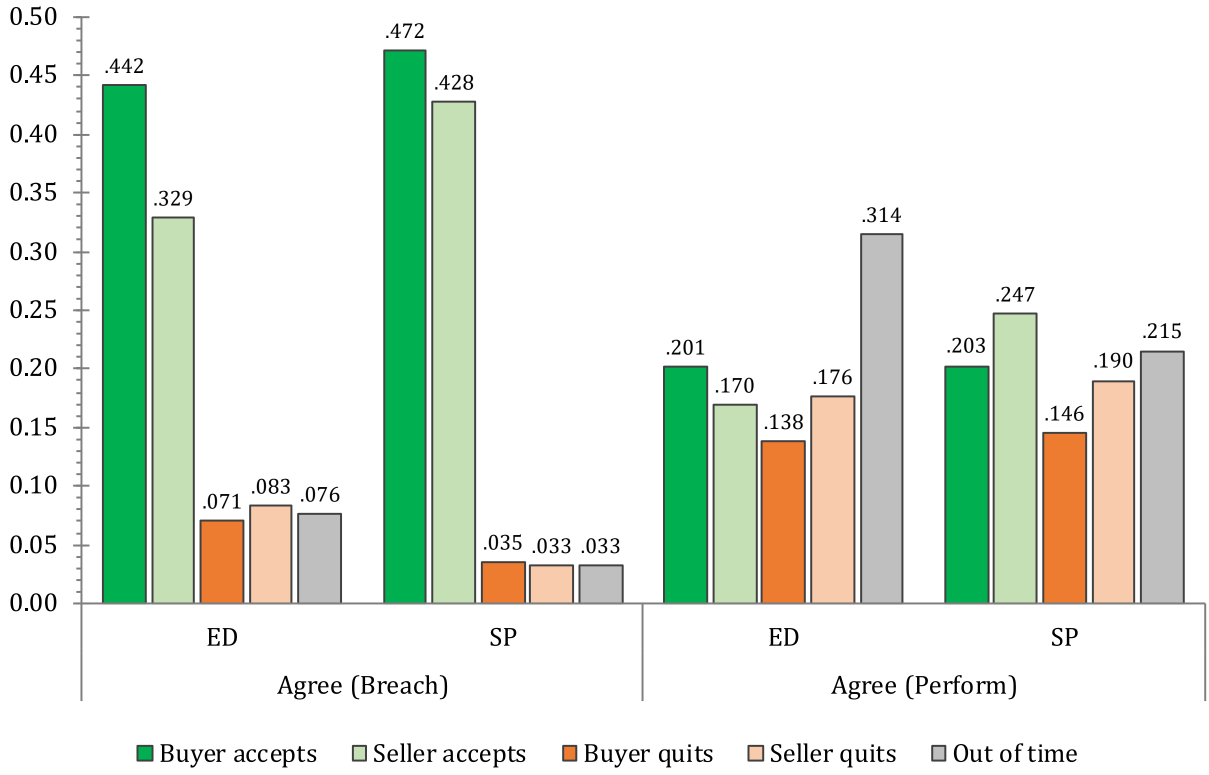

Figure 31: Frequency of negotiation outcomes

Figure 31 displays what led to either an agreement or non-agreement. The main results for the Agree (Breach) region are as follows. First, agreements result significantly more often from buyers accepting the seller's offer than vice versa (p-value = 0.018). Second, SP makes sellers significantly more inclined to accept compared to ED (p-value = 0.035). Third, while the immediate causes for bargaining failure are mixed (either partner quits or players run out of time with similar frequencies), we again find that SP softens the seller's bargaining behavior in making her less likely to actively quit the negotiation (3.3% versus 8.3%; p-value = 0.012). For buyers there are qualitatively similar effects, but they are less pronounced (accepting: 47.2% versus 44.2% with a p-value of 0.165; quitting: 3.5% versus 7.1% with a p-value of 0.087).

The Agree (Perform) region with its tighter agreement range is more difficult to navigate for bargainers. Neither sellers nor buyers appear more willing to accept, and while sellers seem again more ready to concede under SP than under ED the difference is not significant (p-value = 0.213). Non-agreements most often result from standoffs where neither party accepts the other's offer and time expires; the difference between ED and SP is not statistically significant (p-value = 0.199). Sellers terminate negotiations more often than buyers but this is again not statistically significant (p-value = 0.191).

That sellers are more inclined to accept offers and overall less likely to quit in the SP treatment could be the result of buyers making more generous offers than in the ED regime. However, this is not in line with our earlier analysis of final offers: If anything, buyers' offers are somewhat less attractive under SP. A logit regression of the parties' propensities to accept on the treatment variable confirms that sellers are more inclined to agree to a buyer offer under SP than under ED after controlling for both the offer made and the own outside option, as well as for period, gender, year of study, and economics as a study field. The results are reported in Table 3. In the Agree (Breach) region the probability of a seller accepting a given offer is about 8 percentage points higher in the SP treatment relative to ED. There is no treatment effect for buyers.

	Agree (Breach)		Agree (Perform)	
	Seller accepts	Buyer accepts	Seller accepts	Buyer accepts
Specific Performance (0/1)	0.0822*** (0.0284)	–0.0316 (0.0274)	0.0256 (0.0419)	–0.0008 (0.0450)
Partner's final offer	0.0090*** (0.0015)	0.0074*** (0.0021)	0.0163*** (0.0057)	0.0148*** (0.0022)
Own cost (seller) or value (buyer)	0.0064*** (0.0006)	–0.0093*** (0.0007)	0.0143*** (0.0045)	–0.0148*** (0.0020)
Period	0.0003 (0.0028)	0.0013 (0.0030)	0.0107** (0.0050)	–0.0029 (0.0029)
Year of study	–0.0272* (0.0143)	–0.0158* (0.0091)	–0.0058 (0.0125)	0.0038 (0.0100)
Female (0/1)	0.1060*** (0.0328)	0.0179 (0.0310)	–0.0351 (0.0505)	–0.0564 (0.0361)
Economics	–0.0498 (0.0403)	–0.0481 (0.0389)	–0.0285 (0.0467)	–0.0188 (0.0386)
N	795	803	294	298
Prob. > Chi^2	0.0000	0.0000	0.0000	0.0000
Pseudo R^2	0.1083	0.1516	0.2451	0.2979

Table 3: Determinants of accepting offers

*Average marginal effects from logit regressions. Significance at the 10%, 5%, 1% level is denoted by *, ** and *** respectively. "Partner's final offer" is the last offer that the other party made during the negotiation and is therefore the offer that is implemented in the agreement.*

Result 5: Bargaining behavior. *Sellers become tougher negotiators under ED relative to SP. They ask for a greater share of the pie, are more reluctant to accept buyer offers, and display a greater inclination to quit the negotiation altogether. For buyers, there are no clear treatment effects. As discussed earlier (Result 4), sellers ultimately do not benefit from the ED regime whereas buyers suffer from lower payoffs.*

4.6 Conclusion

For more than half a century, it has been a treasured precept of law and economics to “Never Blame a Contract Breaker” (Posner 2009). The idea of encouraging contract breaches figured as a signature claim of the efficiency paradigm while attracting much criticism from its opponents. Our findings suggest that a seller’s option to breach is more problematic even from an efficiency perspective. With two-sided asymmetric information about the cost and value of performance, the parties face the difficult task of determining whether it is in their joint interest to continue or abort the contractual exchange. Bargaining is one road to piece together dissociated information, albeit an imperfect one. In our experiment, the parties scarcely abandon efficient performance but they sometimes fail to agree on efficient reversal of the contract. Giving the seller the ability to breach corrects many such mistakes. It also introduces the new risk that the seller reneges on her promise when it remains efficient. Yet the main harm from the seller’s unilateral option is that it compromises the bargaining process. The seller is emboldened to take a tougher bargaining position and thereby prevents agreements for which a subsequent breach is only a poor substitute. At a more general level, this finding hints at a key advantage of property over liability rules: making an agreement strictly necessary for value creation can reduce the transaction cost of reaching it.

Our experimental design gives subjects much greater bargaining freedom than a rigorous theoretical analysis can afford. Nonetheless, a two-minute negotiation with a restricted message space, no context and weak incentives is still very distant from the real world of high-stakes contracting. Demonstrating the adverse effect of the breach option in the lab is, therefore, only a first step. In moving closer to reality, a straightforward next question to explore is if adding the contractual setting back to the game—and the normative preferences that come with it—change the results. Also, the pivotal role of private information in the lab raises the question whether the same factor explains the considerable heterogeneity of remedies in real-world contracts.

5 Conclusion

The main question of my thesis is how the choice of entitlement protection affects efficiency under asymmetric information in situations that allow for bargaining. We compared two types of rules: the property rule, which requires mutual consent for a transfer, and the liability rule, which allows unilateral takings with compensation. We have considered two forms of models, the taker making a take-it-or-leave-it offer or the owner making a take-it-or-leave-it offer. We applied them first to the scenario of one-sided asymmetric information in chapter 2 and secondly to a scenario of two-sided asymmetric information in chapter 3. This was followed by an analysis of a laboratory experiment in chapter 4 that we conducted to compare how property and liability rules affect bargaining with a more open bargaining protocol. In the experiment, we focused on contract remedies and two-sided asymmetric information.

The main findings of my thesis are as follows: First, liability rules allowing for unilateral takings against monetary compensation might give them an efficiency advantage over property rules when transaction costs impede consensual transfer of an entitlement. Chapter 2 of my thesis shows that transaction costs themselves depend on the mode of entitlement protection. The game theoretic model with one-sided asymmetric information, the owner's valuation being private information, and costly enforcement of compensation, reveals, that only a property rule achieves the first best when the owner of the entitlement has all the bargaining power. The property rule is more efficient than the liability rule when the informed party makes the take-it-or-leave-it offer, as it induces truthful revelation and trade in all efficient cases. In the opposite case with a take-it-or-leave-it offer from the potential taker as the uninformed party, a property rule is more efficient than a liability rule for most parameter values. In that regard it is important to note that my model in chapter 2 assumes that liability rule administration involves costs. Damage assessment replaces agreed transfers with court-designed transactions. These costs reflect the time, effort, and expense devoted to determining damages, including evidence collection and settlement bargaining to avoid higher litigation costs. Conflict costs burden the liability rule, but the competition between property and liability entitlement protection involves more than a simple tradeoff between these costs and allocative efficiency. Welfare losses result from both misallocation of the entitlement and conflict costs. While liability rules can overcome bargaining impasse, they hamper the exchange of information and raise the cost of voluntary transactions. The liability rule often loses on both counts.

Second, the game theoretic model with two-sided asymmetric information in chapter 3 reveals that even with high transaction costs due to two-sided asymmetric information, the liability rule is not superior. This contradicts the conventional belief that liability rules are ideal in scenarios characterized by high transaction costs. Conventional theory recommends liability rules as they allow for unilateral takings of entitlements when parties fail to trade under a property rule.

However, the analysis reveals that asymmetric information complicates the efficiency of the rules in a nuanced manner. It shows that liability rules entail negative side-effects, as it results in inefficient takings and less effective bargaining.

The model demonstrates that neither rule achieves the first best outcome, as both rules suffer from inefficiencies due to either non-trade or over-trade. The relative performance of the rules depends on the distribution of player types. The liability rule works better than the property rule when the expected benefit of transferring the entitlement is high and certain. Conversely, the property rule works better than the liability rule when the expected benefit of transferring the entitlement is low and uncertain. This is because the property rule allows parties to reveal their type through their offers, which helps to determine if the transfer is efficient.

Third, the bargaining experiment with two-sided asymmetric information confirms the theory that both property and liability rules have their benefits. In particular, the experiment supports the theoretical prediction, that property rules facilitate the bargaining process. The analysis reveals that giving the buyer a right to specific performance, which is the equivalent to a property rule, promotes efficient bargaining: The parties more often agree on non-performance, or continue to execute the contract, when it is optimal to do so. The seller's ability to breach the contract, which is the equivalent to take unilaterally, can correct bargaining failure. But in the experiment the benefits are small and outweighed by losses from inefficient breach and costly conflict. Conflict costs arise if the parties do not find an agreement as both property and liability rule involve equal administration costs in the experiment. The seller is emboldened to take a tougher bargaining position and thereby prevents agreements for which a subsequent breach is only a poor substitute.

At the general level, this finding supports the key advantage of property over liability rules: making an agreement strictly necessary for value creation can reduce the transaction cost of reaching it.

The findings of my thesis have wide-ranging implications. They offer valuable perspectives for lawmakers designing remedies in various legal fields, including patent law, contract law, and antitrust law. These insights are also useful for parties negotiating a contract and deciding on appropriate remedies. Beyond conventional legal environments, my results are relevant to other regulatory bodies, such as FIFA, deciding on the penalties to be imposed when a player breaches a contract to move to a different club. This underscores the thesis' broad relevance and applicability across diverse legal and contractual scenarios.

It is important to note that the analysis is subject to some limitations. The thesis gradually moves towards more realistic assumptions, from one-sided asymmetric information to two-sided asymmetric information and from extreme bargaining situations in the models to a more open bargaining protocol in the experiment. However, lab negotiation is still far from real high-stakes contracting. Future research should include the normative preferences to the game. Furthermore, the experiment could be replicated with different distributions of types, to test whether the distribution influences the efficiency of the rules as predicted by the game theoretic model of two-sided asymmetric information. Another interesting research question stipulated by this thesis will be to analyze whether private information is related to the variation of remedies in real-world contracts.

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Appendix

Proofs - Chapter 2

1. Signaling model

1.1. Proposition 1. Equilibrium of the signaling game under the property rule

The taker accepts any offer $x \leq w$and rejects higher offers. The owner prefers acceptance over performance if $x - v \geq 0 \Leftrightarrow x \geq v$. Knowing the taker's valuation, the highest acceptable demand is $x = w$. It follows that the owner demands $x = w$if $v \leq w$, which the taker accepts. If the owner's valuation is higher, $v > w$, the owner prefers the taker to respect his entitlement. Hence, he makes an inacceptable offer $x > w$.

1.2. Proposition 2. Equilibria of the signaling game under the liability rule

1.1.1. Case (I), $t \leq 2\phi$: Separating equilibrium, pure taker strategies

Consider for this equilibrium the owner's belief that the taker respects the entitlement if she rejects an offer. The taker prefers accept over reject-respecting for $w - x \geq 0 \Leftrightarrow x \leq w$ and reject-respecting over accept for $w - x < 0 \Leftrightarrow x > w$. It follows that owners with $v \leq w$ demand $x = w$.

Note for the upper limit of the equilibrium that for the taker to accept $x \leq w$, she also must be better off than with reject-take.

$$w - \mathrm{E}(v|x = w) + \phi = w - \frac{w}{2} - \phi \leq w - x = 0 \Leftrightarrow w \leq 2\phi$$

The owner's belief that the taker respects the entitlement after receiving demands $x > w$is consistent because the taker always prefers to respect the entitlement to take:

$$w - \mathrm{E}(v|x > w) - \phi = w - \frac{w + H}{2} - \phi < 0$$

$$H > w - 2\phi$$

1.1.2. Case (II), $2\phi < w \leq 2\phi \ln 2 + \phi = \bar{v} + \phi$: Separating equilibrium, mixed taker strategy

First note that a mixed strategy of accept and reject-take requires the taker to be indifferent between the two alternatives, i.e., $x = \mathrm{E}(v|x) + \phi$. This is true if the owner demands $x = v + \phi$.

The taker's acceptance probability $p(x)$ must be such that the owner's demand $x = v + \phi$ maximizes his expected payoff. The owner's problem is:

$$\max_{x} p(x)x + \big(1 - p(x)\big)(v - \phi)$$

The first-order condition is:

$$p'(x)x + p(x) - p'(x)(v - \phi) = 0$$

$$\frac{p(x)}{p'(x)} = v - \phi - x \qquad - \quad (1)$$

Inserting the separating demand $x = v + \phi$ into (1) we obtain:

$$-\frac{1}{2\phi}p(x) = p'(x)$$

$$-\frac{1}{2\phi} = \frac{p'(x)}{p(x)} = \frac{d}{dx}\ln\left(p(x)\right)$$

Taking the infinite integral for both side we get:

$$-\frac{1}{2\phi}x + k = \ln\left(p(x)\right)$$

$$e^{-\frac{x}{2\phi}+k} = p(x)$$

$$p(x) = ke^{-\frac{x}{2\phi}}$$

Since $p \in [0,1]$, p is a stepwise function:

$$p(x) = \begin{cases} 1 & x \leq \underline{x} \\ ke^{-\frac{x}{2\phi}} & x > \underline{x} \end{cases}$$

or, alternatively,

$$p(x) = \begin{cases} 1 & x \leq \underline{x} \\ ke^{-\frac{x}{2\phi}} & \underline{x} < x < \bar{x} \\ 0 & x \geq \bar{x} \end{cases}$$

k must be chosen such that $p \in [0,1]$. This implies:

$$ke^{-\frac{\underline{x}}{2\phi}} \leq 1 \Leftrightarrow k \leq e^{\frac{\underline{x}}{2\phi}}$$

and $ke^{-\frac{\bar{x}}{2\phi}} \geq 0 \Leftrightarrow k \geq 0$.

It follows that $p'(x) \leq 0$ and $p''(x) \geq 0$, which ensures that the second-order condition for a maximum is always satisfied because $x > v - \phi$:

$$p''(x)x + 2p'(x) - p''(x)(v - \phi) < 0$$

We derive $\underline{x}$ and k using the requirement that the taker prefers accept over reject-take for $x = \underline{x}$:

$$\underline{x} \leq \mathrm{E}\left(v \middle| x = \underline{x}\right) + \phi \Leftrightarrow \underline{x} \leq \frac{\underline{x} - \phi}{2} + \phi$$

$$\underline{x} \leq \phi$$

Because the taker strictly prefers accept over reject-take for any $x < \phi$ it follows that

$$\underline{x} = \phi$$

$$k = e^{\frac{1}{2}}$$

The equilibrium in case (II) is restricted by $w \leq 2\phi \ln 2 + \phi$ because without the restriction, no $p(x)$ can induce all owners with $v < w - \phi$ to make the separating demand $x = v + \phi$ instead of demanding $x > w$, inducing the taker to respect the entitlement. Owners only make the separating demand $x = v + \phi$ if they prefer the taker's mixed response to inducing the taker to reject and respect the entitlement:

$$p(x)(x - v) + \big(1 - p(x)\big)(-\phi) \geq 0$$

$$p(v + \phi)(\phi) + \big(1 - p(v + \phi)\big)(-\phi) \geq 0$$

We consider the marginal owner with valuation $\bar{v}$ who is just indifferent (and still chooses to make an offer $x = v + \phi$):

$$p(\bar{v} + \phi)(\phi) + \big(1 - p(\bar{v} + \phi)\big)(-\phi) = 0$$

Knowing that $k = e^{\frac{1}{2}}$, we use $p(x) = e^{\frac{\phi - x}{2\phi}}$ to get

$$e^{\frac{-\bar{v}}{2\phi}} = \frac{\phi}{2\phi} \Leftrightarrow \bar{v} = 2\phi \ln 2$$

To induce separation of all owners with $v \leq w - \phi$ it must be that $\bar{v} + \phi \geq w$. This only holds if $w \leq 2\phi \ln 2$.

1.1.3. Case (III), $\bar{v} + \phi < w \leq \frac{H + \overline{vo}}{2} + \phi$: Separating equilibrium with mimicking owners and takers respecting the entitlement in case of demands $x > w$

From case (II), we retain $\bar{v} = 2\phi \ln 2$, the highest valuation for which the taker's mixed strategy can elicit a fully revealing demand. For the taker's valuations above the upper limit of case (II), that is, $w > \bar{v} + \phi$, there exist owners with valuation v such that $\bar{v} < v < w$.

We start by showing that the taker's strategy as stated in case (III) of Proposition 2 is in equilibrium, given that owners with $v \in]\bar{v}, w]$ demand $x > w$ just like owners with $v > w$. Note that this implies no demands $x \in]\bar{v} + \phi, w]$ are made in equilibrium. This permits a taker strategy prescribing reject-take for such demands. (Whether such a strategy survives reasonable refinements for out-of-equilibrium beliefs will be discussed subsequently.) We refer to the proof of case (II) of Proposition 2 for showing that the taker's mixed strategy to demands $x \leq \bar{v} + \phi$ is in equilibrium. It remains to show that the taker still prefers respecting the entitlement to take if she receives a demand $x > w$:

$$0 \geq w - E(v|x > w) - \phi = w - \frac{\bar{v} + H}{2} - \phi = w - \frac{2\phi \ln 2 + H}{2} - \phi$$

$$w \leq \frac{H}{2} + \phi \ln 2 + \phi$$

This gives us the upper limit of case (III).

Turning to the owner, owners with valuations $v \in]\bar{v}, w]$ are better off demanding $x > w$ than by making a demand $x \in]\bar{v} + \phi, w]$, because the owner believes the taker would respond with reject-take. For other owner valuations, the proof of case (II) of Proposition 2 continues to apply.

So far, we have not constrained the owner's strategy for demands $x \in]\bar{v} + \phi, w]$ that do not occur in equilibrium. However, equilibrium responses to off-equilibrium moves should be based on reasonable beliefs. In what follows, we use the intuitive criterion of Cho and Kreps (1987) and the D1 criterion of Banks and Sobel (1987). Applied to our setting, both criteria constrain the taker's beliefs if faced with an out-of-equilibrium demand. This can lead one to dismiss the taker's reject-take response to a deviating demand and induce certain owners to make such a demand, eliminating the respective equilibrium.

Intuitive Criterion. The intuitive criterion of Cho and Kreps (1987) requires the taker to believe that only owner types make a deviating demand whose payoffs are not dominated by their payoffs from following their equilibrium strategy; i.e., their equilibrium payoff is less than the highest possible payoff they could obtain from the out-of-equilibrium demand. Since the taker never desists after rejecting a demand $x < w$, we can restrict attention to his acceptance probability $p(x)$. Formally, for a owner of type v, an out-of-equilibrium demand x, and an equilibrium strategy $x^*(v)$, the set of acceptance probabilities q for which the owner is better off deviating is the following:

$$D(v, x) \coloneqq \{q \in [0, 1] \mid \Pi_O\big(v, x^*(v)\big) \leq q(x - v) + (1 - q)(-\phi)\}$$

After observing a demand x, the intuitive criterion requires the taker to rule out all owner types for which $D(v, x)$ is empty. Remember that out-of-equilibrium demands x are in the interval $]\bar{v} + \phi, w]$.

For owners with $v \leq \bar{v}$, the set $D(v, x)$ is non-empty:

$$\Pi_O(v, x^*(v)) \leq q(x - v) + (1 - q)(-\phi)$$

This inequality is easiest satisfied by setting $q = 1$ because $x > \bar{v} + \phi$:

$$p(v + \phi)(\phi) + \big(1 - p(v + \phi)\big)(-\phi) \leq x - v$$

The latter inequality always holds for off-equilibrium demands $x > \bar{v} + \phi$ from owners with $v \leq \bar{v}$.

For owners with $v > \bar{v}$, the equilibrium payoff is $\Pi_O(v, x^* > w) =$. The payoff from a deviating demand $x \in]\bar{v} + \phi, w]$ dominates the equilibrium payoff for any q that satisfies the following inequality:

$$\Pi_O(v, x^*(v)) \leq q(x - v) + (1 - q)(-\phi)$$

$$0 \leq q(x - v) + (1 - q)(-\phi)$$

$$v \leq x + \phi - \frac{\phi}{q}$$

Again, this inequality is least restrictive for $q = 1$, so that it can be satisfied for all owners with

$$v \leq x$$

Given that for off-equilibrium demands $x > \bar{v} + \phi$, the latter condition for owners $v > \bar{v}$ implies the former one for owners $v \leq \bar{v}$. It follows that if the taker observes a deviating demand, she believes owners with $v \leq x$ to make such a demand. The intuitive criterion further requires the taker to attach the same probability of a deviating demand x to all remaining owner types with a non-empty $D(v, x)$. For our equilibrium to survive the intuitive criterion, the taker must weakly prefer rejecting all deviating demands, i.e., $p(x) = 0$ for all $x \in]\bar{v} + \phi, w]$, to accepting with any strictly positive probability, given the belief so defined. This implies

$$w - x < w - E(v|v \leq x) - \phi$$

$$x > E(v|v \leq x) + \phi$$

$$x > \frac{x}{2} + \phi$$

$$x > 2\phi$$

This inequality is hardest to satisfy for x at the lower end of the interval $]\bar{v} + \phi, w]$:

$$\bar{v} + \phi > 2\phi$$

$$2\phi \ln 2 > \phi$$

As this expression is always true, the equilibrium is robust to the intuitive criterion.

D1 Criterion. The D1 criterion states that the taker believes a deviating move to come from an owner type who is "most likely" to make it; the "most likely" types are the ones who can benefit from the deviation for the largest set of taker responses, compared to their equilibrium strategy. In contrast to the intuitive criterion, the taker's belief does not include all owner types who can potentially improve their payoff.

We now denote as $D(v, x)$ the set of taker responses q for which an owner with valuation v is strictly better off making a deviating demand:

$$D(v,x) \coloneqq \{q \in [0,1] \mid \Pi_O\big(v, x^*(v)\big) < q(x-v) + (1-q)(-\phi)\}$$

The corresponding set $D^0(v,x)$ for the owner being indifferent between the equilibrium and the out-of-equilibrium demand is:

$$D^0(v,x) \coloneqq \{q \in [0,1] \mid \Pi_O\big(v, x^*(v)\big) = q(x-v) + (1-q)(-\phi)\}$$

The D1 criterion provides that if there exists a type of owner v' such that $D(v,x) \cup D^0(v,x) \subset D(v',x)$, then type v can “be pruned from the tree”, that is, the taker, upon observing v, assigns zero probability to the deviating owner being of type v. The taker ascribes positive probability only to the set of types of owners that cannot be eliminated in this way.

No owner can be better off making an off-equilibrium demand $x < v - \phi$. Since we know from the intuitive criterion that only owners with $v \leq x$ can be better off deviating, we can also rule out $x = v - \phi$. For the remaining case $x > v - \phi$, the deviation payoff $q(x-v) + (1-q)(-\phi)$ is strictly increasing in q. Denote as $q^0(x,v)$ the taker’s acceptance probability for an off-equilibrium demand x for which an owner of type v is indifferent between her equilibrium strategy $x^*(v)$ and the deviating demand x. $q^0(x,v)$ is the probability threshold above which the respective owner is strictly better off deviating.

$q^0(x,v)$ is defined by

$$\Pi_O\big(v, x^*(v)\big) = q^0(x,v)(x-v) + \big(1 - q^0(x,v)\big)(-\phi)$$

$$q^0(x,v) = \frac{\Pi_O\big(v, x^*(v)\big) + \phi}{x - v + \phi}$$

For $v \leq \bar{v}$, this becomes

$$q^0(x,v) = \frac{p(v+\phi)(\phi) + \big(1 - p(v+\phi)\big)(-\phi) + \phi}{x - v + \phi}$$

$$q^0(x,v) = \frac{p(v+\phi)2\phi}{x - v + \phi}$$

Differentiating for v gives us

$$\frac{\mathrm{d}\, q^0(x,v)}{\mathrm{d}\, v} = \frac{p'(v+\phi)2\phi}{x - v + \phi} + \frac{p(v+\phi)2\phi}{(x - v + \phi)^2}$$

Using $p(x)$ from above, we get

$$\frac{\mathrm{d}\, q^0(x,v)}{\mathrm{d}\, v} = \frac{-\frac{1}{2\phi} e^{-\frac{v}{2\phi}} 2\phi}{x - v + \phi} + \frac{e^{-\frac{v}{2\phi}} 2\phi}{(x - v + \phi)^2}$$

$$\frac{\mathrm{d}\, q^0(x,v)}{\mathrm{d}\, v} = e^{-\frac{v}{2\phi}} \frac{v + \phi - x}{(x - v + \phi)^2}$$

Because out-of-equilibrium demands satisfy $x \geq \bar{v} + \phi$ and we are considering owners $v \leq \bar{v}$, the derivative is negative: As v increases, the threshold acceptance probability $q^0(x, v)$ declines. Owners with higher valuation are more "likely" in the sense of the D1 criterion to deviate to any given off-equilibrium demand x. This implies that, among the owners with $v \leq \bar{v}$, we can confine attention to the single owner with $v = \bar{v}$.

For owners $v > \bar{v}$, the threshold probability is

$$q^0(x, v) = \frac{\phi}{x - v + \phi}$$

The derivative is $\frac{\mathrm{d}\, q^0(x,v)}{\mathrm{d}\, v} = \frac{\phi v}{(x-v+\phi)^2}$ which is always positive. Thus, we can restrict attention to an owner with $v = \lim_{\epsilon \to 0} \bar{v} + \epsilon$ with equilibrium payoff $\bar{v}$. By construction, this exactly equals the expected equilibrium payoff for owner type $v = \bar{v}$.

As a consequence, the taker's belief under the D1 criterion is that he faces either an owner with $v = \bar{v}$ or one with $v = \lim_{\epsilon \to 0} \bar{v} + \epsilon$. Sticking to her equilibrium strategy of reject-take therefore costs the taker $\bar{v} + \phi$ which is less than accepting an out-of-equilibrium demand $x \in]\bar{v} + \phi, w]$. The D1 criterion is hence satisfied.

1.1.4. Case (IV), $\frac{H+\bar{v}}{2} + \phi < w \leq \mathrm{H}$: Separating equilibrium with mimicking owners and taker playing mixed strategy for demands $x > wt$

The equilibrium of case (IV) differs from the one in case (III) in that the taker responds to a demand $x > w$ with a mixed strategy between respecting the entitlement and appropriating it. This lowers the owner's payoff from making such a high demand and thereby increases the highest owner type that makes a separating demand. Denote this higher threshold $\bar{\bar{v}}$. Owners with $v \leq \bar{\bar{v}}$ make a separating demand $x = v + \phi$. Owners with $v > \bar{\bar{v}}$ demand $x > w$. Demands $x \in]\bar{\bar{v}} + \phi, w]$ do not occur in equilibrium.

To determine $\bar{\bar{v}}$, note first that a strategy mix of accept-take with acceptance probability $p(x) = e^{\frac{-v}{2\phi}}$ places no limitation on $\bar{\bar{v}}$. In case (II) and (III), the relevant constraint came from the owner's alternative strategy to demand $x > w$, thereby forcing the taker to respect the entitlement. The equilibrium in case (IV) instead requires the taker to randomize between take and respecting if faced with a high demand $x > w$. To do this, she has to be indifferent.

$$w - E(v|x > w) - \phi = 0$$

Since $\bar{\bar{v}}$ is the relevant cutoff for owner types, this implies

$$\frac{H + \bar{\bar{v}}}{2} + \phi = w$$

$$\bar{\bar{v}} = 2w - 2\phi - H$$

Given her indifference, the taker can use an equilibrium probability π of respecting the entitlement in response to a high demand $x > w$; with probability $1 - \pi$, she takes. The owner's expected payoff from a high demand is $\Pi_O(x) = (1 - \pi)(-\phi)$. To determine π, we consider the marginal owner with valuation $\bar{\bar{v}}$. Because $\bar{\bar{v}}$ is the threshold, the marginal owner must be just indifferent between the separating demand $x = v + \phi$ and the high demand $x > w$. To the separating demand $x = v + \phi$, the taker responds as in cases (II) and (III) with randomizing accept-take with acceptance probability $p(x)$. For the marginal owner to be indifferent, this gives us:

$$p(\bar{\bar{v}} + \phi)(\phi) + \big(1 - p(\bar{\bar{v}} + \phi)\big)(-\phi) = (1 - \pi)(-\phi)$$

$$\pi = \frac{2p(\bar{\bar{v}} + \phi)\phi}{\phi}$$

$$\pi = 2e^{-\frac{\bar{\bar{v}}}{2\phi}}$$

Plugging in $\bar{\bar{v}}$ yields

$$\pi = 2e^{-\frac{2w - 2\phi - H}{2\phi}}$$

For the taker to randomize, it must be that $\pi > 0$, which is always satisfied. More interestingly, $\pi < 1$ implies

$$w > \frac{H}{2} + \phi \ln 2 + \phi = \frac{H + \bar{v}}{2} + \phi$$

giving us the lower bound of case (IV).

In the course of determining $\bar{\bar{v}}$, we have already established that the taker's mixed strategy for demands $x > w$ is in equilibrium. We know her mixed-strategy response to separating demands $x \leq \bar{\bar{v}} + \phi$ to be in equilibrium from case (II) and case (III). In deriving π, we have implicitly shown that owners with $v \leq \bar{\bar{v}}$ will not make a high demand $x > w$, and owners with $v > \bar{\bar{v}}$ will not make a demand $x \leq \bar{\bar{v}} + \phi$. It remains to demonstrate that owners abstain from making off-equilibrium demands $x \in]\bar{\bar{v}} + \phi, w]$. Again, in a first step we merely prescribe the taker's equilibrium strategy reject-take in response to such demands. As a consequence, owners with $v \leq \bar{\bar{v}}$ are better off making a separating demand $x = v + \phi$ because $p(x)(x - v) + \big(1 - p(x)\big)(-\phi) > -\phi$. Owners with $v > \bar{\bar{v}}$ prefer a demand $x > w$ because $(1 - \pi)(-\phi) > -\phi$.

As in case (III), we also want to ensure that the equilibrium is robust to the intuitive criterion and the D1 criterion.

Intuititive criterion. For the definition of the intuitive criterion we refer to case (III). We start by finding owner types with a non-empty set of taker responses $D(v, x)$ to an out-of-equilibrium demand x under which the respective owner is better off than by playing his equilibrium strategy $x^*(v)$:

$$D(v,x) \coloneqq \{q \in [0,1] \mid \Pi_O\big(v, x^*(v)\big) \leq q(x-v) + (1-q)(-\phi)\}$$

Owners with $v \leq \bar{\bar{v}}$ are clearly better off with a taker response of always accepting, that is, $q = 1$:

$$p(v+\phi)(\phi) + \big(1 - p(v+\phi)\big)(-\phi) \leq x - v$$

This clearly holds for out-of-equilibrium demands $x \in]\bar{\bar{v}} + \phi, w]$. For all of these owners the set $D(v,x)$ is non-empty.

As to owners with $v > \bar{\bar{v}}$, the equilibrium payoff is $\Pi_O(v, x^* > w) = (1-\pi)(-\phi)$. $D(v,x)$ is non-empty for these owners if

$$(1-\pi)(-\phi) \leq q(x-v) + (1-q)(-\phi)$$

$$\pi\phi \leq q(x - v + \phi) \qquad \text{– (2}$$

This inequality is easiest to satisfy with $q = 1$, hence $D(v,x)$ is non-empty if

$$v \leq x + \phi - \pi\phi$$

Denote the corresponding cutoff $\hat{v} = x + \phi - \pi\phi$. $\hat{v}$ is the relevant cutoff if $\hat{v} > \bar{\bar{v}}$:

$$\bar{\bar{v}} < x + \phi - \pi\phi$$

This inequality is hardest to satisfy for the smallest off-equilibrium $x = \bar{\bar{v}} + \phi$, giving us

$$-2\phi < -\pi\phi$$

$$2 > \pi$$

Inserting $\pi = 2e^{-\frac{\bar{\bar{v}}}{2\phi}}$ and simplifying yields

$$1 > e^{-\frac{\bar{\bar{v}}}{2\phi}}$$

$$1 > e^{-\frac{2w-2\phi-H}{2\phi}}$$

$$0 < 2w - 2\phi - H$$

Plugging in the lower boundary of case (IV), $w = \frac{H}{2} + \phi \ln 2 + \phi$, we arrive at

$$0 < 2\,\phi \ln 2$$

which clearly holds. Hence, $\hat{v}$ is the relevant cutoff. When the taker observes a deviating demand, she believes that it comes from an owner with $v \leq \hat{v}$. The equilibrium then survives the intuitive criterion if

$$w - x \leq w - E(v|\, v \leq \hat{v}) - \phi$$

$$x \geq E(v|\, v \leq \hat{v}) + \phi$$

$$x \geq \frac{x + \phi - \pi\phi}{2} + \phi$$

$$x \geq 3\phi - \pi\phi$$

This inequality is hardest to satisfy with the lowest off-equilibrium demand $x = \bar{\bar{v}} + \phi$:

$$2w - 2\phi - H \geq 2\phi - \pi\phi$$

$$2w \geq 4\phi + H - \pi\phi$$

Using $\pi = 2e^{-\frac{2w-2\phi-H}{2\phi}}$ gives us

$$w \geq 2\phi + \frac{H}{2} - \phi e^{-\frac{2w-2\phi-H}{2\phi}}$$

$$w + \phi e^{-\frac{2w-2\phi-H}{2\phi}} \geq 2\phi + \frac{H}{2} \qquad - \quad (3)$$

To establish that inequality (3) always holds, we differentiate the left hand side for w and show that the derivative is positive:

$$1 + \phi\left(-\frac{1}{\phi}\right)e^{-\frac{2w-2\phi-H}{2\phi}} > 0$$

$$e^{\frac{2w-2\phi-H}{2\phi}} > 1$$

$$2w - 2\phi - H > 0$$

Inserting the smallest w in the range of case (IV), $w = \frac{H}{2} + \phi\, ln\, 2 + \phi$:

$$2\phi \ln 2 > 0$$

which is true.

Given that the derivative of the left hand side of inequality (3) is positive, we insert the minimum $w = \frac{H}{2} + \phi\, ln\, 2 + \phi$ in inequality (3):

$$\frac{H}{2} + \phi \ln 2 + \phi + \frac{\phi}{2} \geq 2\phi + \frac{H}{2}$$

$$2 \ln 2 \geq 1$$

$$2\phi \ln 2 \geq \phi$$

As this inequality holds, the equilibrium satisfies the intuitive criterion.

D1 criterion. We know from the intuitive criterion that the most likely deviator must be an owner with either $v \leq \bar{\bar{v}}$ or $v \in]\bar{\bar{v}}, \hat{v}]$. As to the former group, the same reasoning as for case (III) leads us to focus on the marginal owner with $v = \bar{\bar{v}}$. If this were indeed the most likely deviating owner, the taker would still stick to her equilibrium strategy of $q = 0$ if

$$w - \bar{\bar{v}} - \phi > q(w - x) + (1 - q)(w - \bar{\bar{v}} - \phi)$$

$$\bar{\bar{v}} + \phi < qx + (1 - q)(\bar{\bar{v}} + \phi) \qquad (4)$$

$$0 < q(x - \bar{\bar{v}} - \phi)$$

$$\bar{\bar{v}} + \phi < x$$

which is always true because off-equilibrium demands exceed $\bar{\bar{v}} + \phi$.

As to the latter group of owners with $v \in]\bar{\bar{v}}, \hat{v}]$, they benefit from an off-equilibrium demand $x \in]\bar{\bar{v}} + \phi, w]$ if inequality (2) is satisfied. Rearranging inequality (2) gives us

$$v \leq x + \phi - \frac{\pi\phi}{q}$$

This inequality holds for a greater range of q if v is at the lower bound of the interval $]\bar{\bar{v}}, \hat{v}]$. Therefore, the most likely owner to deviate from this interval has a valuation $v = \lim_{\epsilon \to 0} \bar{\bar{v}} + \epsilon$. If this owner turned out to be the most likely deviator in the sense of the D1 criterion, the condition for the taker to play her equilibrium strategy remains the one in inequality (4), which is always satisfied. Without determining whether the owner with $v = \bar{\bar{v}}$ or with $v = \lim_{\epsilon \to 0} \bar{\bar{v}} + \epsilon$ most likely makes an out-of-equilibrium demand, the taker's equilibrium response is robust.

1.3. Proposition 3. Welfare comparison of expectation damages and specific performance

In the signaling model the property rule is superior. It always leads to efficient agreements whereas with a liability rule, the parties' abilities to conclude efficient agreements depends on the taker's valuation.

The owner's expected payoff under the property rule is

$$\mathrm{E}_v(\Pi_{O\,PR}) = \frac{w}{H}w + \left(1 - \frac{w}{H}\right)\left(\frac{w + H}{2}\right)$$

The owner's payoff is

$$\mathrm{E}_v(\Pi_{O\,PR}) = \frac{H}{2} + \frac{w^2}{2H}$$

The taker's expected payoff is

$$\Pi_{T\,PR} = 0$$

Total welfare is

$$\Pi_{PR} = \frac{H}{2} + \frac{w^2}{2H} \tag{5}$$

Insofar as equilibrium strategies under the liability rule equal those under the property rule (case (I) of Proposition 2 with $w \leq 2\phi$), surplus under the two remedies is the same.

All other cases require closer inspection.

1.3.1 Welfare comparison for case (II)

For case (II) of Proposition 2, that is, $2\phi < w \leq 2\phi \ln 2 + \phi$, the owner's expected payoff under the liability rule is

$$\mathrm{E}_v(\Pi_{O\,LRII}) = \frac{w-\phi}{H}(\frac{w-\phi}{2} + E(2p(v+\phi)\phi - \phi | v \leq w-\phi)) + \left(1 - \frac{w-\phi}{H}\right)\left(\frac{w-\phi+H}{2}\right)$$

$$\mathrm{E}_v(\Pi_{O\,LRII}) = \frac{w-\phi}{H}\left(\frac{w-\phi}{2} - \phi + 2\phi\frac{\int_0^{w-\phi} e^{-\frac{v}{2\phi}}\,dv}{w-\phi}\right) + \left(1 - \frac{w-\phi}{H}\right)\left(\frac{w-\phi+H}{2}\right)$$

$$\mathrm{E}_v(\Pi_{O\,LRII}) = \frac{w-\phi}{H}\left(\frac{w-\phi}{2} - \phi + 4\phi^2\frac{1-e^{-\frac{w-\phi}{2\phi}}}{w-\phi}\right) + \left(1 - \frac{w-\phi}{H}\right)\left(\frac{w-\phi+H}{2}\right)$$

$$\mathrm{E}_v(\Pi_{O\,LRII}) = \frac{H}{2} + \frac{\left(5 - 4e^{-\frac{w-\phi}{2\phi}}\right)\phi^2 - \phi w}{H}$$

The taker's payoff is

$$\mathrm{E}_v(\Pi_{T\,LRII}) = \left(\frac{w-\phi}{H}\right)\left(w - \frac{w-\phi}{2} - \phi\right)$$

$$\mathrm{E}_v(\Pi_{T\,LRII}) = \frac{w^2 - 2w\phi + \phi^2}{2H}$$

$$\mathrm{E}_v(\Pi_{T\,LRII}) = \frac{(w-\phi)^2}{2H}$$

Thus, the total welfare is

$$\Pi_{LRII} = \frac{H}{2} + \frac{\left(5 - 4e^{-\frac{w-\phi}{2\phi}}\right)\phi^2 - w\phi}{H} + \frac{(w-\phi)^2}{2H}$$

$$\Pi_{LRII} = \frac{H}{2} + \frac{2\left(5 - 4e^{-\frac{w-\phi}{2\phi}}\right)\phi^2 - 2w\phi}{2H} + \frac{(w-\phi)^2}{2H}$$

$$\Pi_{LRII} = \frac{H}{2} + \frac{2\left(5 - 4e^{-\frac{w-\phi}{2\phi}}\right)\phi^2 - 2w\phi + (w-\phi)^2}{2H}$$

The property rule is more efficient if

$$\Pi_{PR} > \Pi_{LRII}$$

$$\frac{H}{2} + \frac{w^2}{2H} > \frac{H}{2} + \frac{2\left(5 - 4e^{-\frac{w-\phi}{2\phi}}\right)\phi^2 - 2w\phi + (w-\phi)^2}{2H}$$

Subtracting $\frac{H}{2}$ and multiplying by $2H$ and expanding both sides yields

$$w^2 > w^2 - 2w\phi + \phi^2 + 2\left(5 - 4e^{-\frac{w-\phi}{2\phi}}\right)\phi^2 - 2w\phi$$

Simplifying, we arrive at

$$0 > -4w\phi + \phi^2\left(11 - 8e^{-\frac{w-\phi}{2\phi}}\right)$$

Because $w > 2\phi$, the second term on the right hand side is at most $-4(2\phi)\phi = -8\phi^2$. The above inequality thus is satisfied if the following, more restrictive inequality holds

$$0 > \phi^2\left(3 - 8e^{-\frac{w-\phi}{2\phi}}\right)$$

Note that $8e^{-\frac{w-\phi}{2\phi}}$ is decreasing in w. Given that $w \leq 2\phi \ln 2 + \phi$, the minimum is at 4. Plugging this into the latter inequality gives us

$$0 > -\phi^2$$

which is true. Hence, the property rule is more efficient than the liability rule.

1.3.2 Welfare comparison for case (III)

Case (III) obtains for $2\phi \ln 2 + \phi < w \leq \frac{H}{2} + \phi\, ln\, 2 + \phi$. The owner's expected payoff is

$$\mathrm{E}_v(\Pi_{O\ LRIII}) = \frac{\bar{v}}{H}\left(\frac{\bar{v}}{2} + E(2p(v+\phi)\phi - \phi | v \leq \bar{v})\right) + \left(1 - \frac{\bar{v}}{H}\right)\left(\frac{\bar{v} + H}{2}\right)$$

$$\mathrm{E}_v(\Pi_{O\ LRIII}) = \frac{\bar{v}}{H}\left(\frac{\bar{v}}{2} - \phi + 2\phi\frac{\int_0^{\bar{v}} e^{-\frac{v}{2\phi}}\, dv}{\bar{v}}\right) + \left(1 - \frac{\bar{v}}{H}\right)\left(\frac{\bar{v} + H}{2}\right)$$

$$\mathrm{E}_v(\Pi_{O\,LRIII}) = \frac{\bar{v}}{H}\left(\frac{\bar{v}}{2} - \phi + 4\phi^2 \frac{1 - e^{-\frac{\bar{v}}{2\phi}}}{\bar{v}}\right) + \left(1 - \frac{\bar{v}}{H}\right)\left(\frac{\bar{v} + H}{2}\right)$$

$$\mathrm{E}_v(\Pi_{O\,LRIII}) = \frac{H}{2} - \frac{\bar{v}}{H}\phi + 4\phi^2 \frac{1 - e^{-\frac{\bar{v}}{2\phi}}}{H}$$

Using $\bar{v} = 2\phi \ln 2$

$$\mathrm{E}_v(\Pi_{O\,LRIII}) = \frac{H}{2} - \frac{\bar{v}}{H}\phi + \frac{4\phi^2(1 - \frac{1}{2})}{H}$$

$$\mathrm{E}_v(\Pi_{O\,LRIII}) = \frac{H}{2} - \frac{\bar{v}}{H}\phi + \frac{2\phi^2}{H}$$

The taker's expected payoff is

$$\mathrm{E}_v(\Pi_{T\,LRIII}) = -\frac{\bar{v}^2}{2H} + \frac{\bar{v}}{H}(w - \phi)$$

It follows for the total welfare

$$\Pi_{LRIII} = \frac{H}{2} - \frac{\bar{v}}{H}\phi + \frac{2\phi^2}{H} - \frac{\bar{v}^2}{2H} + \frac{\bar{v}}{H}(w - \phi)$$

$$\Pi_{LRIII} = \frac{H}{2} + \frac{-\bar{v}^2 + 2\bar{v}(w - 2\phi) + 4\phi^2}{2H}$$

The property rule is more efficient if

$$\Pi_{PR} > \Pi_{LRIII}$$

$$\frac{H}{2} + \frac{w^2}{2H} > \frac{H}{2} + \frac{-\bar{v}^2 + 2\bar{v}(w - 2\phi) + 4\phi^2}{2H}$$

$$w^2 > -\bar{v}^2 + 2\bar{v}w - 4\bar{v}\phi + 4\phi^2$$

$$w^2 + \bar{v}^2 - 2\bar{v}w + 4\bar{v}\phi - 4\phi^2 > 0$$

$$(w - \bar{v})^2 + 4\phi(\bar{v} - \phi) > 0$$

The first term is positive. Because $\boldsymbol{\bar{v} = 2\phi \ln 2}$, the second term ist strictly positive. Welfare comparison for case (IV)

For case (IV) with $\frac{H}{2} + \phi \ln 2 < w \leq H$, owner's expected payoff under the liability rule is

$$\mathrm{E}_v(\Pi_{O\,LRIV}) = \frac{\bar{\bar{v}}}{H}\left(\frac{\bar{\bar{v}}}{2} - \phi + 4\phi^2 \frac{1 - e^{-\frac{\bar{\bar{v}}}{2\phi}}}{\bar{\bar{v}}}\right) + \left(1 - \frac{\bar{\bar{v}}}{H}\right)\left(\frac{\bar{\bar{v}} + H}{2} + (1 - \pi)(-\phi)\right)$$

$$\text{E}_v(\Pi_{O\,LRIV}) = \frac{H}{2} - \phi\frac{\bar{\bar{v}}}{H} + 4\phi^2\frac{1-e^{-\frac{\bar{\bar{v}}}{2\phi}}}{H} + \left(1-\frac{\bar{\bar{v}}}{H}\right)(-\phi+\pi\phi)$$

$$\text{E}_v(\Pi_{O\,LRIV}) = \frac{H}{2} + 4\phi^2\frac{1-e^{-\frac{\bar{\bar{v}}}{2\phi}}}{H} - \phi + \left(1-\frac{\bar{\bar{v}}}{H}\right)(\pi\phi)$$

Inserting $\pi = 2e^{-\frac{\bar{\bar{v}}}{2\phi}}$ gives us

$$\text{E}_v(\Pi_{O\,LRIV}) = \frac{H}{2} + 4\phi^2\frac{1-e^{-\frac{\bar{\bar{v}}}{2\phi}}}{H} - \phi + \left(1-\frac{\bar{\bar{v}}}{H}\right)\left(2\phi e^{-\frac{\bar{\bar{v}}}{2\phi}}\right)$$

The taker's expected payoff is

$$\text{E}_v(\Pi_{T\,LRIV}) = \frac{\bar{\bar{v}}}{H}\left(w-\frac{\bar{\bar{v}}}{2}-\phi\right) + \left(1-\frac{\bar{\bar{v}}}{H}\right)\left(w-\frac{\bar{\bar{v}}+H}{2}-\phi-\pi\left(w-\phi-\frac{\bar{\bar{v}}+H}{2}\right)\right)$$

Plugging in $\bar{\bar{v}} = 2w-2\phi-H$ provides

$$\text{E}_v(\Pi_{T\,LRIV}) = \frac{\bar{\bar{v}}}{2} = w-\frac{H}{2}-\phi$$

The total welfare then is:

$$\Pi_{LRIV} = \frac{H}{2} + 4\phi^2\frac{1-e^{-\frac{\bar{\bar{v}}}{2\phi}}}{H} - \phi + \left(1-\frac{\bar{\bar{v}}}{H}\right)\left(2\phi e^{-\frac{\bar{\bar{v}}}{2\phi}}\right) + \frac{\bar{\bar{v}}}{2}$$

$$\Pi_{LRIV} = \frac{H}{2} + \frac{8\phi^2 - 4e^{-\frac{\bar{\bar{v}}}{2\phi}}\phi(-H+\bar{\bar{v}}+2\phi) + H(\bar{\bar{v}}-2\phi)}{2H}$$

$$\Pi_{LRIV} = \frac{H}{2} + \frac{8\phi^2 - 8\phi e^{-\frac{2w-2\phi-H}{2\phi}}(-H+w) + H(2w-4\phi-H)}{2H}$$

The property rule is more efficient if

$$\Pi_{PR} > \Pi_{LRIV}$$

This always holds:

$$\frac{H}{2} + \frac{w^2}{2H} > \frac{H}{2} + \frac{8\phi^2 - 4e^{-\frac{\bar{\bar{v}}}{2\phi}}\phi(-H+\bar{\bar{v}}+2\phi) + H(\bar{\bar{v}}-2\phi)}{2H}$$

Subtracting $\frac{H}{2}$ and multiplying by $2H$:

$$w^2 > 8\phi^2 - 4e^{-\frac{\bar{\bar{v}}}{2\phi}}\phi(-H+\bar{\bar{v}}+2\phi) + H\bar{\bar{v}} - 2H\phi$$

Inserting $\bar{\bar{v}} = 2w-2\phi-H$

$$w^2 > 8\phi^2 - 4e^{-\frac{2w-2\phi-H}{2\phi}}\phi(-H + 2w - 2\phi - H + 2\phi) + H(2w - 2\phi - H) - 2H\phi$$

$$w^2 > 8\phi^2 - 8e^{-\frac{2w-2\phi-H}{2\phi}}\phi(-H + w) + H(2w - 2\phi - H) - 2H\phi$$

$$w^2 - 2Hw + H^2 > 8\phi^2 - 8e^{-\frac{2w-2\phi-H}{2\phi}}\phi(-H + w) - 4H\phi$$

$$(w - H)^2 > 8\phi^2 - 8\phi e^{-\frac{2w-2\phi-H}{2\phi}}(-H + w) - 4H\phi$$

The inequality holds because the RHS will always be negative:

$$0 > 8\phi^2 - 8\phi e^{-\frac{2w-2\phi-H}{2\phi}}(-H + w) - 4H\phi$$

$$0 > 2\phi^2 - 2\phi e^{-\frac{2w-2\phi-H}{2\phi}}(-H + w) - H\phi$$

To see this, we show that the RHS has no interior minimum or maximum. For the first derivative in respect to w, we get:

$$-2e^{\frac{H-2(w-\phi)}{2\phi}}(H - w + \phi)$$

The derivative cannot be zero but will always be negative.

Therefore, the RHS has its maximum at the lower bound of the interval for w, i.e., $w = \frac{H}{2} + \phi \ln 2 + \phi$. This maximum is negative:

$$2\phi^2 - 2\phi e^{-\frac{2\left(\frac{H}{2}+\phi\ln 2+\phi\right)-2\phi-H}{2\phi}}\left(-H + \left(\frac{H}{2} + \phi\ln 2 + \phi\right)\right) - H\phi) < 0$$

$$2\phi^2 - 2\phi e^{-\ln 2}\left(-\frac{H}{2} + \phi\ln 2 + \phi\right) - H\phi < 0$$

$$2\phi^2 - \phi\left(-\frac{H}{2} + \phi\ln 2 + \phi\right) - H\phi < 0$$

$$2\phi^2 - \phi(\phi\ln 2 + \phi) - \frac{H}{2}\phi < 0$$

$$\phi^2 - \phi(\phi\ln 2) - \frac{H}{2}\phi < 0$$

$$\phi - \phi\ln 2 < \frac{H}{2}$$

Given that this is true, the RHS in the above inequality is negative. It follows that property rule is more efficient than the liability rule in case (IV) as well.

2. Screening model

2.1 Proposition 4. Equilibrium of the screening game under the property rule

The owner always accepts an offer $x \geq H$ and rejects all offers $x < 0$. For intermediate or "screening" offers $x \in [0, H[$, the owner accepts with probability $\frac{x}{H}$; the expected payoff for the taker is $\Pi_T = \frac{x}{H}(w - x)$. As a function of x, this payoff has a maximum at $x = \frac{w}{2}$. We denote the corresponding payoff to the taker $\dot{\Pi}_{T\,PR} = \frac{\left(\frac{w}{2}\right)^2}{H}$. The taker prefers this payoff over the one from an offer $x < 0$, which is always rejected and yields $\Pi_T = 0$. He strictly prefers the optimal screening offer over the high offer $x = H$ that any owner accepts if

$$\frac{\left(\frac{w}{2}\right)^2}{H} > w - H$$

$$0 > wH - H^2 - \left(\frac{w}{2}\right)^2$$

The right hand side reaches its maximum for $H = \frac{w}{2}$. Plugging this in gives us

$$0 > -\left(\frac{w}{2}\right)^2$$

which never holds. It follows that the taker prefers the screening offer $x = \frac{w}{2}$. Yet to be a "screening" offer, it also has to remain below the upper limit at which all owners accept: $\frac{w}{2} < H \Leftrightarrow w < 2H$. Given the assumption $w \leq H$, the latter condition is not violated.

2.2 Proposition 5. Equilibrium of the screening game under the liability rule

2.2.1 The second and third stage: owner's acceptance and taker's seizure decision

We start by characterizing the equilibria after the taker's offer: the owner's decision to accept or reject an offer and, subsequently, the taker's choice to appropriate the entitlement.

All-accept equilibrium, $x \geq H$. Very high offers $x \geq H$ are always accepted. We denote the taker's payoff in this case $\Pi_T^A = w - x$.

Never-take equilibrium, $x \in [2w - H - 2\phi, H[$. For lower offers, not all owner types accept. In the "never take" equilibrium, if the owner rejects the taker always refrains from taking. Expecting this, the owner accepts if $x \geq v$. For the taker to respect the entitlement, it has to be that $w - \frac{x+H}{2} - \phi \leq 0$. Thus, for offers $x < 0$, the taker's valuation has to satisfy $w \leq \frac{H}{2} + \phi$. These are takers that would not seize the entitlement in the absence of a negotiation; we refer to them as "ex ante respecters". But because no owner—knowing that he faces an "ex ante respecter"—accepts such offers, we relegate the case of $x < 0$ to the all-reject equilibrium below and consider here only higher offers. The never-take equilibrium then requires that $x \geq 2w - H - 2\phi$. The taker's corresponding payoff—omitting the LR subscript—is

$$\Pi_T^N = \frac{x}{H}(w - x)$$

Mixed-strategy equilibrium, $x \in]2w - H - 3\phi, 2w - H - 2\phi[$**.** For offers below the threshold $2w - H - 2\phi$, we again exclude offers that all owner types reject (i.e., $x < -\phi$ and, for "ex ante respecters", $x < 0$; see the discussion of the all-reject equilibrium below). Here, we consider only offers that at least some owner types accept. Suppose that, in response to rejection, the taker always appropriates the entitlement. Believing this, the owner would accept offers $x \geq v - \phi$. For the taker to carry out the owner's belief, it has to be that $w - \frac{x+\phi+H}{2} - \phi > 0$, which implies $x < 2w - H - 3\phi$. Since this threshold differs from the above condition for a never-take equilibrium, it follows that there is no equilibrium with a pure taker response in the interval $]2w - H - 3\phi, 2w - H - 2\phi[$, provided that at least some owners accept. The respective interval always exists since $\phi > 0$.

To determine the taker's mixed strategy, let p be the probability that the taker appropriates the entitlement and let $\check{v}$ be the cutoff value such that owners with $v \leq \check{v}$ accept while higher-valuation owners reject.

For $\check{v} < 0$, all owners reject. After being rejected, the taker's expected payoff is $p\left(w - \frac{H}{2} - \phi\right)$. Given this payoff, the taker would only be willing to randomize—set p between 0 and 1—if $w = \frac{H}{2} + \phi$. With this valuation, the offer has to satisfy $x < 0$ to remain below the upper limit of the mixed-strategy equilibrium. But a taker with this valuation is still an "ex ante respecter" so that all owners reject such an offer and the case falls under the all-reject equilibrium. Hence, we can rule out $\check{v} < 0$.

With $\check{v} \geq 0$, the taker's expected payoff after rejection is $p\left(w - \frac{\check{v}+H}{2} - \phi\right)$. The taker only randomizes if $w - \frac{\check{v}+H}{2} - \phi = 0 \Leftrightarrow \check{v} = 2w - H - 2\phi$. For $\check{v}$ to constitute the cutoff, it must be that $x = p(\check{v} - \phi) + (1-p)\check{v} \Leftrightarrow p = \frac{\check{v}-x}{\phi}$. Inserting the taker's randomization condition, we obtain $p = \frac{2w-H-2\phi-x}{\phi}$, which is between zero and one for offers in the interval of the mixed-strategy equilibrium. The taker's expected payoff then is

$$\Pi_T^M = \frac{\check{v}}{H}(w - x) + \left(1 - \frac{\check{v}}{H}\right)\left(p\left(w - \frac{\check{v} + H}{2} - \phi\right)\right)$$

Inserting the above expressions for $\check{v}$ and p, we obtain

$$\Pi_T^M = x - w + \frac{2(w - x)(w - \phi)}{H}$$

Always-take equilibrium, $x \in [-\phi, 2w - H - 3\phi]$**.** We continue to consider only offers that some owners accept. If such an offer is below the lower bound of the mixed-strategy equilibrium, that is, $x \leq 2w - H - 3\phi$, the taker always takes the entitlement if the owner rejects. This requires $w - \frac{x+\phi+H}{2} - \phi \geq 0$, which transforms into $x \leq 2w - H - 3\phi$. The resulting offer interval $[-\phi, 2w - H - 3\phi]$ is empty if $w < \frac{H}{2} + \phi$, that is, for "ex ante respecters". For other takers, the expected payoff is

$$\Pi_T^T = \frac{x+\phi}{H}(w-x) + \left(1 - \frac{x+\phi}{H}\right)\left(w - \frac{x+\phi+H}{2} - \phi\right)$$

$$\Pi_T^T = w - \frac{H}{2} - \phi - \frac{(x-3\phi)(x+\phi)}{2H}$$

All-reject equilibrium, $x < -\phi$ **or** $x < 0$**.** For $x < -\phi$, all owners reject. As demonstrated in the discussion of the never-take equilibrium, owners also universally reject offers $x < 0$ if they believe to face an "ex ante respecter" with $w \leq \frac{H}{2} + \phi$. In either case, after making an all-reject offer, takers abstain if they are "ex ante respecters" and appropriate the entitlement otherwise. Their expected payoff is

$$\Pi_T^R = \max(0, w - \frac{H}{2} - \phi)$$

2.2.2 The first stage: taker's offer

2.2.2.1 Optimal offers within each range

We proceed by identifying the optimal offers by the taker within each of the offer ranges identified above for the second and third stage:

Optimal all-accept offer, $x \geq H$**.** Clearly, the taker never offers more than $x^A = H$. The resulting optimal payoff is $\Pi_T^A = w - H$.

Optimal never-take offers, $x \in [2w - H - 2\phi, H[$**.** The payoff $\Pi_T^N = \frac{x}{H}(w-x)$ reaches an (interior) maximum at $\dot{x}^N = \frac{w}{2}$ with $\dot{\Pi}_T^N = \frac{\left(\frac{w}{2}\right)^2}{H}$. This maximum does not exceed the upper bound of the relevant interval since that would require $w > 2H$. Conversely, if

$$\frac{w}{2} < 2w - H - 2\phi$$

$$w > \frac{2}{3}(H + 2\phi)$$

an offer $\underline{x}^N = 2w - H - 2\phi$ at the lower limit of the interval yields the maximum payoff with

$$\underline{\Pi}_T^N = \frac{2w - H - 2\phi}{H}(-w + H + 2\phi)$$

Optimal mixed-strategy offers, $x \in]2w - H - 3\phi, 2w - H - 2\phi[$**.** Because the payoff Π_T^M is a linear function of x, the maximum is either at the upper or lower boundary. It follows that the taker never makes a mixed-strategy offer but either a never-take or an always-take offer.

Optimal always-take offers, $x \in [-\phi, 2w - H - 3\phi]$**.** The taker's payoff

$$\Pi_T^T = w - \frac{H}{2} - \phi - \frac{(x - 3\phi)(x + \phi)}{2H}$$

has an interior maximum at $\dot{x}^T = \phi$ with

$$\dot{\Pi}_T^T = w - \frac{H}{2} - \phi + \frac{2\phi^2}{H}$$

$\dot{x}^T$ is always above the lower bound of always-take offers. It is below the upper bound if $w \geq \frac{H}{2} + 2\phi$. Otherwise, there is a border maximum at $\bar{x}^T = 2w - H - 3\phi$ with

$$\overline{\Pi}_T^T = w - \frac{H}{2} - \phi - \frac{(2w - H - 6\phi)(2w - H - 2\phi)}{2H}$$

Optimal all-reject offers, $x < -\phi$ **or** $x < 0$**.** Since all offers in this range are rejected, the taker needs not choose an optimal offer in this range. The payoff is always $\Pi_T^R = \max(0, w - \frac{H}{2} - \phi)$.

2.2.2.2 Eliminating all-accept and all-reject offers

We continue by ruling out certain offer ranges: We have already disposed of mixed-strategy offers. Next, observe that the payoff from a never-take offer is superior to that from an all-accept offer as

$$\dot{\Pi}_T^N = \frac{\left(\frac{w}{2}\right)^2}{H} > \Pi_T^A = w - H$$

$$4H^2 - 4wH + w^2 > 0$$

$$(2H - w)^2 > 0$$

As to all-reject offers, we first consider an "ex ante respecter" taker with $w \leq \frac{H}{2} + \phi$. Her payoff with an all-reject offer never exceeds 0. She can assure herself of the higher interior maximum payoff $\dot{\Pi}_T^N = \frac{\left(\frac{w}{2}\right)^2}{H}$.

Turning to "ex ante takers" with $w > \frac{H}{2} + \phi$, an all-reject offer gives her a payoff of $w - \frac{H}{2} - \phi$. By contrast, an always-take offer generates a higher interior maximum payoff $\dot{\Pi}_T^T = w - \frac{H}{2} - \phi + \frac{2\phi^2}{H}$ if $w \geq \frac{H}{2} + 2\phi$; in the opposite case, the taker prefers the upper-limit maximum of always-take to an all-reject offer:

$$\overline{\Pi}_T^T = w - \frac{H}{2} - \phi - \frac{(2w - H - 6\phi)(2w - H - 2\phi)}{2H} > w - \frac{H}{2} - \phi$$

$$0 > (2w - H - 6\phi)(2w - H - 2\phi)$$

For $w \in]\frac{H}{2} + \phi, \frac{H}{2} + 2\phi[$, the first factor on the RHS is always negative while the second factor is positive. Therefore, the inequality holds and we can dismiss all-reject for the "ex ante taker" type as well.

2.2.2.3 Comparing payoffs from remaining strategies

The following table summarizes the payoffs for the remaining strategies and the relevant domains in terms of w. It also introduces the two relevant threshold values w^T and w^N:

$\bar{x}^T = 2w - H - 3\phi$	$\overline{\Pi}_T^T = w - \frac{H}{2} - \phi - \frac{(2w - H - 6\phi)(2w - H - 2\phi)}{2H}$	$w < w^T = \frac{H}{2} + 2\phi$
$\dot{x}^T = \phi$	$\dot{\Pi}_T^T = w - \frac{H}{2} - \phi + \frac{2\phi^2}{H}$	$w \geq w^T$
$\dot{x}^N = \frac{w}{2}$	$\dot{\Pi}_T^N = \frac{\left(\frac{w}{2}\right)^2}{H}$	$w \leq w^N = \frac{2}{3}(H + 2\phi)$
$\underline{x}^N = 2w - H - 2\phi$	$\underline{\Pi}_T^N = \frac{2w - H - 2\phi}{H}(-w + H + 2\phi)$	$w > w^N$

Table 4: Comparison payoffs screening game to determine equilibrium strategy

Note that the two thresholds $w^T$and w^N are greater than zero. To narrow down which strategies we need to compare, we determine the relation between these two thresholds:

$$w^N > w^T$$

$$\frac{2}{3}(H + 2\phi) > \frac{H}{2} + 2\phi$$

$$H > 4\phi$$

The following Figure 32 illustrates which offers need to be compared.

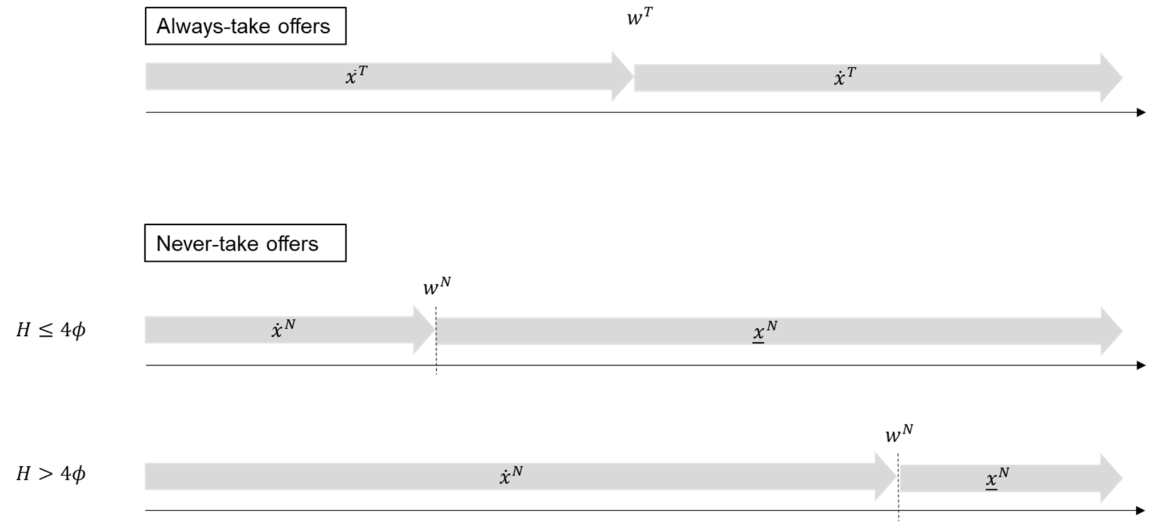


Figure 32: Relevant combinations of optimal offers

We proceed by comparing the relevant combinations between the remaining five offers $\bar{x}^T$, $\dot{x}^T$, $\dot{x}^N$, and $\underline{x}^N$ for their respective domains.

Upper maximum always-take vs. interior maximum never-take. To determine which of the offers $\bar{x}^T$ and $\dot{x}^N$ provides the taker with the highest payoff, we define the function $\Delta\bar{\Pi}_T^T\dot{\Pi}_T^N(w) = \bar{\Pi}_T^T - \dot{\Pi}_T^N$:

$$\Delta\bar{\Pi}_T^T\dot{\Pi}_T^N(w) = w - \frac{H}{2} - \phi - \frac{(2w - H - 6\phi)(2w - H - 2\phi)}{2H} - \frac{\left(\frac{w}{2}\right)^2}{H}$$

The function is continuous, twice differentiable, and has a single maximum. Setting $\Delta\bar{\Pi}_T^T\dot{\Pi}_T^N(w) = 0$ yields two cutoffs

$$w_{1,2}^{\bar{T}\dot{N}} = \frac{2}{9}\left(3H + 8\phi \pm \sqrt{\phi(3H + 10\phi)}\right)$$

The upper cutoff $w_1^{\bar{T}\dot{N}}$ can be ignored because it is above w^N(where $\dot{x}^N$ is already inferior to $\underline{x}^N$). We therefore drop the subscript and write only $w^{\bar{T}\dot{N}}$:

$$w^{\bar{T}\dot{N}} = \frac{2}{9}\left(3H + 8\phi - \sqrt{\phi(3H + 10\phi)}\right)$$

$w^{\bar{T}\dot{N}}$ is always above zero and below w^N. Furthermore, $w^{\bar{T}\dot{N}}$ needs to be below w^T in order to be in the relevant domain. This is the case if

$$0 < 4\phi - 3H + 4\sqrt{\phi(3H + 10\phi)}$$

The RHS as a function of H is continuous and has a strictly negative first derivative. The only intercept is at

$$H^I = 4\phi\left(1 + \sqrt{2}\right)$$

Hence, $w^{\bar{T}\dot{N}}$ is below w^T if $H < H^I$. Overall, offer $\bar{x}^T$ is superior to $\dot{x}^N$ iff $w > w^{\bar{T}\dot{N}}$ and $H < H^I$.

Upper maximum always-take vs. lower maximum never-take. We again define a function $\Delta\bar{\Pi}_T^T \underline{\Pi}_T^N(w)$ to choose between offers $\bar{x}^T$ and $\underline{x}^N$:

$$\Delta\bar{\Pi}_T^T \underline{\Pi}_T^N(w) = w - \frac{H}{2} - \phi - \frac{(2w - H - 6\phi)(2w - H - 2\phi)}{2H} - \frac{2w - H - 2\phi}{H}(-w + H + 2\phi)$$

$$\Delta\bar{\Pi}_T^T \underline{\Pi}_T^N(w) = \frac{\phi(2w - H + 2\phi)}{H}$$

This increasing linear function equals zero at

$$w^{\bar{T}\underline{N}} = \frac{H}{2} + \phi$$

Since $w^{\bar{T}\underline{N}}$ is below w^N, $\bar{x}^T$ is superior to $\underline{x}^N$ in the relevant range, for $w^N < w < w^T$.

Interior maximum always-take vs. interior maximum never-take. The choice between $\dot{x}^T$ and $\dot{x}^N$ is governed by $\Delta\dot{\Pi}_T^T \dot{\Pi}_T^N(w)$:

$$\Delta\dot{\Pi}_T^T \dot{\Pi}_T^N(w) = w - \frac{H}{2} - \phi + \frac{2\phi^2}{H} - \frac{\left(\frac{w}{2}\right)^2}{H}$$

The function is continuous, concave, and has a maximum. The roots are at

$$w_{1,2}^{\dot{T}\dot{N}} = 2H \pm \sqrt{2}\sqrt{H^2 - 2H\phi + 4\phi^2}$$

where $w_1^{\dot{T}\dot{N}} > H$ so that we are left with the only relevant cutoff

$$w^{\dot{T}\dot{N}} = 2H - \sqrt{2}\sqrt{H^2 - 2H\phi + 4\phi^2}$$

$w^{\dot{T}\dot{N}}$ is below w^N. However, it is above w^T and hence in the domain of $\dot{x}^T$ only if

$$0 > 4\phi - 3H + 2\sqrt{2}\sqrt{H^2 - 2H\phi + 4\phi^2}$$

The RHS as a function of H, again, is strictly negative throughout. The only intercept is at H^I so that the inequality is satisfied for $H > H^I$.

Overall, $\dot{x}^T$ is superior to $\dot{x}^N$ iff $H < H^I$ or $w > w^{\dot{T}\dot{N}}$.

Interior maximum always-take vs. upper maximum never-take. $\dot{x}^T$ also yields a higher payoff than $\underline{x}^N$:

$$w - \frac{H}{2} - \phi + \frac{2\phi^2}{H} > \frac{2w - H - 2\phi}{H}(-w + H + 2\phi)$$

$$2Hw - H^2 - 2H\phi + 4\phi^2 > -(2w - H - 2\phi)(2w - 2H - 4\phi)$$

$$H^2 - 4Hw + 4w^2 + 6H\phi - 12w\phi + 12\phi^2 > 0$$

The LHS is twice differentiable and convex in w. Without constraints on w, the minimum is at $w = \frac{1}{2}H - \frac{3}{2}\phi$. This is below w^N, the lower limit of $\underline{x}^N$. Hence, the minimum of the LHS in the relevant domain is at $w = w^N = \frac{2}{3}(H + 2\phi)$. Inserting this into the inequality gives us

$$\frac{1}{9}H(H - 2\phi) + \frac{28}{9}\phi^2 > 0$$

The first term on the LHS is negative for $\phi > \frac{H}{2}$. In this range, the first derivative of the LHS with respect to is strictly positive. Evaluated with $\phi = \frac{H}{2}$, the inequality holds. Hence, it is satisfied throughout the relevant domain.

2.2.2.4 Equilibrium offers

The following table summarizes the results:

$\bar{x}^T \succ \dot{x}^N$	iff $H < H^I = 4\phi(1 + \sqrt{2})$ and $w > w^{\bar{T}\dot{N}} = \frac{2}{9}\left(3H + 8\phi - \sqrt{\phi(3H + 10\phi)}\right)$
$\bar{x}^T \succ \underline{x}^N$	always holds
$\dot{x}^T \succ \dot{x}^N$	iff $H < H^I$ or $w > w^{\dot{T}\dot{N}} = 2H - \sqrt{2}\sqrt{H^2 - 2H\phi + 4\phi^2}$
$\dot{x}^T \succ \underline{x}^N$	always holds

Table 5: Summary equilibrium offers screening game

The following collates the equilibrium offers for the various ranges of H and w. Proposition 5 reflects these results:

(I) For $H \leq H^I = 4\phi(1 + \sqrt{2})$:

Takers with $w \leq w^{\bar{T}\dot{N}} = \frac{2}{9}\left(3H + 8\phi - \sqrt{\phi(3H + 10\phi)}\right)$ offer $\dot{x}^N$.

Takers with $w^{\bar{T}\dot{N}} < w \leq w^T$ offer $\bar{x}^T$.

Takers with $w > w^T$ offer $\dot{x}^T$.

(II) For $H > H^I$

Takers with $w \le w^{\dot{T}\dot{N}} = 2H - \sqrt{2}\sqrt{H^2 - 2H\phi + 4\phi^2}$ offer $\dot{x}^N$.

Takers with $w > w^{\dot{T}\dot{N}}$ offer $\dot{x}^T$.

2.3 Proposition 6. Welfare comparison of the property and liability rules

To study the welfare implications, we consider the owner's payoff as an expected value over owner types. For the property rule and the taker's equilibrium offers, we have

$x = \frac{w}{2}$	$\mathrm{E}_v(\Pi_{O\ PR}) = \frac{\frac{w}{2}}{H}\frac{w}{2} + \left(1 - \frac{\frac{w}{2}}{H}\right)\frac{\frac{w}{2}+H}{2} = \frac{H}{2} + \frac{w^2}{8H}$

Table 6: Owner's payoff in screening game under property rule

For the liability rule we obtain

$\dot{x}^N = \frac{w}{2}$	$\mathrm{E}_v(\dot{\Pi}^N_{O\ LR}) = \mathrm{E}_v(\dot{\Pi}_{O\ PR}) = \frac{H}{2} + \frac{w^2}{8H}$
$\bar{x}^T = 2w - H - 3\phi$	$\mathrm{E}_v(\overline{\Pi}^T_{O\ LR}) = \frac{\bar{x}^T + \phi}{H}\bar{x}^T + \left(1 - \frac{\bar{x}^T + \phi}{H}\right)\left(\frac{\bar{x}^T + \phi + H}{2} - \phi\right)$ $= H - 2w + \phi + \frac{2(w-\phi)^2}{H}$
$\dot{x}^T = \phi$	$\mathrm{E}_v(\dot{\Pi}^T_{O\ LR}) = \frac{2\phi}{H}\phi + \left(1 - \frac{2\phi}{H}\right)\left(\frac{2\phi+H}{2} - \phi\right) = \frac{H}{2} - \phi + \frac{2\phi^2}{H}$

Table 7: Owner's payoff in screening game under liability rule

As to the taker's payoffs, we refer to 2.2.2.3 above.

Calculating the total expected payoffs for the various equilibrium offers under the property rule and the liability rule:

$$\Pi_{PR} = \mathrm{E}_v(\Pi_{O\ PR}) + \Pi_{T\ PR} = \frac{H}{2} + \frac{w^2}{8H} + \frac{\left(\frac{w}{2}\right)^2}{H} =$$
$$\frac{H}{2} + \frac{3}{8}\frac{w^2}{H}$$

$$\dot{\Pi}^N_{LR} = \Pi_{PR} = \frac{H}{2} + \frac{3}{8}\frac{w^2}{H}$$

$$\overline{\Pi}^T_{LR} = \mathrm{E}_v(\overline{\Pi}^T_{O\ LR}) + \overline{\Pi}^T_{T\ LR} =$$
$$H - 2w + \phi + \frac{2(w-\phi)^2}{H} + w - \frac{H}{2} - \phi - \frac{(2w - H - 6\phi)(2w - H - 2\phi)}{2H} =$$

$$w + 4\phi\left(\frac{w-\phi}{H} - 1\right)$$

$$\dot{\Pi}^T_{LR} = \mathrm{E}_v\left(\dot{\Pi}^T_{O\,LR}\right) + \dot{\Pi}^T_{T\,LR} = \frac{H}{2} - \phi + \frac{2\phi^2}{H} + w - \frac{H}{2} - \phi + \frac{2\phi^2}{H} = w - 2\phi + \frac{4\phi^2}{H}$$

Proposition 6 reflects comparisons of total payoffs under the two rules as a function of w. The relevant combinations reflect the equilibrium ranges from Propositions 4 and 5. Inspecting the relations between the various cutoffs in Proposition 5 from above, we arrive at Figure 33 for the relevant cases.

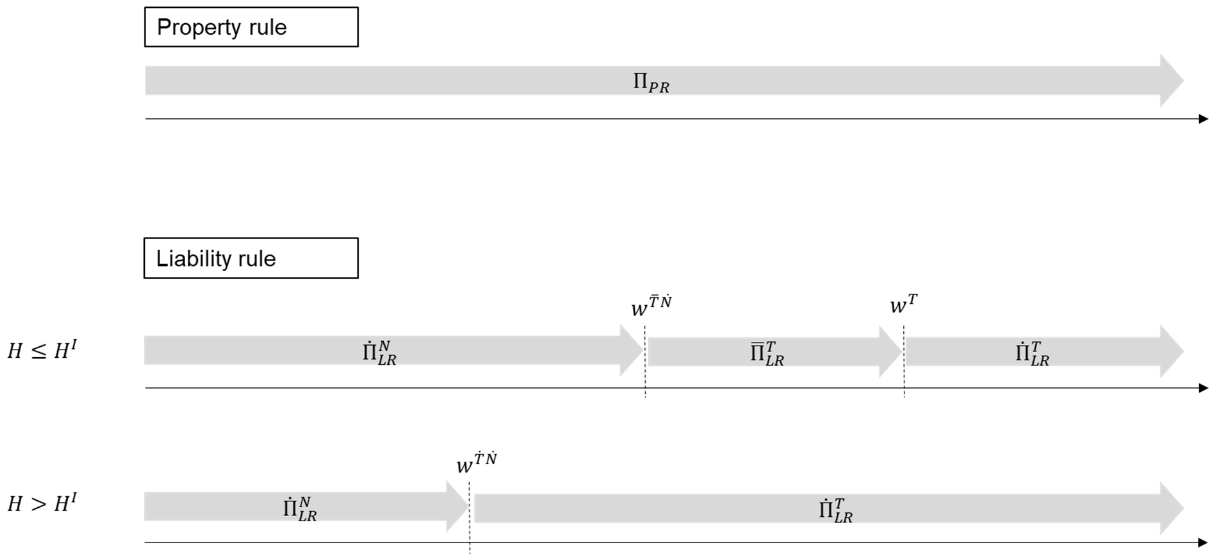


Figure 33: Relevant combinations of total equilibrium payoffs

We know that $\Pi_{PR} = \dot{\Pi}^N_{LR}$.

Equilibrium property rule vs. upper always-take equilibrium liability rule.

$$\Pi_{PR} \geq \bar{\Pi}^T_{LR}$$

$$\frac{H}{2} + \frac{3}{8}\frac{w^2}{H} \geq w + 4\phi\left(\frac{w-\phi}{H} - 1\right)$$

$$0 \geq w - \frac{H}{2} + 4\phi\left(\frac{w-\phi}{H} - 1\right) - \frac{3}{8}\frac{w^2}{H}$$

The RHS as a function of w is concave, always has a maximum and two roots at $w = \frac{4}{3}H + \frac{16}{3}\phi \pm \frac{2}{3}\sqrt{H^2 + 8H\phi + 40\phi^2}$. The higher root always exceeds H and thus is outside the relevant range. The inequality holds if the lower root is above w^T (outside the domain of the always-take equilibrium under case (I) of Proposition 5). For it to be below w^T, it must be that $H <$

$\left(\frac{8}{3}\sqrt{6}-4\right)\phi$. But when this condition is satisfied, the lower root exceeds H. It follows that $\dot{\Pi}_{PR} \geq \overline{\Pi}_{LR}^{T}$ whenever the two equilibria combine.

Equilibrium property rule vs. interior always-take equilibrium liability rule.

$$\Pi_{PR} \geq \dot{\Pi}_{LR}^{T}$$

$$\frac{H}{2}+\frac{3}{8}\frac{w^2}{H} \geq w-2\phi+\frac{4\phi^2}{H}$$

$$0 \geq w-\frac{H}{2}-2\phi+\frac{4\phi^2}{H}-\frac{3}{8}\frac{w^2}{H}$$

The RHS as a function of w is concave throughout and always has a maximum. It has roots at $w_{1,2}=\frac{4}{3}H \pm \frac{2}{3}\sqrt{H^2-12H\phi+24\phi^2}$, which exist only for $H \notin]\left(6-2\sqrt{3}\right)\phi\,,\left(6+2\sqrt{3}\right)\phi[$. If the RHS has no roots, the inequality is satisfied and the property rule dominates.

For $H \leq H^I$ (that is, case (1) of Proposition 5), the two equilibria only coincide if $H \geq w^T$, which leads to $H \geq 4\phi$. Yet the interval $[4\phi, \left(6-2\sqrt{3}\right)\phi]$ is empty, implying that the inequality holds and the property rule prevails. For $H > \left(6+2\sqrt{3}\right)\phi$, the higher root w_1 exceeds H and can be ignored; for $H \leq H^I$, the same is true for the lower root w_2. It follows that the property rule is superior in these instances as well.

Turning to $H > H^I$ (case (II) of Proposition 5), the interval $]H^I, \left(6-2\sqrt{3}\right)\phi]$ is empty. For $]\left(6-2\sqrt{3}\right)\phi, \left(6+2\sqrt{3}\right)\phi[$, the RHS has no roots and its maximum is negative. For $H \geq \left(6+2\sqrt{3}\right)\phi$, the higher root w_1 exceeds H. As to the lower root, $w_2 \leq H$ if and only if $H \geq \left(8+4\sqrt{2}\right)\phi = H^{II}$. It follows that the property rule prevails except for $H \geq H^{II}$ and $w > w_2 = \frac{4}{3}H-\frac{2}{3}\sqrt{H^2-12H\phi+24\phi^2}$. In the Proposition, we refer to w_2 as w_{PRLR}.

Proofs - Chapter 3

1. First best

We first determine the first best as a reference. The total payoff in the first best scenario depends on the relationship between the owner's and the taker's valuation:

$$\Pi_{FB} = \begin{cases} w & v \leq w \\ v & v > w \end{cases}$$

The expected total payoff is

$$\mathrm{E}(\Pi_{FB}) = \alpha\overline{v} + \delta(1 - \alpha - \beta)\underline{w} + \delta\beta v_c + (1 - \delta)(1 - \alpha)\overline{w}$$

2. Taker making a take-it-or-leave-it offer

2.1 Preliminaries

Before we set out to proof the perfect Bayesian Nash equilibrium, we make some observations regarding the parties' strategies and beliefs. Those observations are independent from the remedy in place and underly the following proofs.

> Lemma 1: In equilibrium there is no owner's strategy where he accepts offers $\boldsymbol{x} < \boldsymbol{v}$ and rejects offers $\boldsymbol{x} \geq \boldsymbol{v}$ independent from his belief about the taker's type.

To see this, first suppose the owner has the strategy to accept offers $x < v$. If he receives an offer $x < v$ he always prefers to deviate from his strategy and reject the offer. Rejecting provides him with a higher payoff equal to his valuation either through the taker respecting his entitlement or through compensation. This finding holds for all types of owners. In addition, it is independent from the owner's belief about the taker's type.

For the second part, suppose the owner plays a strategy to reject offers $x \geq v.$ Such strategy is strictly dominated by a strategy that involves accepting offers $x \geq v.$ If he rejects the offer, he only gets his valuation either because the taker respects his entitlement or through compensation. Importantly, since we assume that the owner prefers an agreement in case he is indifferent the finding also holds for $x = v.$ Again, the finding is independent form the owner's type and his belief about the taker's type.

For the taker's strategy about making an offer for all types we note:

Lemma 2: In equilibrium the taker does not play a strategy where she makes offers $x > w$.

Suppose the taker has a strategy to make an offer $x^* > w$. Further suppose that at least one of the owner types plays a strategy where she accepts $x = x^*$. The taker can unilaterally improve her expected payoff by reducing her offer and having no agreements until $x^* \leq w$. In addition, we eliminate equilibria that involve none of the owner types to play a strategy where she accepts $x = x^*$ based on the "trembling hand" refinement criterion: If the taker allows accounts for the possibility that the owner mistakenly accepts $x = x^*$ with some probability $q > 0$ she can improve her expected payoff by making a lower offer until $x^* \leq w$.

2.2 Proposition 1. Equilibria under the property rule if taker offers

2.2.1 Case (I): $(\mathbf{1} - \boldsymbol{\alpha} - \boldsymbol{\beta})(\overline{\boldsymbol{w}} - \underline{\boldsymbol{v}}) > (\mathbf{1} - \boldsymbol{\alpha})(\overline{\boldsymbol{w}} - \boldsymbol{v_c})$

The equilibrium to proof consists of the following beliefs and strategies: Both types of takers have the strategy to make an offer $x = \underline{v}$. If the owner rejects both taker types respect; under the property this is no decision as no other option exists.

$$s_T{}^*(w) = \begin{cases} x = \underline{v}, & w = \overline{w} \\ x = \underline{v}, & w = \underline{w} \end{cases}$$

The owner's belief and strategy sets are as follows:

$$s_O{}^*(x) = \begin{cases} accept, & x \geq v \\ reject, & x < v \end{cases}$$

$$b_O{}^*(x) = \begin{cases} w \in \{\overline{w}, \underline{w}\}, & x \leq \underline{w} \\ w \in \{\overline{w}\}, & x > \underline{w} \end{cases}$$

Note that the owner's strategy is determined by the finding shown by Lemma 1. No further proof is necessary. Furthermore, this implies that the owner's belief about the taker's type does not affect his strategy.

The taker's problem is to maximize

$$\mathrm{E}(\Pi_{\underline{T}}) = prob(x\ accepted)(w - x)$$

First take the low taker's perspective. Lemma 2 tells us that she only makes offers $x \leq \underline{w}$. From owner's strategy it follows that

$$prob(x\ accepted) = \begin{cases} 0, & x < \underline{v} \\ (1 - \alpha - \beta), & \underline{v} \leq x \leq \underline{w} \end{cases}$$

Thus, to maximize her profit the low taker offers $x = \underline{v}$. Making a higher offer would not increase $prob(x\ accepted)$ but lower the payoff.

For the high taker Lemma 2 tells us that she only makes offers $x \leq \overline{w}$. From the owner's strategy we deduce

$$prob(x\ accepted) = \begin{cases} 0, & x < \underline{v} \\ (1-\alpha-\beta), & \underline{v} \leq x < v_c \\ (1-\alpha), & v_c \leq x \leq \overline{w} \end{cases}$$

Since making an offer $\underline{v} < x < v_c$ and $v_c < x < \overline{w}$ does not increase the $prob(x\ accepted)$ making such offers is dominated by $x = \underline{v}$ or $x = v_c$, respectively.

Hence, we get

$$\mathrm{E}(\Pi_{\underline{T}}(x = \underline{v})) = (1-\alpha-\beta)(w - \underline{v})$$

and

$$\mathrm{E}(\Pi_{\underline{T}}(x = v_c)) = (1-\alpha)(w - v_c)$$

In the given case (I) the high taker prefers $x = \underline{v}$ because by assumption it holds that

$$(1-\alpha-\beta)(\overline{w} - \underline{v}) > (1-\alpha)(\overline{w} - v_c)$$

2.2.2 Case (II): $(\mathbf{1}-\boldsymbol{\alpha}-\boldsymbol{\beta})(\overline{\boldsymbol{w}} - \underline{\boldsymbol{v}}) \leq (\mathbf{1}-\boldsymbol{\alpha})(\overline{\boldsymbol{w}} - \boldsymbol{v_c})$

For case (II) the equilibrium to proof consists of the following beliefs and strategies:

$$s_T^*(w) = \begin{cases} x = v_c, & w = \overline{w} \\ x = \underline{v}, & w = \underline{w} \end{cases}$$

$$s_O^*(x) = \begin{cases} accept, & x \geq v \\ reject, & x < v \end{cases}$$

$$b_O^*(x) = \begin{cases} w = \overline{w}, & x \leq v_c \\ w = \underline{w}, & x > v_c \end{cases}$$

Again, we note that the owner's strategy is driven by the finding of Lemma 1 and that it is independent from his beliefs. Thus, we can concentrate on the taker's strategy. For the low taker we can refer to case (I).

Regarding the high taker her problem remains the same but now $(1-\alpha-\beta)(\overline{w} - \underline{v}) \leq (1-\alpha)(\overline{w} - v_c)$. Hence, in case (II) the high taker prefers $x = v_c$.

2.3 Proposition 2. Equilibrium under the liability rule if taker offers

In contrast to the property rule, under the liability rule the taker has a second decision to make if the owner rejects. We have three cases.

2.3.1 Case (I): $\boldsymbol{\alpha\overline{v} + \beta v_c \geq (\alpha + \beta)\overline{w}}$ and $\boldsymbol{(1 - \alpha - \beta)(\overline{w} - \underline{v}) > (1 - \alpha)(\overline{w} - v_c)}$

In case (I) the equilibrium to proof consists of the following strategies and beliefs:

The taker's strategy and beliefs are:

$$s_T{}^*(w) = \begin{cases} \{x = \underline{v}, respect\} & w = \overline{w} \\ \{x = \underline{v}, respect\} & w = \underline{w} \end{cases}$$

$$b_T{}^*(\{accept, reject\}) = \begin{cases} x \geq v, & accept \\ x < v, & reject \end{cases}$$

The owner's strategy and beliefs are as follows:

$$s_O{}^*(x) = \begin{cases} accept, & x \geq v \\ reject, & x < v \end{cases}$$

$$b_O{}^*(x) = \begin{cases} w \in \{\overline{w}, \underline{w}\}, & x \leq \underline{w} \\ w \in \{\overline{w}\}, & x > \underline{w} \end{cases}$$

As under the property rule, the owner's strategy is determined by our finding Lemma 1. His belief does not affect his strategy and is therefore irrelevant. No further proof is necessary.

Turn to the taker's problem. She needs to decide about the offer x and to take or respect if the owner has rejected the offer. His respective payoffs are.

$$\mathrm{E}(\Pi_{\underline{T}}\ (x, respect)) = prob(x\ accepted)(w - x)$$

$$\mathrm{E}(\Pi_{\underline{T}}\ (x, take)) = prob(x\ accepted)(w - x) + (1 - prob(x\ accepted))(w - v)$$

First, note that the taker's belief is consistent with the owner's strategy.

Second, the strategy $x = \underline{v}$ dominates the strategy $\underline{v} < x < v_c$ because it only reduces the profit from an agreement but does not increase its probability. We have shown that already for the property rule. Analogously, $x = v_c$dominates the strategy $v_c < x < \overline{v}$.

Third, observe that the strategy $x < \underline{v}$ is dominated by $x = \underline{v}$. For the strategy that the taker respects upon rejection this holds because

$$\mathrm{E}(\Pi_{\underline{T}}\ (x = \underline{v}, respect)) > \mathrm{E}(\Pi_{\underline{T}}\ (x < \underline{v}, respect))$$

$$prob\big(x\ accepted, x = \underline{v}\big)(w - x) > prob\big(x\ accepted, x < \underline{v}\big)(w - x)$$

$$prob\big(x\ accepted, x = \underline{v}\big)(w - x) > 0\ (w - x)$$

$$(1-\alpha-\beta)\left(w-\underline{v}\right)>0$$

This holds as $(1-\alpha-\beta)>1$ and $\left(w-\underline{v}\right)>1$ are true by assumption.

If the taker has the strategy to take upon rejection this holds in combination with the assumption that the parties prefer an agreement over respect and take if she is indifferent because

$$\mathrm{E}(\Pi_{\underline{T}}\ (x=\underline{v}, take)) = \mathrm{E}(\Pi_{\underline{T}}\ (x<\underline{v}, take))$$

and

$$prob\left(x\ accepted, x=\underline{v}\right)>prob\left(x\ accepted, x<\underline{v}\right)$$

$$(1-\alpha-\beta)>0$$

Hence, regarding the offer x there remain only two candidates for the taker's strategy: $x=\underline{v}$ and $x=v_c$.

Regarding the low taker we can infer as follows: Based on Lemma 2 the low taker makes the offer $x=\underline{v}$ because $x<\underline{w}<v_c$. Furthermore, she prefers to respect the entitlement upon rejection:

$$\mathrm{E}(\Pi_{\underline{T}}\ (w=\underline{w}, x=\underline{v}, respect)) > \mathrm{E}(\Pi_{\underline{T}}\ (w=\underline{w}, x=\underline{v}, take))$$

$$(1-\alpha-\beta)\left(\underline{w}-\underline{v}\right)>(1-\alpha-\beta)\left(\underline{w}-\underline{v}\right)+\alpha\left(\underline{w}-\overline{v}\right)+\beta(\underline{w}-v_c)$$

$$0>\alpha\left(\underline{w}-\overline{v}\right)+\beta(\underline{w}-v_c)$$

This holds because the right-hand side is always negative.

For the high taker the expected payoff is as follows:

$$\mathrm{E}(\Pi_{\underline{T}}\ (w=\overline{w}, x=\underline{v}, respect)) = (1-\alpha-\beta)\left(\overline{w}-\underline{v}\right)$$

$$\mathrm{E}(\Pi_{\underline{T}}\ (w=\overline{w}, x=v_c, respect)) = (1-\alpha)(\overline{w}-v_c)$$

$$\mathrm{E}(\Pi_{\underline{T}}\ (w=\overline{w}, x=\underline{v}, take)) = (1-\alpha-\beta)\left(\overline{w}-\underline{v}\right)+\ \alpha(\overline{w}-\overline{v})+\beta(\overline{w}-v_c)$$

$$\mathrm{E}(\Pi_{\underline{T}}\ (w=\overline{w}, x=v_c, take)) = (1-\alpha)(\overline{w}-v_c)+\ \alpha(\overline{w}-\overline{v})$$

Comparing the different expected payoffs, we first note that the strategy to offer $x=v_c$ and take is dominated by offering $x=v_c$ and respect because

$$\mathrm{E}(\Pi_{\underline{T}}\ (w=\overline{w}, x=v_c, respect)) > \mathrm{E}(\Pi_{\underline{T}}\ (w=\overline{w}, x=v_c, take))$$

$$(1-\alpha)(\overline{w}-v_c)>(1-\alpha)(\overline{w}-v_c)+\ \alpha(\overline{w}-\overline{v})$$

$$0>\alpha(\overline{w}-\overline{v})$$

$$\overline{v} > \overline{w}$$

In case (I) the high taker prefers to offer $x = \underline{v}$ and respect over offering $x = \underline{v}$ and take:

$$E(\Pi_{\underline{T}}\ (w = \overline{w}, x = \underline{v}, respect)) \geq E(\Pi_{\underline{T}}\ (w = \overline{w}, x = \underline{v}, take))$$

$$(1 - \alpha - \beta)(\overline{w} - \underline{v}) \geq (1 - \alpha - \beta)(\overline{w} - \underline{v}) + \alpha(\overline{w} - \overline{v}) + \beta(\overline{w} - v_c)$$

$$0 \geq \alpha(\overline{w} - \overline{v}) + \beta(\overline{w} - v_c)$$

$$\alpha\overline{v} + \beta v_c \geq (\alpha + \beta)\overline{w}$$

This is true by assumption for case (I) and based on our assumption that the parties prefer respect over take if they are indifferent.

In case (I) the high taker prefers to offer $x = \underline{v}$ and respect over offering $x = v_c$ and respect:

$$E(\Pi_{\underline{T}}\ (w = \overline{w}, x = \underline{v}, respect)) > E(\Pi_{\underline{T}}\ (w = \overline{w}, x = v_c, respect))$$

$$(1 - \alpha - \beta)(\overline{w} - \underline{v}) > (1 - \alpha)(\overline{w} - v_c)$$

2.3.2 Case (II): $(\mathbf{1} - \boldsymbol{\alpha} - \boldsymbol{\beta})(\boldsymbol{v_c} - \underline{\boldsymbol{v}}) \leq \boldsymbol{\alpha}(\overline{\boldsymbol{v}} - \overline{\boldsymbol{w}})$ and $(\mathbf{1} - \boldsymbol{\alpha} - \boldsymbol{\beta})(\overline{\boldsymbol{w}} - \underline{\boldsymbol{v}}) \leq (\mathbf{1} - \boldsymbol{\alpha})(\overline{\boldsymbol{w}} - \boldsymbol{v_c})$

The equilibrium consists of the following strategies and beliefs:

$$s_T^*(w) = \begin{cases} \{x = \underline{v}, respect\}, w = \underline{w} \\ \{x = v_c, respect\}, \quad w = \overline{w} \end{cases}$$

$$b_T^*(\{accept, reject\}) = \begin{cases} x \geq v, & accept \\ x < v, & reject \end{cases}$$

The owner's strategy and beliefs are as follows:

$$s_O^*(x) = \begin{cases} accept, & x \geq v \\ reject, & x < v \end{cases}$$

$$b_O^*(x) = \begin{cases} w \in \{\overline{w}, \underline{w}\}, & x \leq \underline{w} \\ w \in \{\overline{w}\}, & x > \underline{w} \end{cases}$$

For the proof with respect to the low taker we can refer to case (I). For the high taker we can mostly build on the proof shown in case (I) and concentrate on the last step, i.e. comparing the expected payoffs.

The high taker prefers to offer $x = v_c$ and respect over both alternative options:

First see that

$$E(\Pi_{\underline{T}}\ (w = \overline{w}, x = v_c, respect)) \geq E(\Pi_{\underline{T}}\ (w = \overline{w}, x = \underline{v}, take))$$

$$(1-\alpha)(\overline{w}-v_c) \geq (1-\alpha-\beta)(\overline{w}-\underline{v}) + \alpha(\overline{w}-\overline{v}) + \beta(\overline{w}-v_c)$$

$$\alpha(\overline{v}-\overline{w}) \geq (1-\alpha-\beta)(v_c-\underline{v})$$

In addition, the following comparison holds by assumption:

$$\mathrm{E}(\Pi_{\underline{T}}\,(w=\overline{w}, x=v_c, respect)) \geq \mathrm{E}(\Pi_{\underline{T}}\,(w=\overline{w}, x=\underline{v}, respect))$$

$$(1-\alpha)(\overline{w}-v_c) \geq (1-\alpha-\beta)(\overline{w}-\underline{v})$$

2.3.3 Case (III): $\boldsymbol{\alpha\overline{v}+\beta v_c} < (\boldsymbol{\alpha}+\boldsymbol{\beta})\overline{\boldsymbol{w}}$ and $(\mathbf{1}-\boldsymbol{\alpha}-\boldsymbol{\beta})(\boldsymbol{v_c}-\underline{\boldsymbol{v}}) > \boldsymbol{\alpha}(\overline{\boldsymbol{v}}-\overline{\boldsymbol{w}})$

The equilibrium consists of the following strategies and beliefs:

$$s_T{}^*(w) = \begin{cases} \{x=\underline{v}, respect\}, & w=\underline{w} \\ \{x=\underline{v}, take\}, & w=\overline{w} \end{cases}$$

$$b_T{}^*(\{accept, reject\}) = \begin{cases} x \geq v, & accept \\ x < v, & reject \end{cases}$$

The owner's strategy and beliefs are as follows:

$$s_O{}^*(x) = \begin{cases} accept, & x \geq v \\ reject, & x < v \end{cases}$$

$$b_O{}^*(x) = \begin{cases} w \in \{\overline{w}, \underline{w}\}, & x \leq \underline{w} \\ w \in \{\overline{w}\}, & x > \underline{w} \end{cases}$$

Regarding the low taker we can refer to the proof of case (I). For the high taker we can mostly build on the proof shown in case (I) and concentrate on the last step, i.e. comparing the expected payoffs.

The high taker prefers to offer $x=\underline{v}$ and take to offering $x=\underline{v}$ and respect because by assumption

$$\mathrm{E}(\Pi_{\underline{T}}\,(w=\overline{w}, x=\underline{v}, take)) > \mathrm{E}(\Pi_{\underline{T}}\,(w=\overline{w}, x=\underline{v}, respect))$$

$$(\alpha+\beta)\overline{w} > \alpha\overline{v}+\beta v_c$$

The high taker prefers to offer $x=\underline{v}$ and take over offering $x=v_c$ and respect:

$$\mathrm{E}(\Pi_{\underline{T}}\,(w=\overline{w}, x=\underline{v}, take)) > \mathrm{E}(\Pi_{\underline{T}}\,(w=\overline{w}, x=v_c, respect))$$

$$(1-\alpha-\beta)(\overline{w}-\underline{v}) + \alpha(\overline{w}-\overline{v}) + \beta(\overline{w}-v_c) > (1-\alpha)(\overline{w}-v_c)$$

$$(1-\alpha-\beta)(\overline{w}-\underline{v}) + \alpha(\overline{w}-\overline{v}) > (1-\alpha-\beta)(\overline{w}-v_c)$$

$$(1-\alpha-\beta)(v_c-\underline{v}) > \alpha(\overline{v}-\overline{w})$$

This holds by the second assumption of case (III).

2.4 Proposition 3. Welfare comparison if taker offers

Recall the expected total payoff in the first best to be

$$\mathrm{E}(\Pi_{FB}) = \alpha\overline{v} + \delta(1-\alpha-\beta)\underline{w} + \delta\beta v_c + (1-\delta)(1-\alpha)\overline{w}$$

For the property rule we note that its case (II) provides the same total payoff as the first best. From **Proposition 1** we can infer for the total payoff that

$$\Pi_{PR\ Case\ 2} = \begin{cases} w & v \leq w \\ v & v > w \end{cases}$$

Thus, for the expected total payoff it follows:

$$E(\Pi_{PR\ Case\ 2}) = \alpha\overline{v} + \delta(1-\alpha-\beta)\underline{w} + \delta\beta v_c + (1-\delta)(1-\alpha)\overline{w} = \mathrm{E}(\Pi_{FB})$$

Case (I) of the property rule implies an efficiency loss. Recall that we do not see a transfer from the intermediate type to the high taker. We get:

$$E(\Pi_{PR\ Case\ 1}) = \beta v_c + \alpha\overline{v} + (1-\alpha-\beta)\big(\delta\underline{w} + (1-\delta)\overline{w}\big)$$

Regarding the liability rule **Proposition 1** and **Proposition 2** show that case (I) of the liability rule leads to the same outcome as case (I) of the property rule and case (II) leads to the first best outcome like case (II) of the property rule:

$$E(\Pi_{LR\ Case\ 1}) = E(\Pi_{PR\ Case\ 1}) = \beta v_c + \alpha\overline{v} + (1-\alpha-\beta)\big(\delta\underline{w} + (1-\delta)\overline{w}\big)$$

$$E(\Pi_{LR\ Case\ 2}) = E(\Pi_{PR\ Case\ 2}) = \mathrm{E}(\Pi_{FB})$$

Based on **Proposition 2**, for case (III) of the liability rule we get an expected total payoff of

$$E(\Pi_{LR\ Case\ 3}) = (1-\delta)\overline{w} + \delta(1-\alpha-\beta)\underline{w} + \delta\alpha\overline{v} + \delta\beta v_c$$

Based on those findings we can infer:

For $\alpha\overline{v} + \beta v_c \geq (\alpha+\beta)\overline{w}$ and $(1-\alpha-\beta)\big(\overline{w} - \underline{v}\big) > (1-\alpha)(\overline{w} - v_c)$, both rules are equally efficient. The second constraint implies that under the property rule equilibrium case (I) applies. The combination of the constraints determines that under the liability rule case (I) is on hand. As stated, both lead to the same expected total payoff.

Equivalently, for $(1-\alpha-\beta)\big(v_c - \underline{v}\big) \leq \alpha(\overline{v} - \overline{w})$ and $(1-\alpha-\beta)\big(\overline{w} - \underline{v}\big) \leq (1-\alpha)(\overline{w} - v_c)$ we find that both rules are equally efficient. According to the second constraint the case (II) of the equilibrium under the property rule applies. Both constraints specify that under the liability rule case (II) applies. Both cases lead to the first best outcome.

For the remaining area $\alpha\overline{v} + \beta v_c < (\alpha+\beta)\overline{w}$ and $(1-\alpha-\beta)\big(v_c - \underline{v}\big) > \alpha(\overline{v} - \overline{w})$, case (III) of the liability rule applies. Regarding the property rule, case (II) applies if $(1-\alpha-\beta)\big(\overline{w} - \underline{v}\big) \leq$

$(1-\alpha)(\overline{w}-v_c)$ and case (I) otherwise. In the former scenario, the property rule is more efficient:

$$E(\Pi_{PR\ Case\ 2}) = \mathrm{E}(\Pi_{FB}) > E(\Pi_{LR\ Case\ 3})$$

$$\alpha\overline{v} + \delta(1-\alpha-\beta)\underline{w} + \delta\beta v_c + (1-\delta)(1-\alpha)\overline{w} > (1-\delta)\overline{w} + \delta(1-\alpha-\beta)\underline{w} + \delta\alpha\overline{v} + \delta\beta v_c$$

$$(1-\delta)\alpha(\overline{v}-\overline{w}) > 0$$

This holds by assumption.

Otherwise, the liability rule is more efficient:

$$E(\Pi_{PR\ Case\ 1}) < E(\Pi_{LR\ Case\ 3})$$

$$\beta v_c + \alpha\overline{v} + (1-\alpha-\beta)\left(\delta\underline{w} + (1-\delta)\overline{w}\right) < (1-\delta)\overline{w} + \delta(1-\alpha-\beta)\underline{w} + \delta\alpha\overline{v} + \delta\beta v_c$$

$$(1-\delta)(\beta v_c + \alpha\overline{v}) < (\alpha+\beta)(1-\delta)\overline{w}$$

$$\beta v_c + \alpha\overline{v} < (\alpha+\beta)\overline{w}$$

Recall that the first constraint for case (II) is: $\alpha\overline{v} + \beta v_c < (\alpha+\beta)\overline{w}$. Thus, we observe case (III) of the liability rule only when it is more efficient than case (I) of the property rule.

3. Owner making a take-it-or-leave-it demand

3.1 Preliminaries

Like for the analysis above where the taker made the take-it-or-leave-it offer we start with two observations which will help us for the following proofs.

> Lemma 3: In equilibrium there is no owner's strategy where he demands $y < v$.

Suppose the owner has a strategy to make a demand $y^* < v$. Further suppose that at least one of the taker types plays a strategy where she accepts $y = y^*$. The owner can unilaterally improve his expected payoff by increasing his demand. Either the taker still accepts the demand, i.e. a higher payoff for the owner, or she rejects the offer providing the owner with a payoff equal to his valuation, i.e. higher than if the taker accepted $y^* < v$.

Suppose neither taker type accepts $y = y^*$. Like for Lemma 1 we eliminate such equilibria based on the "trembling hand" refinement criterion.

> Lemma 4: In equilibrium the taker does not play a strategy where she accepts demands $\boldsymbol{y} > \boldsymbol{w}$.

Suppose the taker has a strategy to accept a demand $y > w$. The taker's payoff would be $\Pi_T = w - y < 0$. Such strategy is dominated by a strategy to reject demands $y > w$ and respect the entitlement where the taker's payoff would be $\Pi_T = 0$.

3.2 Proposition 4. Equilibrium under the property rule if owner demands

3.2.1 Case (I): $\underline{\boldsymbol{w}} \geq (\boldsymbol{1} - \boldsymbol{\delta})\overline{\boldsymbol{w}} + \boldsymbol{\delta}\underline{\boldsymbol{v}}$

For case (I) there is a family of fully separating equilibria. All of them are outcome equivalent. They consist of the following sets of strategies and beliefs:

$$s_O{}^*(v) = \begin{cases} y \geq \overline{v}, & v = \overline{v} \\ y = \overline{w}, & v = v_c \\ y = \underline{w}, & v = \underline{v} \end{cases}$$

$$s_T{}^*(y) = \begin{cases} reject, & y > w \\ accept, & y \leq w \end{cases}$$

$$b_T{}^*(y) = \begin{cases} v \in \{v_c, \overline{v}\}, & y \geq \overline{v} \\ v \in \{\underline{v}\}, & y < \overline{v} \end{cases}$$

The high owner makes a separating demand equal or above his valuation, $y \geq \overline{v}$. All those possible demands represent a continuum of separating demands each being an equilibrium.

First consider the taker's set of strategy. Her strategy to reject demands $y > w$ is shown by Lemma 4. For the second aspect of her strategy consider that accepting demands $y \leq w$ provides her with a payoff of $\Pi_{\underline{T}} = w - y$ and rejecting leaves her with a payoff of zero. Thus, as long as $\Pi_{\underline{T}} = w - y \geq 0$ she prefers to accept. In case of indifference this is based on our assumption that the parties prefer an agreement over respecting the entitlement. Equivalently to the equilibrium in **Proposition 1** the taker's strategy is independent from her belief about the owner's type; thus, the beliefs are irrelevant.

The owner's problem is

$$\mathrm{E}(\Pi_O) = prob(y)(y - v)$$

The high type making a demand $y \geq \overline{v}$ bases on Lemma 3 and provides him with a payoff of zero. The intermediate owner's expected payoff from demanding $y = \overline{w}$ is

$$\mathrm{E}(\Pi_O(v = v_c, y = \overline{w})) = (1 - \delta)(\overline{w} - v_c)$$

Making a demand $y > \overline{w}$ would provide him with a payoff of zero and is therefore a dominated strategy. Lemma 3 tells us that he does not make demand $y < v_c$. Demanding $v_c \leq y < \overline{w}$ does not increase the probability to find an agreement but only reduces the profit from an agreement. Hence, such strategy is dominated by demanding $y = \overline{w}$.

The low owner's expected payoff from demanding $y = \underline{w}$ is

$$\mathrm{E}(\Pi_O(v = \underline{v}, y = \underline{w})) = \underline{w} - \underline{v}$$

Demanding less would only lower the profit but not increase the probability of an agreement. Demanding $y > \overline{w}$ result in a payoff of zero and is therefore dominated. Demanding $\underline{w} < y \leq \overline{w}$ increases the profit from an agreement but lowers the probability of an agreement because only the high taker accepts and the low taker rejects such demands. Note that demanding $\underline{w} < y < \overline{w}$ is dominated by $y = \overline{w}$ because the probability of an agreement does not differ but the profit is higher.

In case (I) the low owner prefers to demand $y = \underline{w}$ over demanding $y = \overline{w}$ because

$$\mathrm{E}(\Pi_O(v = \underline{v}, y = \underline{w})) \geq \mathrm{E}(\Pi_O(v = \underline{v}, y = \overline{w}))$$

$$\underline{w} - \underline{v} \geq (1 - \delta)(\overline{w} - \underline{v})$$

$$\underline{w} \geq (1 - \delta)\overline{w} + \delta\underline{v}$$

This is true by assumption for case (I) and in case of indifference due to the assumption that the parties prefer to find an agreement over respect of the entitlement.

3.2.2 Case (II): $\underline{\boldsymbol{w}} < (\mathbf{1}-\boldsymbol{\delta})\overline{\boldsymbol{w}} + \boldsymbol{\delta}\underline{\boldsymbol{v}}$

$$s_O{}^*(v) = \begin{cases} y \geq \overline{v}, & v = \overline{v} \\ y = \overline{w}, & v = v_c \\ y = \overline{w}, & v = \underline{v} \end{cases}$$

$$s_T{}^*(y) = \begin{cases} reject, & y > w \\ accept, & y \leq w \end{cases}$$

$$b_T{}^*(y) = \begin{cases} v \in \{v_c, \overline{v}\}, & y \geq \overline{v} \\ v \in \{\underline{v}\}, & y < \overline{v} \end{cases}$$

For the proof of the family of equilibria in case (II) we can mostly refer to case (I). The only difference is that the low owner prefers to demand $y = \overline{w}$ instead of $y = \underline{w}$ because

$$\mathrm{E}(\Pi_O(v = \underline{v}, y = \underline{w})) < \mathrm{E}(\Pi_O(v = \underline{v}, y = \overline{w}))$$

$$\underline{w} - \underline{v} < (1-\delta)(\overline{w} - \underline{v})$$

$$\underline{w} < (1-\delta)\overline{w} + \delta\underline{v}$$

This reflects the counter boundary of case (II).

Proposition 5. Equilibrium under the liability rule

3.2.1 Case (I), $\overline{w} \leq \frac{\beta v_c + \alpha \overline{v}}{\beta + \alpha}$:

We will proceed in two steps. First, we will show that an equilibrium exists that leads to the outcome given by Proposition 5. In a second step we show that there is no equilibrium that leads to a different outcome.

3.2.1.1 Existence of Equilibrium resulting in Proposition 5 Case (I)

The family of perfect Bayesian Nash equilibria we proof to exist is a continuum of semi-pooling equilibria, with one such equilibrium associated with each possible pooling demand.

Consider the owner's strategy $s_O{}^*(v)$. The high and intermediate owner make a semi-pooling demand $y \geq \overline{v}$; each of this continuum of possible pooling demands leads to the family of perfect Bayesian Nash equilibria. The low owner makes a separating demand $y = \underline{v}$. Now turn to the taker's strategy ($s_T{}^*(y)$). Both types of takers reject demands $y \geq \overline{v}$ followed by respecting the entitlement. They reject demands $\underline{v} < y < \overline{v}$ and take the entitlement unilaterally. They accept offers $y \leq \underline{v}$.

Upon observing the owner's demand, the taker will try to infer what type she faces as that determines the expected amount of expectation damages she pays if she takes unilaterally. In that the taker's belief ($b_T{}^*(y)$) enters her objective function. In our equilibrium the taker believes that if she receives a demand $x \geq \overline{v}$ that she faces either a high or intermediate owner. Otherwise, she believes to face a low owner.

We can summarize the equilibrium as follows:

$$s_O{}^*(v) = \begin{cases} y \geq \overline{v}, & v = \overline{v} \\ y \geq \overline{v}, & v = v_c \\ y = \underline{v}, & v = \underline{v} \end{cases}$$

$$s_T{}^*(y) = \begin{cases} \textit{reject and respect}, & y \geq \overline{v} \\ \textit{reject and take}, & \underline{v} < y < \overline{v} \\ \textit{accept}, & y \leq \underline{v} \end{cases}$$

$$b_T{}^*(y) = \begin{cases} v \in \{v_c, \overline{v}\}, & y \geq \overline{v} \\ v \in \{\underline{v}\}, & y < \overline{v} \end{cases}$$

To see that this is in equilibrium we start considering the owner's perspective. For the high owner we can revert to Lemma 3 to see that he demands $y \geq \overline{v}$.

Next, consider the intermediate owner's payoff to see that he would not deviate from his strategy. Making a demand $y < \overline{v}$ leads the taker either to reject and take or to accept the demand depending on her type. Both would render the intermediate owner worse off. Recall that by assumption he prefers reject and respect over reject and take. Making an offer $y \leq \underline{v}$ which would be accepted would lead to a lower payoff.

The low owner would be worse off by making a lower demand than $y = \underline{v}$ which would be accepted. Furthermore, he prefers the agreement to a rejection with the same payoff he would get if he makes a higher demand.

Both types of takers reject offers $y \geq \overline{v}$ based on their belief that it is either the high or intermediate owner who made the demand and the assumption of Case (I) of **Proposition 4**: $\overline{w} \leq \frac{\beta v_c + \alpha \overline{v}}{\beta + \alpha}$. They do not accept the demand because it is above their valuation. In addition, their belief implies that taking unilaterally involves expectation damages which exceed their valuations. Their belief is consistent with the owners' strategy.

Both types of takers accept demands $y = \underline{v}$ based on their belief to face a low owner and the assumption that they prefer an agreement over respect or take. Their belief is consistent with the owners' strategy.

The strategy to reject demands $\underline{v} < y < \overline{v}$ and take bases on the takers' belief that in such case they would face a low owner. This is an out-off-equilibrium since we do not observe such demands in equilibrium by any type. With respect to demands $\underline{v} < y < v_c$ the belief is not implausible because only the low owner can increase his payoff through such demands if the taker accepts. With respect to demands $v_c \leq y < \overline{v}$ also the intermediate owner can increase his payoff if the demand is accepted. But the low owner profits even more than the intermediate owner relative to the equilibrium outcome if the demand is accepted. Thus, the belief to face a low type is not implausible.

3.2.1.2 Eliminating equilibria implying different result than Proposition 5 Case (I)

We first recall Lemma 3 stating that a potential equilibrium requires the owner to make a demand equal or above his valuation. Even if the taker rejects such demands in equilibrium such equilibria would not survive the *"trembling hand"* refinement criterion.

This implies that the remaining potential equilibria we need to eliminate involve the three types of owners either to make a separating demand or a pooling demand.

We start with a separating demand. Suppose the intermediate owner makes a fully separating demand where he demands more than his valuation: $y > v_c$. Consider the taker's perspective. Accepting the demand is dominated by reject and take. The high taker would reject and take receiving the demand while the low taker respects entitlement. In addition, both takers would reject a demand by the high owner $y \geq \overline{v}$ followed by respect. It shows that the separating demand is not an equilibrium. The intermediate owner prefers that both types of takers respect his entitlement. He is incentivized to mimic the high owner.

Suppose the intermediate owner makes a fully separating demand equal to his valuation $y = v_c$. Based on our assumption that the parties prefer an agreement over all alternatives if they receive the same payoff, we can infer the following. The high taker accepts $y = v_c$ while the low taker rejects and respects assuming their consistent beliefs to face an intermediate type.

But consequently, the low owner prefers to deviate and mimic the intermediate owner. The high taker accepts demands $y = v_c$ which provides the low owner with a greater payoff than to make a lower separating demand. Thus, a fully separating demand is no equilibrium.

Next, suppose that all owners make a pooling demand $y \geq \overline{v}$. The takers would reject such demands because reject and take dominates accept. Now take the low owner's perspective. He would deviate from making a pooling demand and offer $y = \underline{v}$ which the taker prefers to accept. Importantly, the taker prefers to accept such demand regardless of what type she believes to face. This allows us to eliminate also a pooling equilibrium.

3.2.2 Case (II), $\overline{w} > \frac{\beta v_c + \alpha \overline{v}}{\beta + \alpha}$:

Again, we will proceed in two steps; showing that an equilibrium exists that leads to the outcome in Proposition 5 case (II) case (II) followed by outlining that there is no equilibrium that leads to a different outcome.

3.2.2.1 Existence of Equilibrium resulting in Proposition 5 case (I)

The family of equilibria resembles those we found for case (I). It differs only in that the high taker rejects and takes after observing the semi-pooling demand $y \geq \overline{v}$.

$$s_O{}^*(v) = \begin{cases} y \geq \overline{v}, & v = \overline{v} \\ y \geq \overline{v}, & v = v_c \\ y = \underline{v}, & v = \underline{v} \end{cases}$$

$$s_T{}^*(y, w) = \begin{cases} \text{reject and take}, & y \geq \overline{v}\ if\ w = \overline{w} \\ \text{reject and respect}, & y \geq \overline{v}\ if\ w = \underline{w} \\ \text{reject and take}, & \underline{v} < y < \overline{v} \\ \text{accept}, & y \leq \underline{v} \end{cases}$$

$$b_T{}^*(y) = \begin{cases} v \in \{v_c, \overline{v}\}, & y \geq \overline{v} \\ v \in \{\underline{v}\}, & y < \overline{v} \end{cases}$$

We start with the owner: For the high owner we can simply refer to Lemma 3. The intermediate owner does not deviate from his strategy and make a demand $v_c \leq y < \overline{v}$ because the taker would reject and take. The owner prefers the taker to respect the entitlement. He induces at least the low taker to respect the entitlement by demanding $x \geq \overline{v}$. The low owner prefers the taker to accept his demand and as a result does not deviate by making a higher demand the taker would reject.

Next, consider the taker's perspective. Both types of taker accept the demand $v = \underline{v}$ because they prefer an agreement over reject. The high taker rejects and takes after receiving a demand $x \geq \overline{v}$ because in case (II) $\overline{w} > \frac{\beta v_c + \alpha \overline{v}}{\beta + \alpha}$. The low taker rejects and respects the entitlement because $\underline{w} < \frac{\beta v_c + \alpha \overline{v}}{\beta + \alpha}$.

The strategies of both types of takers involve rejecting and take upon receiving a demand $\underline{v} < y < \overline{v}$. This is based on their belief to face a low owner. This belief is not implausible. For a closer view we refer to the discussion for case (I) which applies equivalently.

3.2.2.2 Eliminating equilibria implying different result than Proposition 5 case (II)

In this section we eliminate equilibria where the owner makes a fully separating demand or a pooling demand.

Suppose the intermediate owner's strategy is to make a fully separating demand with $y > v_c$. Based on the same reasoning as for case (I) this would not be an equilibrium because the intermediate owner would prefer to mimic the high owner.

Suppose the intermediate owner makes a fully separating demand $y = v_c$. Like in case (I) the high taker would accept such demand and the low taker would reject and respect based on their belief to face an intermediate owner. But as before, this would cause the low owner to prefer mimicking the intermediate owner; thus, the equilibrium unravels.

Last, we consider a pooling demand. Suppose all types of owners make a pooling demand $y \geq \overline{v}$. We can eliminate such equilibrium based on the argument outlined for case (I): The low owner would deviate from making a pooling demand and offer $y = \underline{v}$ which the taker prefers to accept.

3.3 Proposition 6. Welfare comparison

First, recall the first best which we have established above.

$$\mathrm{E}(\Pi_{FB}) = \alpha\overline{v} + \delta(1-\alpha-\beta)\underline{w} + \delta\beta v_c + (1-\delta)(1-\alpha)\overline{w}$$

The expected total payoff under the property rule differs between its cases. Based on Proposition 4 we see that Case (I) leads to the same outcome as the first best.

$$E(\Pi_{PR\ Case\ 1}) = E(\Pi_{FB}) = \alpha\overline{v} + \delta(1-\alpha-\beta)\underline{w} + \delta\beta v_c + (1-\delta)(1-\alpha)\overline{w}$$

For case (II) we get:

$$E(\Pi_{PR\ Case\ 2}) = \alpha\overline{v} + \delta(1-\alpha-\beta)\underline{v} + \delta\beta v_c + (1-\delta)(1-\alpha)\overline{w}$$

This implies a welfare loss of the property rule in case (II) equal to

$$E(\Pi_{FB}) - E(\Pi_{PR\ Case\ 2}) = \delta(1-\alpha-\beta)(\underline{w}-\underline{v})$$

The liability rule yields the following expected total payoffs based on Proposition 5:

$$E(\Pi_{LR\ Case\ 1}) = \beta v_c + \alpha\overline{v} + (1-\alpha-\beta)\big(\delta\underline{w} + (1-\delta)\overline{w}\big)$$

$$E(\Pi_{LR\ Case\ 2}) = (1-\delta)\overline{w} + \delta(1-\alpha-\beta)\underline{w} + \delta\alpha\overline{v} + \delta\beta v_c$$

The welfare loss for case (I) is given by $E(\Pi_{FB}) - E(\Pi_{LR\ Case\ 1}) = (1-\delta)\beta(\overline{w}-v_c)$ while we observe a welfare loss of $E(\Pi_{FB}) - E(\Pi_{LR\ Case\ 2}) = \alpha(1-\delta)(\overline{v}-\overline{w})$ for case (II).

We can compare the expected total payoffs based on the welfare losses we just derived. This means that for the comparison of case (I) of the property rule we can simply refer to the welfare loss under the liability rule. Furthermore, it shows that the expected total payoff under case (II) of the property rule is greater than under the liability rule if:

$$\Pi_{PR\ Case\ 2} > \Pi_{LR\ Case\ 1}$$

$$(1-\delta)\beta(\overline{w}-v_c) > \delta(1-\alpha-\beta)(\underline{w}-\underline{v})$$

$$E(\Pi_{PR\ Case\ 2}) > E(\Pi_{LR\ Case\ 2})$$

$$\alpha(1-\delta)(\overline{v}-\overline{w}) > \delta(1-\alpha-\beta)(\underline{w}-\underline{v})$$

Experimental instructions and interface - chapter 4

1. Experimental instructions (translated)

Welcome and thank you for participating! In this experiment you will have the opportunity to earn, depending on your choices, a certain number of “thalers”. At the end of today’s session, we will convert these thalers to an amount of money, at an exchange rate of 4 thalers = 1 Euro (or, correspondingly, 1 thaler = 25 Cents). We will then pay you this amount in private and in cash.

Before we begin, please note that it is very important to us that all participants are solely focused on their own decisions during the experiment. Please do not talk to the other participants or communicate with them in any other way. If you have a question during the experiment, just raise your hand and we will come to you.

The experiment today consists of 25 rounds that all proceed in the same way. In each round you will run through the following stages.

Stage 1: Random pairings, allocation of roles, and start balance

At the beginning of stage 1, the computer will randomly match today’s participants into pairs. That is, in each round you will interact with exactly one other person and the identity of that person will change from round to round. You will not learn whom you have been matched with.

In each pair, one participant will assume the role of “person A” and the other one the role of “person B”. The allocation of roles is random. Both players receive a start balance of 10 thalers.

Stage 2: Assignment of a personal number

In stage 2, the computer will assign a random number between 0 and 100 to you. It will inform only person A of person A’s number and inform only person B of person B’s number. The computer will determine the numbers completely randomly and independently of each other, and each number (0, 1, 2, … 99, 100) is equally likely.

Stage 3: Negotiation

In stage 3, person A and person B will have the opportunity to negotiate over how to split 100 thalers between them. Only a limited time will be available—4 minutes in the first round and less time in later rounds (the remaining time will be shown throughout). During this time, you can send proposals to your negotiation partner. For this purpose, there will be a slider that you can use to select how many of the 100 thalers you wish to allocate to yourself and how many to the other person, and a button that you have to click in order to submit your proposal. You can make as many proposals as you like. As soon as you submit a new proposal, only this latest proposal is valid. Additionally, the computer will display the most recent proposal submitted by your negotiation partner. You can accept your negotiation partner's current proposal at any point in time at the click of the respective button. Furthermore, you can exit the negotiation at any point in time, again at the click of a button.

There are three possible outcomes for Stage 3:

Outcome 1: One person accepts their negotiation partner's current proposal. The stage ends immediately and the 100 thalers are divided as indicated in the accepted proposal. In addition, both persons receive the 10 thalers from Stage 1.

Outcome 2: One of the two persons exits the negotiation. The stage ends immediately, and the negotiation concludes without any result.

Outcome 3: The time limit is reached without either person accepting a proposal. The stage ends and the negotiation concludes without any result.

[SP treatment only:]

In case that the negotiation concludes without any result (outcome 2 or outcome 3), each person receives their personal number from Stage 2 as payment. However, person A and person B forgo the 10 thalers from Stage 1.

[ED treatment only:]

In case that the negotiation concludes without any result (outcome 2 or outcome 3), the round continues with Stage 4. Otherwise (outcome 1) the round ends at this point.

Stage 4: "Personal number" or "100 thalers – X"

In Stage 4, only person A makes a decision. He/she can choose between two alternatives.

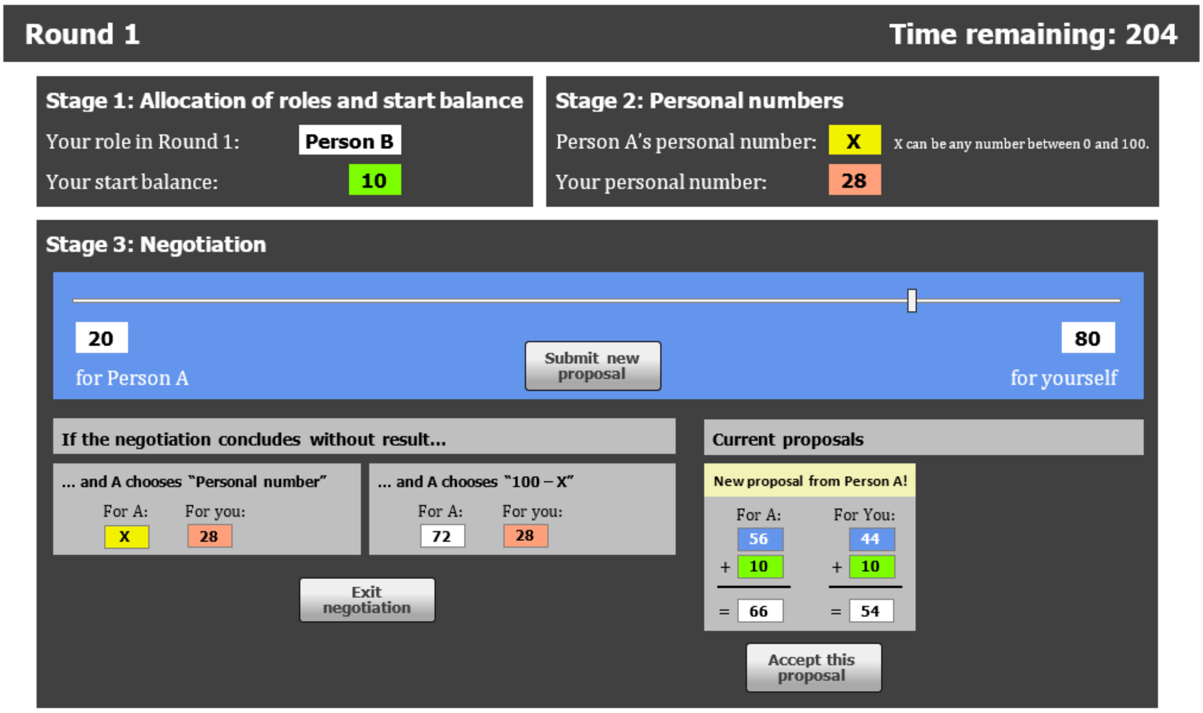
- If (s)he opts for "personal number", then each person receives his/her personal number from Stage 2 as payment in thalers.
- If (s)he opts for "100 thalers – X", then person A receives the 100 thalers from Stage 3 but has to pass on person B's personal number in thalers to person B. This transfer happens automatically.

Thus, in both cases person B receives his/her personal number in thalers. However, person A and person B forgo the 10 thalers from Stage 1 in either case.

[Both treatments:]

Your earnings for participating in the experiment are determined as follows. At the end of the experiment six rounds out of the 25 rounds are randomly selected—three when you were in the role of person A and three when you were in the role of person B. Your payment is the average payoff you received in these six selected rounds.

2. Screenshot of “Person B’s” (buyer's) interface (translated)



Summary of the Dissertation

My thesis examines the efficiency and welfare implications of property rules and liability rules as legal mechanisms for protecting entitlements in scenarios of bargaining under asymmetric information. These rules, which are key in many legal areas like torts, contracts, intellectual property or antitrust law, differ in that property rules require consent of the entitlement holder for transfer, while liability rules allow non-consensual transfers subject to compensation.

The choice between these two types of rules has been extensively debated in the law and economics literature. The conventional belief suggests that liability rules are superior when transaction costs are high, and property rules when costs are low. Others even argue that liability rules always enhance welfare by enabling efficient takings, regardless of transaction costs.

The novelty of my thesis lies in considering asymmetric information, a significant source of transaction costs that alters bargaining behavior and can lead to inefficient or no trade. My thesis analyzes whether this effect of asymmetric information on bargaining and efficiency differs between property and liability rules and identifies the factors influencing the optimal rule choice.

My thesis combines theoretical models and empirical analysis, covering both one-sided and two-sided asymmetric information. It comprises three main chapters, each based on a distinct paper.[37] Chapter 2 begins with a game-theoretic approach, modeling the interaction between an entitlement owner and a potential taker as a bargaining game with one-sided asymmetric information, the owner‘s valuation being private information. Chapter 3 extends this analysis to two-sided asymmetric information, the owner‘s and the taker’s valuation being private information.

In both scenarios, I apply two bargaining models where either the potential taker or the owner makes a take-it-or-leave-it offer. This allows for an examination of how the distribution of bargaining power influences the outcomes.

These theoretical models are then paired with a laboratory experiment involving two-sided asymmetric information. Unlike the formal theoretical analysis, which necessitates restrictive assumptions on the bargaining process, the experimental approach implements a more real-

[37] Chapter 2 is based on a paper *“Ask, don’t just take: Property rules are more efficient than liability rules under asymmetric information”* written in collaboration with Prof. Dr. Andreas Engert (unpublished working paper). Chapter 3 is based on my paper *“Bargaining in the shadow of the law: Property versus liability protection under two-sided asymmetric information”* (Unpublished working paper). Chapter 4 is based on a paper *“The inefficiency of efficient breach: An experiment on contract renegotiation under asymmetric information”* written in collaboration with Prof. Dr. Andreas Engert and Prof. Dr. Henrik Orzen (Unpublished working paper).

istic bargaining protocol permitting players to freely and simultaneously make and accept offers. This experiment, focusing on contract remedies, provides insights into how real-world players would renegotiate a contract under two-sided asymmetric information.

Such unstructured bargaining approaches may not be as popular, but they have the potential to inform future theories and test broader predictions that stem from theoretical analysis. Our approach follows this line of thought, aiming to test a more general prediction. We argue that, compared to expectation damages (liability rule), specific performance (property rule) increases the surplus from an agreement when the contract performance has become inefficient. This leads us to the hypothesis that specific performance improves the likelihood of reaching an agreement.

The experimental design focuses on individual incentives, removing the contractual context. This is not to deny the importance of normative preconceptions and preferences for promise keeping or contract breaching with compensation. However, it's beneficial to distinguish various factors influencing the optimal remedy choice.

An important assumption throughout my thesis is that the court compensates the owner based on his true valuation if his entitlement is taken. This "variable" liability rule leaves the owner indifferent between retaining the entitlement or being compensated. In contrast, "fixed" liability rules, where damages are set in advance or based on market value, do not make the owner indifferent. While fixed rules are argued to favor bargaining, real-world liability rules are typically variable. For example, in the US, liability for torts follows the make-whole principle, extends to consequential damages, and covers even unforeseeable harm rooted in the plaintiff's conditions (American Law Institute 2010, §§ 2, 4, 6, 7). My thesis models the law based on its actual content, not its "presumable" ideal form or judicial shortcomings.

The main findings of my thesis are as follows: First, liability rules allowing for unilateral takings against monetary compensation might give them an efficiency advantage over property rules when transaction costs impede consensual transfer of an entitlement. My thesis shows that transaction costs themselves depend on the mode of entitlement protection. The game theoretic model with one-sided asymmetric information, the owner's valuation being private information, and costly enforcement of compensation, reveals, that only a property rule achieves the first best when the owner of the entitlement has all the bargaining power. The property rule is more efficient than the liability rule when the informed party makes the take-it-or-leave-it offer, as it induces truthful revelation and trade in all efficient cases. In the opposite case with a take-it-or-leave-it offer from the potential taker as the uninformed party, a property rule is more efficient than a liability rule for most parameter values. In that regard it is important to note that my model of one-sided asymmetric information assumes that liability rule administration involves costs. Damage assessment replaces agreed transfers with court-designed transactions. These costs reflect the time, effort, and expense devoted to determining damages, including evidence collection and settlement bargaining to avoid higher litigation costs. Conflict costs burden the liability rule, but the competition between property and liability entitlement protection involves more than a simple tradeoff between these costs and allocative efficiency. Welfare losses result from both misallocation of the entitlement and conflict costs. While liability rules can overcome bargaining impasse, they hamper the exchange of information and raise the cost of voluntary transactions. The liability rule often loses on both counts.

Second, the game theoretic model with two-sided asymmetric information reveals that even with high transaction costs due to two-sided asymmetric information, the liability is not superior. This contradicts the conventional belief that liability rules are ideal in scenarios characterized by high transaction costs. Conventional theory recommends liability rules as they allow for unilateral takings of entitlements when parties fail to trade under a property rule. However, the analysis reveals that asymmetric information complicates the efficiency of the rules in a nuanced manner. It shows that liability rules entail negative side-effects, as it results in inefficient takings and less effective bargaining.

The model demonstrates that neither rule achieves the first best outcome, as both rules suffer from inefficiencies due to either non-trade or over-trade. The relative performance of the rules depends on the distribution of player types. The liability rule works better than the property rule when the expected benefit of transferring the entitlement is high and certain. Conversely, the property rule works better than the liability rule when the expected benefit of transferring the entitlement is low and uncertain. This is because the property rule allows parties to reveal their type through their offers, which helps to determine if the transfer is efficient.

Third, the bargaining experiment with two-sided asymmetric information confirms the theory that both property and liability rules have their benefits. In particular, the experiment supports the theoretical prediction, that property rules facilitate the bargaining process. The analysis reveals that giving the buyer a right to specific performance, which is the equivalent to a property rule, promotes efficient bargaining: The parties more often agree on non-performance, or continue to execute the contract, when it is optimal to do so. The seller's ability to breach the contract, which is the equivalent to take unilaterally, can correct bargaining failure. But in the experiment the benefits are small and outweighed by losses from inefficient breach and costly conflict. Conflict costs arise if the parties do not find an agreement as both property and liability rule involve equal administration costs in the experiment. The seller is emboldened to take a tougher bargaining position and thereby prevents agreements for which a subsequent breach is only a poor substitute.

At the general level, this finding supports the key advantage of property over liability rules: making an agreement strictly necessary for value creation can reduce the transaction cost of reaching it.

The findings of my thesis have wide-ranging implications. They offer valuable perspectives for lawmakers designing remedies in various legal fields, including patent law, contract law, and antitrust law. These insights are also useful for parties negotiating a contract and deciding on appropriate remedies. Beyond conventional legal environments, my results are relevant to other regulatory bodies, such as FIFA, deciding on the penalties to be imposed when a player breaches a contract to move to a different club. This underscores the thesis's broad relevance and applicability across diverse legal and contractual scenarios.

It is important to note that the analysis is subject to some limitations. The thesis is gradually moving towards more realistic assumptions, from one-sided asymmetric information to two-sided asymmetric information and from extreme bargaining situations in the models to a more open bargaining protocol in the experiment. However, lab negotiation is still far from real high-stakes contracting. Future research should include the normative preferences to the game. Furthermore, the experiment could be replicated with different distributions of types, to test whether the distribution influences the efficiency of the rules as predicted by the game theoretic model of two-sided asymmetric information. Another interesting research question stipulated by this thesis will be to analyze whether private information is related to the variation of remedies in real-world contracts.

Zusammenfassung der Dissertation

Meine Dissertation untersucht die Effizienz und die Wohlfahrtseffekte von Eigentumsregeln („Property rules“) und Haftungsregeln („Liability rules“) als Regelungsmechanismen zum Schutz von Rechten in Verhandlungssituationen unter asymmetrischer Information. Diese Regelungstypen, die in vielen Rechtsbereichen wie dem Deliktsrecht, Vertragsrecht, geistigem Eigentum oder Kartellrecht von zentraler Bedeutung sind, unterscheiden sich darin, dass Eigentumsregeln die Zustimmung des Rechteinhabers zur Übertragung des Rechts erfordern, während Haftungsregeln einseitige Übertragungen bei Zahlung von Schadensersatz zulassen.

Die Wahl zwischen diesen beiden Arten von Regeln wurde in der Literatur zu Recht und Ökonomik ausführlich diskutiert. Nach herrschender Ansicht sind Haftungsregeln überlegen, wenn die Transaktionskosten hoch sind, und Eigentumsregeln, wenn die Kosten niedrig sind. Andere argumentieren sogar, dass Haftungsregeln immer die Effizienz fördern, indem sie effiziente Übernahmen ermöglichen, unabhängig von den Transaktionskosten.

Die Neuheit meiner Arbeit liegt in der Berücksichtigung asymmetrischer Informationsbeziehungen, einer bedeutenden Quelle von Transaktionskosten, die das Verhandlungsverhalten verändern und zu ineffizienten Rechteübertragungen führen oder diese gänzlich verhindern. In meiner Arbeit untersuche ich, ob sich die Auswirkungen asymmetrischer Informationsbeziehungen auf das Verhandlungsverhalten und das Wohlfahrtsergebnis zwischen Eigentums- und Haftungsregeln unterscheiden und es werden die Faktoren ermittelt, die die Wahl der optimalen Regel zum Schutz von Rechten beeinflussen.

Meine Arbeit kombiniert theoretische Modelle und empirische Methoden, die sowohl einseitige als auch zweiseitige Informationsasymmetrien analysieren. Meine Arbeit besteht aus drei Hauptkapiteln, die jeweils auf einem eigenen Aufsatz beruhen. Kapitel 2 beginnt mit einem spieltheoretischen Ansatz, der die Interaktion zwischen einem Rechteinhaber und einem Interessenten als Verhandlungsspiel mit einseitig asymmetrischer Informationsbeziehung modelliert, wobei Wert für den Inhaber eine persönliche Information ist. In Kapitel 3 wird diese Analyse auf eine zweiseitig asymmetrische Informationsbeziehung erweitert, wobei der Wert für den Rechteinhaber und den Interessenten persönliche Informationen sind.

In beiden Szenarien wende ich zwei Verhandlungsmodelle an, bei denen entweder der Interessent oder der Rechteinhaber ein Angebot macht, das er annehmen oder ablehnen kann. Auf diese Weise lässt sich untersuchen, wie die Verteilung der Verhandlungsmacht die Ergebnisse beeinflusst.

Die theoretischen Modelle werden mit einem Laborexperiment in Kombination gebracht, bei dem es um zweiseitig asymmetrische Informationsbeziehungen geht. Im Gegensatz zur formalen theoretischen Analyse, die restriktive Annahmen über den Verhandlungsprozess erfordert, ermöglicht der experimentelle Ansatz ein realistischeres Verhandlungsprotokoll, das es den Spielern erlaubt, frei und gleichzeitig Angebote zu machen oder zu akzeptieren. Dieses Experiment, das sich auf vertragliche Rechtsmittel zum Schutz von vertraglichen Ansprüchen konzentriert, bietet Einblicke, wie Parteien in der realen Welt einen Vertrag bei zweiseitig asymmetrischer Informationsbeziehung nachverhandeln würden.

Solche unstrukturierten Verhandlungsansätze sind nicht populär, aber sie haben das Potenzial, künftige Theorien zu untermauern und allgemeinere Vorhersagen zu testen, die sich aus der theoretischen Analyse ergeben. Unser Ansatz folgt diesem Gedankengang und zielt darauf ab, eine allgemeinere Vorhersage zu testen. Wir argumentieren, dass im Vergleich zum Schadenersatzanspruch (entspricht einer Haftungsregel) der Naturalerfüllungsanspruch (entspricht einer Eigentumsregel) den Mehrwert einer Vereinbarung erhöht, wenn die Vertragserfüllung ineffizient geworden ist. Dies führt uns zu der Hypothese, dass der Anspruch auf Naturalerfüllung die Wahrscheinlichkeit einer Einigung erhöht.

Das Design des Experiments setzt den Fokus auf individuelle Anreize und lässt den vertraglichen Kontext außer Acht. Damit soll nicht zum Ausdruck gebracht werden, dass es keine normativen Meinungen und Präferenzen über die Einhaltung von Versprechen oder Vertragsbrüche gäbe. Es ist jedoch von Vorteil, zwischen verschiedenen Faktoren, die die Wahl der optimalen Regelung zum Schutz von Rechten beeinflussen, zu unterscheiden.

Eine wichtige Annahme, die sich durch meine gesamte Arbeit zieht, ist, dass das Gericht dem Rechtinhaber Schadensersatz in Höhe seiner persönlichen Bewertung des Rechts zuspricht, wenn ihm sein Recht entzogen wird. Bei dieser "variablen" Haftungsregel ist der Inhaber indifferent zwischen der Inhaberschaft des Rechts oder des Schadensersatzes. Im Gegensatz dazu wird der Rechteinhaber bei "fixierten" Haftungsregeln, das sind solche, bei denen der Schadenersatz beispielsweise im Voraus festgelegt wurde oder auf dem Marktwert basiert, nicht vollständig für den Entzug des Rechts entschädigt. Es wird behauptet, dass feste Regeln Verhandlungen begünstigen, aber in der Praxis sind Haftungsregeln in den meisten Fällen variabel gestaltet. In den USA beispielsweise folgt die Haftung für unerlaubte Handlungen dem Grundsatz der Wiedergutmachung, erstreckt sich auf Folgeschäden und deckt sogar unvorhersehbare Schäden ab, die in den Umständen des Klägers begründet sind (American Law Institute 2010, §§ 2, 4, 6, 7). Meine Arbeit modelliert das Recht auf der Grundlage seines tatsächlichen Inhalts, nicht auf der Grundlage einer "mutmaßlichen" idealen Form oder Grenzen der Judikatur.

Die Hauptergebnisse meiner Arbeit lassen sich folgendermaßen zusammenfassen: Erstens können Haftungsregeln zwar Effizienzvorteile gegenüber Eigentumsregeln bieten, wenn Transaktionskosten die einvernehmliche Übertragung eines Rechts verhindern. Allerdings zeigt meine Arbeit, dass die Transaktionskosten selbst von der Art der Regeln zum Schutz von Rechten abhängen. Das spieltheoretische Modell mit einseitig asymmetrischer Informationsbeziehung, bei dem die Bewertung des Eigentümers als private Information vorliegt und die Kosten für die Durchsetzung von Entschädigungen berücksichtigt werden, zeigt, dass nur die Eigentumsregel das bestmögliche Ergebnis erreicht, in dem Fall, dass der Inhaber über die gesamte Verhandlungsmacht verfügt. Die Eigentumsregel ist in diesem Fall effizienter als die Haftungsregel, da sie in allen Fällen zur wahrheitsgemäßen Offenlegung der Bewertung durch den Inhaber führt und soweit wohlfahrtsfördernd, zu einer Übertragung des Rechts führt. Im umgekehrten Fall, wenn der Interessent als uninformierte Partei ein Angebot macht, ist eine Eigentumsregel für die meisten Parameter effizienter als eine Haftungsregel. In diesem Zusammenhang ist es wichtig zu beachten, dass mein Modell der einseitigen asymmetrischen Informationsbeziehung davon ausgeht, dass die Durchsetzung von Haftungsregeln mit Kosten verbunden ist. Die Schadensbeurteilung ersetzt die vereinbarte Übertragung des Rechts durch gerichtlich festgelegte Transaktionen.

Diese Kosten spiegeln die Zeit, den Aufwand und die Kosten wider, die für die Ermittlung des Schadensersatzes aufgewendet werden, einschließlich der Sammlung von Beweisen und der Verhandlung von Vergleichen, um höhere Prozesskosten zu vermeiden. Konfliktkosten stellen einen Nachteil für die Haftungsregeln dar, aber der Vergleich zwischen dem Schutz von Eigentums- und Haftungsregeln beinhaltet mehr als einen einfachen Kompromiss zwischen diesen Konfliktkosten und der Allokationseffizienz. Wohlfahrtsverluste bei Haftungsansprüchen resultieren sowohl aus einer Fehlallokation des Rechts als auch aus Konfliktkosten. Haftungsregeln können zwar Verhandlungshindernisse überwinden, aber sie behindern den Informationsaustausch und erhöhen die Kosten für freiwillige Transaktionen. Die Haftungsregel unterliegt oft in beiderlei Hinsicht.

Zweitens zeigt das spieltheoretische Modell mit zweiseitig asymmetrischer Informationsbeziehung, dass selbst bei hohen Transaktionskosten aufgrund der zweiseitig asymmetrischen Informationsbeziehung die Haftungregel weder über- noch unterlegen ist. Dies widerspricht der herkömmlichen Annahme, dass Haftungsregeln in Szenarien mit hohen Transaktionskosten ideal seien. Die herkömmliche Theorie empfiehlt Haftungsregeln, da sie eine einseitige Übertragung von Rechten ermöglicht, wenn die Parteien sich bei einer Eigentumsregel nicht auf eine Übertragung des Rechts einigen könnten. Die Analyse zeigt jedoch, dass asymmetrische Informationsbeziehungen die Effizienz unter beiden Regelungen auf nuancierte Art und Weise erschweren. Sie zeigt, dass Haftungsregeln negative Nebeneffekte mit sich bringen, da sie zu ineffizienten Übertragungen und weniger effektiven Verhandlungen führen.

Das Modell zeigt, dass keine der beiden Regeln das bestmögliche Ergebnis erzielt, da beide Regeln unter Ineffizienzen leiden, die entweder auf verpasste Übertragungen des Rechts oder auf ineffiziente Übertragungen des Rechts zurückzuführen sind. Die relative Leistungsfähigkeit der Regeln hängt von der Verteilung der Spielertypen ab. Die Haftungsregel funktioniert besser als die Eigentumsregel, wenn der erwartete Nutzen der Übertragung des Rechts hoch und sicher ist. Umgekehrt liefert die Eigentumsregel bessere Ergebnisse als die Haftungsregel, wenn der erwartete Nutzen aus der Übertragung des Rechts gering und unsicher ist. Der Grund dafür ist, dass die Eigentumsregel es den Parteien ermöglicht, ihre Bewertung bzw. ihren Typ durch das Machen von Angeboten offenzulegen, was den Parteien hilft, festzustellen, ob die Übertragung effizient wäre.

Drittens bestätigt das Verhandlungsexperiment mit zweiseitig asymmetrischen Informationsbeziehungen meine zuvor aufgestellte Theorie, dass sowohl Eigentums- als auch Haftungsregeln ihre jeweiligen Vorteile haben. Insbesondere stützt das Experiment die theoretische Vorhersage, dass Eigentumsregeln Verhandlungen positiv beeinflussen. Die Analyse zeigt, dass das Recht auf Naturalerfüllung, das einer Eigentumsregel entspricht, effiziente Verhandlungen fördert: Die Parteien einigen sich häufiger auf Nichterfüllung oder führen den Vertrag weiter aus, je nachdem was optimal ist. Die Möglichkeit des Verkäufers, den Vertrag zu brechen, was einer einseitigen Übertragung bei einer Haftungsregel gleichkommt, kann das Scheitern von Verhandlungen teilwiese kompensieren. Im Experiment ist dieser Vorteil jedoch gering und wird durch die Verluste bei ineffizienten Vertragsbrüchen oder Konfliktkosten übertroffen. Konfliktkosten entstehen, wenn die Parteien keine Einigung erzielen, da im Experiment sowohl die Durchsetzung der Eigentums- als der Haftungsregel mit denselben Kosten verbunden sind. Der Verkäufer wird durch die Haftungsregel ermutigt, eine härtere Verhandlungsposition einzunehmen und dadurch Einigungen zu verhindern, für die ein nachgelagerter Vertragsbruch nur ein minderwertiger Ersatz ist.

Allgemein gedacht stützt diese Erkenntnis den Hauptvorteil von Eigentums- gegenüber Haftungsregeln in folgender Weise: Die Schaffung eines Wertes von einer Vereinbarung abhängig zu machen, kann die Transaktionskosten für das Zustandekommen der Vereinbarung senken.

Die Ergebnisse meiner Arbeit haben weitreichende Auswirkungen. Sie bieten wertvolle Perspektiven für den Gesetzgeber bei der Gestaltung von Ansprüchen zum Schutz von Rechen in verschiedenen Rechtsbereichen, darunter das Patentrecht, Vertragsrecht oder Kartellrecht. Diese Erkenntnisse sind auch für Parteien nützlich, die einen Vertrag verhandeln und über angemessene Ansprüche zum Schutz von Rechten entscheiden. Über das herkömmliche juristische Umfeld hinaus sind meine Ergebnisse auch für andere Regulierungseinheiten wie die FIFA von Bedeutung, die darüber entscheiden, welche Strafen verhängt werden, wenn ein Spieler seinen Vertrag bricht und zu einem anderen Verein wechselt. Insgesamt unterstreicht dies die breite Relevanz und Anwendbarkeit dieser Arbeit in verschiedenen rechtlichen Szenarien.

Es ist zu beachten, dass die Analyse einigen Einschränkungen unterliegt. Die Arbeit geht schrittweise zu realistischeren Annahmen über: einerseits von einseitig asymmetrischen Informationsbeziehungen zu zweiseitig asymmetrischen Informationsbeziehung und andererseits von extremen Verhandlungssituationen in den Modellen zu einem offeneren Verhandlungsprotokoll im Experiment. Allerdings sind Verhandlungen im Labor noch weit von realen Vertragsverhandlungen mit hohem Einsatz entfernt. Künftige Forschungsarbeiten sollten die normativen Präferenzen in das Experiment einbeziehen. Darüber hinaus könnte das Experiment mit unterschiedlichen Verteilungen von Typen wiederholt werden, um zu testen, ob die Verteilung die Effizienz der Regeln beeinflusst, wie es das spieltheoretische Modell der zweiseitigen asymmetrischen Informationsbeziehungen vorhersagt. Eine weitere interessante Forschungsfrage, die sich aus dieser Arbeit ergibt, besteht darin, zu analysieren, ob asymmetrische Informationsbeziehungen mit der Variation von Ansprüchen zum Schutz von Rechten in realen Verträgen zusammenhängen.