Essays in Law and Economics

Inaugural-Dissertation
zur Erlangung des Grades eines Doktors
der Wirtschafts- und Gesellschaftswissenschaften
durch die
Rechts- und Staatswissenschaftliche Fakultät
der Rheinischen Friedrich-Wilhelms-Universität
Bonn

vorgelegt von
Daniel Göller
aus Lohmar

Bonn 2011

Dekan:	Prof. Dr. Klaus Sandmann
Erstreferent:	Prof. Dr. Urs Schweizer
Zweitreferent:	Prof. Dr. Matthias Kräkel

Tag der mündlichen Prüfung: 02.12.2011

Acknowledgements

There are many people I am indebted to for their invaluable support. First and foremost, I owe thanks to my supervisor Urs Schweizer. Above all, it was his patience and experience that guided me on how to evolve mere research ideas into well written and polished research papers. Whenever I was stuck it was him who had the big picture in mind and brought me back on track. I also want to thank Matthias Kräkel for acting as a referee on my thesis committee and for providing me with many helpful comments.

I would like to thank Alexander Stremitzer, who contributed to Chapter I of this thesis. It was him, who introduced me to the art of writing a modern law and economics research paper. Not only that he helped me to expand my background of law, he also taught me how to convey, in a nutshell, the often complicated economic intuition to the reader. Moreover, I am grateful to have worked together with Michael Hewer on Chapter III. Having a great background not only in economics but also in law, he added to our work many insightful sources from the legal literature and really brought law and economics together.

Without the stimulating research environment provided by the Bonn Graduate School of Economics (BGSE), my work would not have been possible. I am not only grateful for financial support but in particular for the possibility to take part in many great research seminars and workshops. The feedback I received presenting my work in the BGSE Micro Workshop proved to be even more valuable than what I took home from international conferences. I am especially grateful to Urs Schweizer, who encouraged me to join the BGSE and who has, in his position as the BGSE's director, managed to establish our institution at the very top of all graduate schools in Germany. I also owe thanks to Susanne Goldlücke, Daniel Müller, Ansgar Wohlschlegel and many other colleagues in Bonn for proofreading and providing me with many helpful comments.

Finally, I am deeply indebted to my family and friends. Most notably to my parents, who have unwaveringly supported me in everything I do.

Contents

List of Figures

Introduction

The papers that constitute the main part of this thesis represent only a small proportion of the insights and knowledge I accumulated during my time in the Bonn Graduate School of Economics. It would, hence, be too short-sighted to use this space solely to discuss and to emphasize the importance of the results I worked out in the main part. Instead, let me present to you the big picture my work is part of. To do so, I look back to recapitulate on how my research ideas came to be and how they evolved into full-fledged economic research papers. Moreover, I want to point out a few misconceptions I stumbled upon while broadening my knowledge of the law and economics literature.

Two of the three papers that constitute this thesis are situated in a branch of the literature that is most often referred to as the "economic analysis of contract law". This literature, that perhaps began blooming with the seminal work by Shavell (1980), considers the performance of contracts against the background of so called legal "breach remedies". A breach remedy constitutes a standard legal rule that determines the consequences of a breach of contract. As an example, the default breach remedy of common law, "expectation damages", stipulates that the victim of breach receives a payment that makes her or him, if possible, as well of as performance would have. Given that such a breach remedy defines the legal background, economists try try to figure out how an optimal contract should be specified. At this point, for someone who is not accustomed to the literature it would be natural to enquire what really are the defining criterions of an optimal contract. The first, and perhaps most important, criterion that surely springs to an economist's mind is efficiency. In this respect, a contract is optimal if it maximizes the expected joint trade surplus of all parties involved. But should economic efficiency really be the only criterion to consider if one wants to assess the performance of a contract? This important question is tackled in Chapter I.

From the perspective of "contract theory", it may be hard to understand the importance of the economic analysis of contract law. Contract theory uses a mechanism design approach to work out under certain constraints an optimal contract. As an example for such a constraint, consider that some information may not be verifiable and thus not contractible. From this point of view, one may wonder what really is the scope of the economic analysis of contract law. The answer to this question is surprisingly straightforward. Breach remedies constitute default rules in contract law and should hence perform well. It can, however, be the case that contracts governed by a certain breach remedy fail to induce the first best even though the information required to operate the remedy is in theory sufficient to do so. This important issue is raised in Chapter I where a seller makes a so called “hybrid investment” that increases, in expectation, the buyer’s benefit from trade and decreases the seller’s cost of production. As we will see, “reliance damages”, a breach remedy that is often used in government contracting, performs poorly unless the benefit-increasing effect is sufficiently strong compared to the cost-decreasing effect of investment. Under the reliance damages remedy, the victim of breach is reimbursed her or his non-recoverable ex-ante reliance expenditures. Expectation damages, in contrast, perform surprisingly well not only in Chapter I but also in Chapter II where a buyer and a seller invest cooperatively to increase, in expectation, the benefit of their trading partner.

The third chapter of this dissertation is situated in the takings literature. We consider a situation where a landowner and the government may invest ex-ante, anticipating the government’s ex-post taking decision. Whereas the landowner invests to increase the expected private value of her property, the government does so to increase the expected social value of a public good that can be supplied only if the landowner’s property is taken ex-post. At this point, you, the reader, may question if and how Chapter III is connected to the economic analysis of contract law. At first glance, the two topics seem to be interweaved only very loosely. After all, for a government it is not feasible to ex-ante sign contracts with every potential victim of a taking. At this point, it is illuminating to take a glance at the so called “hold-up literature”. It is a well known result of this literature that parties tend to underinvest in absence of contractual protection (Williamson, 1979, 1985; Grout, 1984; Grossman and Hart, 1986; Hart and Moore, 1988). Thus, because contracting may often not be possible, law provides an alternative institution to protect ex-ante investment expenditures. Related to the function of a contract, governed by some breach remedy, a compensation regime stipulates a default outcome for the situation that property changes ownership from the landowner to the government. It thus comes as no surprise, that the optimal compensation regime derived in Chapter III.3 is related to Cooter’s (1985) notion of “efficient expectation damages”. Cooter (1985) suggests that expectation damages should not be calculated on the basis of true but socially efficient investment. In the same vein, Chapter III.3 demonstrates that the first best is achieved by a regime that grants as compensation the hypothetical value of the landowner’s property had he or she invested efficiently.

Breach Remedies Inducing Hybrid Investments

The research idea behind Chapter I roots back to a seminar I attended back in 2006, organized by Professors Christoph Engel, Urs Schweizer and Gerhard Wagner, way before I started my graduate studies. Attending this seminar, I must say, was one of the best decisions I ever made. To be frank, before taking part, I would never have imagined how much one can learn from and how interesting it is to apply the tools of an economist to a supposedly dry subject such as law. Thanks to this seminar, however, I came to appreciate law and economics and in particular the economic analysis of contract law. I had to work through an article by Che and Chung (1999) that considers a situation where a buyer and a seller contract for the future delivery of a good. Before delivery takes place, the seller makes a so called "cooperative investment", an investment that has no value to the outside market but increases the future value of the good to the buyer. The authors' focus lies on analyzing the efficiency of standard legal breach remedies such as expectation damages or reliance damages. Reading their work, I stumbled upon the following statement:

> *"In practise, most specific investments have elements of both selfish and cooperative investments. In this mixed environment, the performance of the contract damages will depend on the relative importance of each element, so the courts must evaluate the nature of underlying reliance investments in determining a remedy."*
>
> — *Yeon-Koo Che and Tai-Yeong Chung*

Their reasoning left me back puzzled. The underlying idea, I figured, is that expectation damages outperform reliance damages if investment is purely "selfish", i.e. increases in expectation the benefit of the investing party, as has been demonstrated by Shavell (1980) and Rogerson (1984). Moreover, Che and Chung (1999) claim to have demonstrated the superiority of reliance damages in a setting of purely cooperative investment. Thus, in a mixed environment the performance of a contract remedy must depend on the relative importance of each element, right? Few years later, now a graduate student in the Bonn Graduate School of Economics, I had to get started on my first research project. Pondering over research ideas, I remembered Che and Chung's (1999) article and more importantly their statement that left me back puzzled few years before in the seminar. Hence, as a first project, it appeared natural to me to find out if their conjecture was true. To do so, my aim was to explicitly model a situation where investment is of a hybrid nature, i.e. influences both the buyer's benefit from trade and the seller's cost of production. At a very early stage of the project, during which I was playing around with the model setup, I had a fruitful discussion with my colleague Alexander Stremitzer. I knew that Alexander was currently working on a paper in which he demonstrates that it is indeed possible to achieve the first best with a contract governed by expectation damages in Che and Chung's (1999) setting. What I did not know was that he had, about the same time as me, the idea to analyze the performance of expectation damages in a setting of hybrid investment. We were both amazed that we, independent of each other, had a very similar research idea in mind. It comes as no surprise that we decided to work together.

The main finding of our work is twofold. First, we show that it is possible to induce the first best using a so called "Cadillac contract", governed by expectation damages. Second, we demonstrate that reliance damages induce overinvestment if investment is sufficiently selfish. A Cadillac contract, as defined by Edlin (1996), specifies the highest possible quantity and/or quality combined with a sufficiently low price. In his article, Edlin (1996) analyzes the efficiency of expectation damages in a setting of selfish investment. If the seller is the investing party, he demonstrates that if the parties write a Cadillac contract a sufficiently low contract price ensures that it will always be the investing seller who breaches the contract. Consequently, the seller, as the breaching party, is in the position of a residual claimant of the trade relationship. In order to make the seller accept such a low price, the contract also specifies up-front lump sum payment from the buyer to the seller.

Our result differs in two respects. First, we are concerned with inducing hybrid investments as opposed to purely selfish investments. While efficient purely selfish investments, in our setting, could be achieved through a contract that specifies the highest possible quantity but is silent about quality, parties need to specify the highest possible quantity and the highest possible quality level in order to achieve first best hybrid investments. This is because the value increasing effect of investment can only be internalized through the seller's expected damage payments which arise when quality is non-conforming to the contract. The second major difference to Edlin (1996) is that we do not rely on up-front payments as, in equilibrium, the bilateral breach game considered in Chapter I leads to the same payoff profile for the investing party as if we assumed that only the seller may breach the contract. Parties can therefore use the contract price as an instrument to divide the expected gains from trade.

The intuition behind our result that reliance damages may induce the seller to over-invest can be explained as follows. Compared to Che and Chung (1999), the seller has additional incentives to invest in our setting. We explain that he or she internalizes the cost-decreasing effect of his or her investment regardless of whether the parties trade the good or not. In contrast, a benevolent social planner does not internalize this cost-decreasing effect of investment in those states of the world where trade is undesirable from a social perspective. It is thus clear that if the investment incentives generated by this cost-decreasing effect are sufficiently strong, the seller has an incentive to overinvest.

Chapter I closes the gap between Edlin (1996) and Stremitzer (2010). If just one party invests, a well-specified contract governed by expectation damages induces the first best regardless of whether investment is of a cooperative, hybrid or selfish nature. Since reliance damages perform poorly if investment is selfish (see e.g. Shavell, 1980; Rogerson, 1984) and, as we demonstrated, hybrid, courts have no reason to evaluate the nature of underlying reliance investments to determine a remedy, as proposed in Che and Chung (1999). The main role for alternative regimes such as reliance damages therefore is to offer alternative solutions for situations where informational constraints render them easier to assess than expectation damages.

Expectation Damages and Bilateral Cooperative Investments

Chapter II undoubtedly can be regarded as the cornerstone of this thesis. Before discussing how the research idea behind it came to be, let me call attention to a contribution that should not be overlooked. I created a generally applicable machinery that does not require differentiability and allows me to derive results, in my opinion, in a very elegant way. The reason I felt the urge to create a new model framework can be traced back to the paper that constitutes Chapter I of this thesis. Because our work is closely related to the article by Che and Chung (1999), Alexander and I decided to stay as close as possible to their model framework. This decision had, however, its drawbacks. Using an augmented version of their model setup, our proofs turned out to be more tedious to read than was acceptable. We figured that we had to balance generality against readability and implemented the following two design decisions. First, we decided that variable costs and the buyer's valuation are stochastically independent and second that the highest possible benefit of the buyer is equal to the highest possible realization of variable cost. The first decision can be justified by the fact that, in theory, it is easier to align the parties incentives in a setting of positive stochastic dependence. To be perfectly honest, the second decision that is in a sense a simplifying assumption, sounds weird. To our defense, our results remain qualitatively the same if this assumption is relaxed.

Nonetheless, when I sat at my desk pondering over a new research idea, that involved bilateral investment by both the buyer and the seller, I realized the following. Compared to Che and Chung (1999), the situation I was interested in is more difficult to analyze. If I decided to use a model setup related to theirs, I was likely to run into readability problems again. It thus figures that I had to start from scratch. Scouring the literature for inspiration, I yet again came across a marvelous article I red before, Schweizer (2006). In his work, Professor Schweizer, like Che and Chung (1999), considers a setting of unilateral cooperative investment. In contrast, however, Schweizer's (2006) analysis is a lot easier to read and does not require any function to be differentiable. My setting is different to the one of Schweizer (2006) in two respects: Ex-ante, both parties may invest and ex-post both parties may breach the contract. Using his work as inspiration, I thus created a new model framework.

The economic research idea behind Chapter II also roots back to the time I was working on the joint project with Alexander. Reading the literature, I realized that there exists an important gap in the economic analysis of contract law. Several papers analyze the performance of expectation damages in a setting of unilateral and cooperative investment (see e.g. Che and Chung, 1999; Schweizer, 2006; Stremitzer, 2010). The papers that consider bilateral investment, restrict themselves, however, on purely selfish investment (see e.g. Edlin and Reichelstein, 1996; Ohlendorf, 2009). The gap may exist due to a well known result by Che and Hausch (1999), who also consider bilateral investment but are situated in the contract theory literature. They demonstrate under the strict assumption that courts are not able to verify any direct or indirect signal about investment and the state of the world that contracting becomes irrelevant if investment is sufficiently cooperative. From their work, I could thus deduce that the situation I was interested in was, in theory, the most difficult to solve. The articles that anaylze contract law work, however, under less strict assumptions than Che and Hausch (1999). My aim thus was to demonstrate that a contract governed by expectation damages can solve the parties' contracting problem if investment is bilateral and of a purely cooperative nature. Moreover, to enforce the contract, a court should not need more information than is required in Edlin and Reichelstein (1996) or Ohlendorf (2009).

From working together with Alexander and also from reading Edlin (1996), I knew that an optimal Cadillac contract induces efficient investment incentives if only one party invests. But more importantly, they are also very robust. As an example, consider Chapter I where our first-best result holds for a wide range of prices. If the seller is the investing party, an optimal Cadillac contract stipulates a very high quality such that the buyer receives damages due to non-conformity of the good. Hence, as discussed in the previous section, the seller becomes a residual claimant of the trade relationship. If the buyer is protected in the sense that he or she is compensated by the seller if quality falls below a certain level, wouldn't it make sense to consider that the seller is protected in a similar way, I asked myself. More importantly, would this distort the seller's investment incentives? I quickly rushed to my desk to analyze what happens if the parties not only specify a quality- but also a cost-threshold such that any cost above the latter threshold are borne by the buyer. What I found can be seen as a testimony to the robustness of Cadillac contracts. If the specified price is sufficiently low, adding a cost-threshold does not distort the seller's investment incentives. In Chapter II, I explain that this enables the parties to use the cost-threshold as an instrument to balance the buyer's incentives. An optimal contract in my setting, which I refer to as an augmented Cadillac contract, thus combines aspects from Cadillac contracts as in Edlin (1996) and balancing contracts (see e.g. Chung, 1991; Edlin and Reichelstein, 1996; Ohlendorf, 2009). Alternatively, the parties can specify a sufficiently low cost-threshold such that the buyer becomes a residual claimant and use the quality-threshold to balance the seller's incentives.

To understand the importance of my result, it has to be put in context with the preexisting literature. At this point, it is instructive to consider the following statement by Edlin (1996) about the performance of expectation damages:

"This article shows that up-front payments can eliminate the overinvestment effect identified by Shavell (1980), by controlling which party breaches a contract. At the same time, "Cadillac" contracts (contracts for a very high quality or quantity) can protect against underinvestment due to Williamsonian holdups. This combination provides efficient investment incentives when courts use expectation damages as a remedy for breach. The expectation damages remedy is therefore well-suited to multidimensional but one-sided investment problems, in contrast to specific performance, which is well-suited to two-sided but umdimensional investment problems."

— *Aaron S. Edlin*

The basic idea behind Edlin's statement is that Edlin and Reichelstein (1996) have supposedly demonstrated that expectation damages perform poorly if both the buyer and the seller make a selfish investment. However, as Ohlendorf (2009) has pointed out, this can be attributed to Edlin and Reichelstein's (1996) assumption of a deterministic and linear cost function: If it is sufficiently concave, expectation damages can indeed induce the first best in Edlin and Reichelstein's (1996) setting. If only one party invests, Che and Chung (1999) claim that expectation damages do not induce any investment incentives at all. However, Schweizer (2006) and Stremitzer (2010) demonstrate, in a slightly richer contractual framework than the one considered in Che and Chung (1999), that the first best can yet again be achieved under the expectation damage remedy. There are two important lessons to be learned. First, in order to judge the performance of a remedy, economists should consider a variety of contracts and not restrict themselves to one specific setup. Second, that in all settings examined so far it is possible to induce the first best with a reasonable simple contract governed by expectation damages.

Economic Analysis of Taking Rules: the Bilateral Case

The origin of the research idea that constitutes Chapter III can be found in one of the many discussions I had with my colleague Michael Hewer. Being an economist, I am always eager to discuss legal cases as this is perhaps the best way to develop an understanding of how legal scholars think. Michael, who besides economics also studied law seemed to be the predestined person to talk to. On the one hand, he has a good knowledge of the law. On the other, as an economist, he understands my arguments that sometimes are in stark contrast to what the law stipulates. One day, we discussed a situation where a government used its power of eminent domain on behalf of an airport, that planned to construct a new runway. Michael reasoned that this is a predestined example of why it is important that a government has the power of eminent domain. In absence of this power the landowner would have, he argued, an incentive to delay her or his sale to extract some of the airport's profits. Moreover, he continued, law stipulates that private property should only be taken for public use and not without just compensation.[1] "What does just compensation really mean?", I inquired. Scouring the legal literature, we found that just compensation is most commonly interpreted as fair market value. In other words, the victim of a taking should receive as compensation the hypothetical value of her or his property in absence of the risk of a taking. This interpretation left us back puzzled. If the landowner is fully compensated, he or she is fully insured and thus has an incentive to ex-ante overinvest in her or his property. It was at this point that we rushed to our desks to develop a model to analyze how different commonly proposed compensation regimes affect the landowner's incentives. What we should have done before, however, is to carefully scout the economic literature. Blume et al. (1984) have, about twenty-six years before us, analyzed a model similar to ours and therefore derived very similar results. Time to start from scratch.

Scouring the literature also had its positives. We came across an interesting article, Hermalin (1995), that considers a situation where the government or state may have non-benevolent motives but where, as in Blume et al. (1984), only the landowner invests. Trying to defend why a government or state may not solely follow benevolent motives, Hermalin (1995) argues:

> *"In legal writing one motive for compensating a citizen for taken property is to restrain the state from the tyrannical use of its rights of regulation or eminent domain. That is, the state is assumed not to act benevolently but to act on behalf of the interest of the majority (i.e., the rest of society) while essentially ignoring the interest of the individual property owner."*
>
> — *Benjamin E. Hermalin*

[1] See e.g. the takings clause of the Fifth Amendment to the United States Constitution.

This statement is what really got us started. If an important motive for compensation is to affect not only the incentives of a potential victim of a taking but also those of the government, it makes sense to consider a situation where also the government invests ex-ante. Several examples popped up in our mind. A government that evaluates if a certain parcel of land is suitable to use as a disposal site for nuclear waste surely must inquire about the area's geological conditions and infrastructure. Moreover, the airport mentioned before also has ex-ante expenditures. It needs to develop a construction plan and analyze the expected profit associated with constructing the new runway. We thus rushed back to our desks to develop a model to represent the situations we had in mind. We decided to follow Hermalin's (1995) notion of a non-benevolent government. In our work, the government suffers from "fiscal" illusion in the sense that its perceived cost of a taking is equal to the amount of compensation it has to pay. Consequently, it has an incentive to initiate a taking whenever the social benefit of the taking exceeds compensation. What we essentially had to analyze is, as in Chapter II, a situation of bilateral investment. It goes without saying that it was not a hard decision to adopt the machinery I developed there.

In our work, we demonstrate that all standard compensation regimes perform poorly. If the victim of a taking is fully compensated, he or she is fully insured and therefore has an incentive to ex-ante overinvest in his or her property. Our finding is thus in line with the literature, confirming the result of Blume et al. (1984). Advocates of the full compensation regime may like to read that, at least, the government has efficient incentives. Because it essentially compares the social benefit to the amount of compensation it has to pay, it takes the property whenever the social benefit exceeds the value of the landowner's property. Because the government's taking decision is efficient, it internalizes the benefit of its investment in exactly the same states of the world a benevolent social planner would do so and therefore has efficient incentives to invest. In contrast, if the landowner is not compensated at all as proposed in Blume et al. (1984), the government always takes her or his property. It is not surprising that the landowner has no incentive to invest ex-ante. Hermalin (1995) suggests a regime where the landowner receives as compensation the entire social benefit of the taking. This makes, he argues, the landowner a residual claimant of the trade relationship who consequently has efficient investment incentives. The main problem of this regime is, however, that the government's ex-post payoff is essentially zero. Ex-ante, it therefore has no incentive to invest. All commonly proposed standard compensation regimes perform, in one way or another, rather poorly in our setting. We are, however, able to demonstrate that there does exist a compensation regime that induces the first best. Under this regime, the landowner receives as compensation the hypothetical value of her or his property had he or she invested efficiently. What is crucial here is that neither the government's taking decision nor its ex-post payoff depend on the landowner's investment. If the government invests efficiently, it internalizes the benefit of its investment in exactly the same states of the world a benevolent social planner would do so. Thus, the government has no incentive to deviate from the socially optimal investment level. Given that the government invests efficiently, we demonstrate that the landowner is a residual claimant of the bilateral relationship and also has efficient incentives to invest.

As a benchmark, we consider the situation that the government is benevolent, i.e. maximizes expected social welfare. Assuming that the government cannot ex-ante commit itself on an ex-post inefficient taking decision, it is sufficient to analyze the landowner's incentives. Ex-post, the government initiates a taking whenever it is socially desirable to do so and ex-ante it chooses the socially best response to the landowner's investment. We demonstrate, under two plausible assumptions, that any compensation regime other than the social benefit compensation regime, proposed by Hermalin (1995), induces the landowner to overinvest in her or his property. Our first assumption is that the government is wealth constrained in the sense that it cannot raise capital above the social benefit of the taking. The second assumption is that we only consider compensation regimes in which compensation is non-decreasing in the landowner's investment. Intuitively, the landowner has an incentive to overinvest for two reasons. First, in contrast to the objective of a benevolent social planner, the landowner's investment may increase the expected amount of compensation whereas it does not affect the value of the public good. Second, in case of a taking, the landowner only receives compensation instead of the social benefit of the taking. She thus has an incentive to overinvest to reduce the probability that a taking takes place. Under the social benefit compensation regime both sources of inefficiency do not exist.

The significance of our work can only be understood if we consider how our main results are connected to each other. Perhaps naively, one may think that society must be better of under a benevolent government. After all, in equilibrium, the government chooses the socially best response to what the landowner does. Our work highlights, however, that this must not be the case. If the government, perhaps due to public pressure, can only pay compensation less than the social benefit of the taking, there does not exist any compensation regime to induce the first best under a benevolent government. If it is non-benevolent, we explained that optimal compensation is equivalent to the hypothetical value of the landowner's property had she invested efficiently. This amount of compensation is, given that a taking occurs, generally less than the social benefit of the taking. Consequently, if the government is sufficiently wealth constrained, the first best may only be attained if the government is non-benevolent. To understand the intuition behind this puzzling conclusion, it is eye-opening to draw a connection between our work and Blume et al. (1984). They demonstrate that if the government can commit to initiate a taking whenever the social benefit of the taking is higher than the hypothetical value of the landowner's property had he or she invested efficiently, any lump sum compensation plan induces the landowner to invest according to the first best. If the government is non-benevolent, as in our model, it must, however, not be able to commit. At the point where it decides whether to take the property or not, it compares the social benefit of the taking to the amount of compensation it has to pay. Consequently, if compensation is equivalent to the hypothetical value of the landowner's property had he or she invested efficiently, the non-benevolent government chooses out of its own interest the very same taking decision the benevolent government would like to commit to.

I. Breach Remedies Inducing Hybrid Investments

We show that parties in bilateral trade can rely on the default common law breach remedy of 'expectation damages' to induce simultaneously first-best relationship-specific investments of both the selfish and the cooperative kind. This can be achieved by writing a contract that specifies a sufficiently high quality level. In contrast, the result by Che and Chung (1999) that 'reliance damages' induce the first best in a setting of purely cooperative investments, does not generalize to the hybrid case. We also show that if the quality specified in the contract is too low, 'expectation damages' do not necessarily induce the ex-post efficient trade decision in the presence of cooperative investments.

1. Introduction

A risk neutral buyer and seller contract for the future delivery of a good. Before delivery can take place, the seller makes an investment which has no value to the outside market but which decreases the seller's cost of production *and* increases the future value of the good to the buyer. That is, the investment is *hybrid*, combining cooperative investments in the sense of Che and Chung (1999) with selfish investments as traditionally analyzed in the literature (see e.g. Chung, 1991; Aghion, Dewatripont and Rey, 1994; Edlin and Reichelstein 1996; Shavell, 1980, 1984; Rogerson, 1984).[1]

This type of investments are highly relevant. Consider the famous General Motors - Fisher Body case, which deals with Fisher Body's decision to build a plant adjacent to General Motors. Such an arrangement offered benefits to both parties by lowering shipping costs *and* improving supply reliability (see Che and Hausch, 1999). Or consider the example of Marks & Spencer, which routinely organizes joint trips to trade shows with its suppliers. The trips enhance mutual understanding and help both parties to identify new products that they could develop cooperatively. By facilitating bilateral communication, Marks & Spencer adds valuable items to its product line while lowering the risk of costly reengineering of products for the suppliers (see Kumar, 1996).

In the absence of contractual protection, the parties negotiate the terms of trade after investments are sunk and after the quality of the product is revealed. Unless the investing party has all the bargaining power, that party can only internalize a fraction of the investment benefit in such negotiations. Recognizing this potential for hold-up, the seller invests less than is socially desirable (Williamson, 1979, 1985; Grout, 1984; Grossman and Hart, 1986; Hart and Moore, 1988).

We develop a model where parties write a contract specifying a *price* for future trade and the *quality* of the good to be traded. If breach occurs, where either the seller fails to deliver or the buyer fails to accept the good, or the seller delivers a good of inadequate quality, the breached-against party can ask for *expectation damages* at trial. Under this commonly-applied legal remedy, the victim of breach receives a payment that makes him as well off as performance would have. We show that, under this legal

[1] In their seminal paper, Che and Hausch (1999) also allow for hybrid investments and prove for a special informational setting that, if investments are sufficiently cooperative, contracting becomes irrelevant. In contrast, Che and Chung (1999), who deal with legal breach remedies, consider a different informational set-up and only allow for *purely* cooperative investments. Cooperative investments were first studied in an incomplete contract setting by MacLeod and Malcomson (1993) and are also referred to as "cross investments" (e.g. Guriev, 2003) or "investments with externalities" (e.g. Nöldeke and Schmidt, 1995). Other articles that consider cooperative investments include e.g. Bernheim and Whinston (1998), Maskin and Moore (1999), De Fraja (1999), Rosenkranz and Schmitz (1999) , Segal and Whinston (2002), and Roider (2004).

regime, the contract induces first-best investment incentives and the efficient ex-post breach decision when the parties set the quality required under the contract sufficiently high.[2] This result holds independent of whether parties can renegotiate. However, if the quality specification is set at an intermediate level, investment incentives are inefficient and the standard result (see e.g. Posner, 1977; Shavell, 1980; Kornhauser, 1986; Craswell, 1988) that expectation damages induce the ex-post efficient breach decision can be shown to no longer hold. The result generalizes Edlin (1996) and Stremitzer (2010) who had analyzed the expectation damages regime in a setting of purely selfish and purely cooperative investments, respectively.[3]

What makes this result interesting is that another well known efficiency result for this setting, due to Che and Chung (1999), cannot be generalized to the hybrid case. Che and Chung (1999) assume that parties can write a contract in which they stipulate the *price* of the good to be traded and an *up-front payment*. If breach occurs, under which the buyer refuses to accept the good, the seller can ask for *reliance damages*, i.e., he is reimbursed his non-recoverable investment expenses. Che and Chung (1999) show that there exists a price for which the contract induces the first best if renegotiation is possible. Yet, the logic of the argument cannot be extended to the hybrid setting. Indeed, it is always possible to construct examples where reliance damages induce overinvestment regardless of price. Although the precise argument is more complicated, this negative result is driven by the well known insight that reliance damages induce overinvestment

[2] Edlin (1996) also analyses 'Cadillac contracts' in the context of expectation damages but makes a different point: He considers a setting where the seller makes *selfish* investments. In the absence of a contract, there will be underinvestment due to the hold-up problem. If, however, the contract stipulates the highest possible quality/quantity, and it is the buyer who breaches the contract, the seller will overinvest. This is because he is fully insured and fails to take into account the states of the world where it is inefficient to trade (This is a version of the 'overreliance' result by Shavell (1984) who implictly assumes Cadillac contracts by modelling the trade decision as binary). To solve this problem, Edlin (1996) proposes to set the price so low, that it will always be the investing seller who breaches the contract. That makes him the residual claimant and provides him with efficient investment incentives. Yet, in order to make the seller accept a contract with such a low price, the buyer has to pay the seller a lump sum up front. By contrast, in our model, we are concerned with *hybrid* investments and need not rely on any up-front payments.

[3] Che and Chung (1999) had argued that 'expectation damages' perform very badly in such a setting inducing *zero* cooperative investments. Yet, as Stremitzer (2010) has shown this follows from their implicit assumption that the contract stays silent in terms of *required quality* which will rarely be the case. Indeed, even if the parties do not stipulate anything explicit as to quality in their contract (express warranty), the court will do it for them by default, e.g. by requiring the good to serve its ordinary purpose (implied warranty of merchantability, see Section 2-314 and 2-315 of the Uniform Commercial Code (UCC)). Taking this feature of real world contracting into account, Stremitzer (2010) shows that 'expectation damages' will always induce *positive* levels of cooperative investments and achieve the first best if parties choose a sufficiently high quality specification.

if investments are purely selfish (Shavell, 1980; Rogerson, 1984). For this reason, it is not surprising that overinvestment occurs when investment is sufficiently selfish.[4]

This chapter is organized as follows: Section 2 describes our model and Section 3 derives the socially optimal level of investment. We then show in Section 4, that the argument by Che and Chung (1999) on the efficiency of reliance damages cannot be extended to the hybrid case. Section 5 contains our main result that first-best investment levels can be achieved under expectation damages if the quality required under the contract is set sufficiently high. If not, investment incentives will be inefficient and expectation damages may even fail to induce the efficient ex-post trade decision. Section 6 concludes.

2. The model

Consider a buyer-seller relationship where risk-neutral parties potentially trade a good. At date 0, the parties sign a contract (see Figure I.1). The contract specifies a fixed price, p, which has to be paid by the buyer if the seller performs in accordance with the contract and, in the case of expectation damages, a quality threshold, $\bar{v}$. Moreover, the parties can specify a lump sum transfer, t, to split the expected gains from trade. At date 1, the seller makes a relation-specific investment, $e \in \mathbb{R}_0^+$, which stochastically determines the buyer's benefit from trade as well as the seller's cost of production. At date 2, both the buyer's potential benefit from trade, v, and the seller's potential cost of performance, c, are drawn from the intervals $[0, v_h]$ and $[c_l, c_h]$ by the conditional distribution functions $F(\cdot|e)$ and $G(\cdot|e)$ respectively.At date 3, the parties play a breach game in which it is decided whether trade occurs or not. When renegotiations are possible, they are costless and can occur anytime between date 3 and date 4 when parties have to make the final trade decision. The potential renegotiation surplus is split at an exogenously given ratio with the seller receiving a share of $\alpha \in [0, 1]$. As an example, consider the case where an engineering firm develops a new motor for a car manufacturer. In the first stage, the engineering firm invests in know-how and develops a construction plan. The know-how may reduce the costs of production and/or increase the quality of the motor. Once the construction plan is ready, the parties know the costs and benefits associated with the motor. Only then do they decide whether the motor shall be produced.

The informational requirements depend on the breach remedy the court applies. Under reliance damages, the court must be able to verify the seller's investment whereas,

[4] That is, if the effect of seller's investment on the cost of production is sufficiently large relative to the effect on the good's quality.

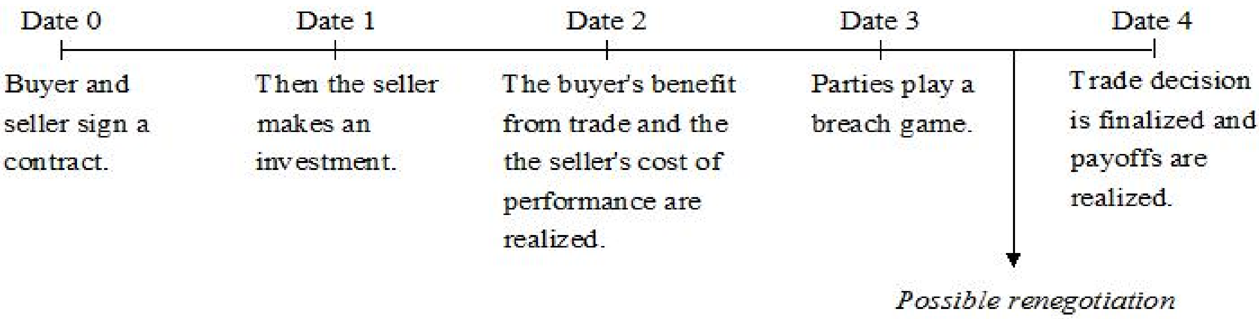

Figure I.1.: Timeline of the model.

under expectation damages, it must be able to verify the buyer's valuation and the seller's variable costs. Note that this information is also sufficient to decide whether the quality of the product is below or above a certain quality threshold. While investment may be private information, everything else is observable and verifiable to all parties. Finally, the following technical assumptions apply throughout:

- **Assumption I.1** $F(\cdot|\cdot)$ and $G(\cdot|\cdot)$ are twice continuously differentiable.
- **Assumption I.2** $F_e(\cdot|e) < 0$ and $F_{ee}(\cdot|e) > 0$ for all $v \in (0, v_h)$ and $e \geq 0$.
- **Assumption I.3** $G_e(\cdot|e) > 0$ and $G_{ee}(\cdot|e) < 0$ for all $c \in (c_l, c_h)$ and $e \geq 0$.
- **Assumption I.4** $F_e(v|0) = -\infty$ and/or $G_e(c|0) = \infty$

  for all $v \in (0, v_h)$ and for all $c \in (c_l, c_h)$.
- **Assumption I.5** $F_e(v|\infty) = 0$ for all $v \in (0, v_h)$ and $G_e(c|\infty) = 0$ for all $c \in (c_l, c_h)$
- **Assumption I.6** $F_{v|c}((v|c)|e) = F_v(v|e)$ and $G_{c|v}((c|v)|e) = G_c(c|e)$ for $(c, v) \in \mathbb{R}^2$.

Assumption I.2 implies that an increase in e moves the distribution to the right at a decreasing rate in the sense that $F(\cdot|e')$ first-order stochastically dominates $F(\cdot|e)$ for any $e' > e$. In the same way Assumption I.3 implies that an increase in e moves the distribution to the left at a decreasing rate in the sense that $G(\cdot|e')$ first-order stochastically dominates $G(\cdot|e)$ for any $e' < e$. Assumptions I.4 and I.5 ensure an interior solution to the social welfare problem while Assumption I.6 implies that variable costs, c, and the buyer's valuation, v, are stochastically independent. To save notation we assume that the highest possible benefit of the buyer is equal to the highest possible realization of variable cost, $v_h = c_h$.[5]

[5]This assumption is not crucial for our main results. If $v_h \geq c_h$, a contract which specifies a

3. Benchmark

We consider the socially optimal allocation as a benchmark. A social planner cares for two things: First, he wants parties to trade whenever trade is efficient ex-post, $v \geq c$. Second, given the ex-post optimal trade decision, he wants the seller to choose the investment level e^* which maximizes the expected gains of trade:

$$e^* \in arg\ max\ W(e) = \int_{c_l}^{c_h} \int_{c}^{v_h} (v - c) F_v(v|e)\ dv\ G_c(c|e)\ dc - e. \tag{I.1}$$

Twice integrating by parts and differentiating, the efficient investment level, e^*, can be characterized by the following first-order condition:

$$W'(e^*) = \int_{c_l}^{c_h} ([1 - F(c|e^*)]\ G_e(c|e^*) - F_e(c|e^*)\ G(c|e^*))\ dc - 1 = 0. \tag{I.2}$$

We assume that W(e) is strictly quasi-concave in e. This ensures that e^* is unique and well defined.

4. Reliance damages with renegotiations

Che and Chung (1999) show that, in a setting of purely cooperative investments, there exists a price such that reliance damages induce the first best if renegotiation is possible. On the other hand, Shavell (1980) and Rogerson (1984) show that reliance damages perform poorly in an environment of selfish investments, inducing overreliance. These two results lead us to the question of how reliance damages perform in a hybrid setting, which contains aspects of both cooperative and selfish investments. We find that it is not possible to extend the result by Che and Chung (1999) to the hybrid case. Indeed, reliance damages may fail to induce the first best regardless of price.[6]

To show this, we analyze the game induced by a simple contract specifying price, p, and some lump sum transfer, t, if that contract is governed by reliance damages (see Figure I.2).[7] Under reliance damages, the seller is reimbursed his reliance expenses e if the buyer announces breach ($\bar{A}$). If the buyer is willing to accept the good and

quality specification above the highest possible realization of quality induces the first best under expectation damages. Reliance damages may lead to overinvestment regardless of price if the cost decreasing effect of investment is sufficiently strong compared to the value increasing effect of investment.

[6]Since Che and Chung (1999) have already shown that 'reliance damages' fail to induce the first best in a setting of purely cooperative investments if renegotiation is not possible, we focus on the case where renegotiation is possible.

[7]In Figure I.2, after the buyer decided whether to accept or not, the terms in the first line represent the seller's ex-post payoff whereas the buyer's ex-post payoff is given in the second line.

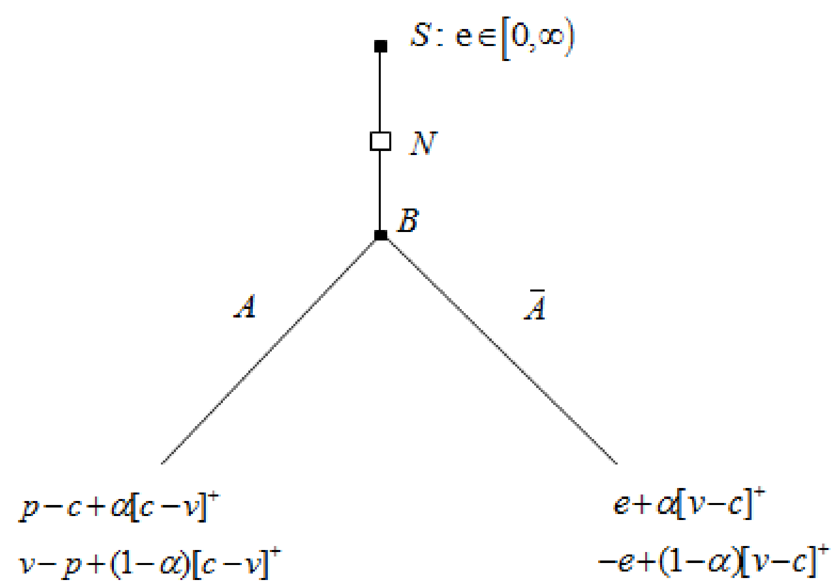

Figure I.2.: Subgame induced by RD if renegotiations are possible.

trade occurs, the seller and the buyer receive $p-c$ and $v-p$, respectively.[8] Moreover, whenever the buyer's decision is ex post inefficient, the parties renegotiate towards the ex post efficient trade decision and split the potential renegotiation surplus with the seller receiving a fixed share of $\alpha \in [0,1]$.[9] For example, if $v > c$, but the buyer announces breach, the seller derives $\alpha[v-c]^+$ from renegotiations, where we shall frequently use the notation $[\cdot]^+ = max[\cdot, 0]$. Hence, the buyer will announce breach if and only if

$$-e + (1-\alpha)[v-c]^+ > v - p + (1-\alpha)[c-v]^+ \qquad \text{(I.3)}$$

or equivalently if

$$v < \hat{v} \equiv min\ [\frac{p-e-c}{\alpha} + c,\ v_h]. \qquad \text{(I.4)}$$

So far the analysis is identical to Che and Chung (1999) except that cost of production is deterministic in their setting while it is stochastic in ours. Let us now revisit the intuition behind Che and Chung's result that there always exists a price which induces first-best investment in a setting of purely cooperative investments. First, note that the seller's expected payoff decreases in e, conditional on the buyer accepting the good. Since the buyer will never breach if price is set sufficiently low the parties can implement zero investment by specifying $p = 0$. A very high price, on the other hand, ensures

[8] In order to stay close to the setting studied by Che and Chung (1999), we take over their assumption that the buyer can legally compel the seller to deliver.

[9] Note that the bargaining set-up considered in Che and Chung (1999) differs from Rogerson (1984) who implicitly assumes that parties can only renegotiate prior to the buyer's breach decision. Also Lyon and Rasmusen (2004) and Watson (2007) consider alternative bargaining models.

that the buyer always announces breach. Given the reliance damages remedy, the seller is sure to regain his investment and, in addition, to receive a renegotiation surplus of $\alpha[v-c]^+$, which is increasing in e. Anticipating this, the seller invests as much as he can, overinvesting relative to the efficient level.[10] Hence, given that investment depends continuously on price, there must exist an intermediate price that induces first-best investment.

However, this simple intuition fails in a setting of hybrid investments. To see this, first consider the case where the parties specify a very high price. Again, the seller overinvests because his payoff $\alpha[v-c]^+ + e - e$ is strictly increasing in e. Yet, even for $p = 0$, the seller may have an incentive to overinvest. If investment is hybrid, his cost of production is decreasing in e. We can prove the following proposition:

Proposition I.1: *If parties can only stipulate a price, p, and a lump sum payment, t, and their contract is governed by reliance damages, a price inducing first-best hybrid investments does not always exist. Moreover, compared to $p = 0$ a positive price induces weakly stronger incentives to invest.*

Proof. To prove Proposition I.1, it is sufficient to construct an example where the seller overinvests regardless of price. Here, we consider the simple case where the seller's bargaining power is very small, $\alpha \longrightarrow 0$.[11] The proof comes in three steps. (i) We derive the investment level that maximizes the seller's expected payoff. (ii) Let $e^{\overline{RD}}$ be the investment level that maximizes the seller's expected payoff for $p = 0$. We can then derive a condition for which $e^{\overline{RD}}$ is higher than the social optimal level, e^*. (iii) We show that the seller never invests less than $e^{\overline{RD}}$ if the contract specifies a positive price. If the condition that is given in the second part of the proof holds, it then directly follows that the seller overinvests regardless of price.

(i) Anticipating the buyer's decision at date 3, the seller, at date 1, expects to receive the following payoff:

$$\begin{aligned} U^{RD}(e) = & \int_{c_l}^{c_h} \int_0^{\hat{v}} (e + \alpha[v-c]^+) F_v(v|e)\ dv\ G_c(c|e)\ dc \\ & + \int_{c_l}^{c_h} \int_{\hat{v}}^{v_h} (p - c + \alpha[c-v]^+) F_v(v|e)\ dv\ G_c(c|e)\ dc - e. \end{aligned} \tag{I.5}$$

We assume that $U^{RD}(e)$ is strictly quasi-concave in e for all p to ensure that there exists a unique equilibrium investment level. Let $\tilde{v} \equiv \frac{p-e-c_h}{\alpha} + c_h$ and $\hat{c} \equiv \frac{p-e-\alpha v_h}{1-\alpha}$ where $\hat{c}$ is

[10] Technically speaking, the seller's investment would be arbitrarily close to infinity since Che and Chung (1999) do not impose any wealth constraint but assume $e \in R_0^+$.

[11] It is not necessary that the seller's bargaining power is marginal, as in our example, to prove that overreliance can occur. However this example allows for a relatively simple intuition compared to cases of larger bargaining powers.

defined such that $c \leq \hat{c}$ implies $\hat{v} = v_h$ and $c \geq \hat{c}$ implies $\hat{v} = \frac{p-e-c}{\alpha} + c$ (see expression I.4). Twice integrating by parts and reorganizing we can rewrite (I.5) as follows:[12]

$$
\begin{aligned}
U^{RD}(e) = p - e - c_h - \alpha \int_{c_h}^{\tilde{v}} F(v|e) + \int_{c_l}^{c_h} G(c|e)\ dc \\
- \alpha \int_{c_l}^{c_h} F(c|e)G(c|e)\ dc - (1-\alpha) \int_{\hat{c}}^{c_h} F(\hat{v}|e)G(c|e)\ dc \\
- (1-\alpha) \int_{c_l}^{\hat{c}} G(c|e)\ dc.
\end{aligned}
\tag{I.6}
$$

Hence, the investment level e^{RD} that maximizes the seller's expected payoff is given by the following first-order condition:

$$
\begin{aligned}
U_e'^{RD}(e^{RD}) = F(\tilde{v}|e^{RD}) - \alpha \int_{c_h}^{\tilde{v}} F_e(v|e^{RD})\ dv + \int_{c_l}^{c_h} G_e(c|e^{RD})\ dc \\
- \alpha \int_{c_l}^{c_h} [F_e(c|e^{RD})G(c|e^{RD}) + F(c|e^{RD})G_e(c|e^{RD})]\ dc \\
- (1-\alpha) \int_{\hat{c}}^{c_h} [F_e(\hat{v}|e^{RD}) - \frac{1}{\alpha} F_v(\hat{v}|e^{RD})]\ G(c|e^{RD})\ dc \\
- (1-\alpha) \int_{\hat{c}}^{c_h} F(\hat{v}|e^{RD})G_e(c|e^{RD})\ dc + [1 - F(\hat{v}|e^{RD})]G(\hat{c}|e^{RD}) \\
- (1-\alpha) \int_{c_l}^{\hat{c}} G_e(c|e^{RD})\ dc - 1 = 0.
\end{aligned}
\tag{I.7}
$$

(ii) To show that overinvestment relative to the socially optimal level can arise for $p = 0$, consider the case where the seller's bargaining power is very small, $\alpha \longrightarrow 0$. Inserting p = 0 into (I.7) yields:

$$
\begin{aligned}
U_e'^{RD}(e^{\overline{RD}}) = \alpha \int_{\tilde{v}}^{c_h} F_e(v|e^{\overline{RD}})\ dv + \int_{c_l}^{c_h} G_e(c|e^{\overline{RD}})\ dc \\
- \alpha \int_{c_l}^{c_h} [F_e(c|e^{RD})G(c|e^{\overline{RD}}) + F(c|e^{\overline{RD}})G_e(c|e^{\overline{RD}})]\ dc - 1 = 0
\end{aligned}
\tag{I.8}
$$

and the limit as α goes to zero is given by:

$$
\lim_{\alpha \to 0} U'^{RD}(e^{\overline{RD}}) = \int_{c_l}^{c_h} G_e(c|e^{\overline{RD}})\ dc - 1 = 0.
$$

It is clear that $e^{\overline{RD}} > e^*$ if the first derivative of the expected social welfare function (I.2) evaluated at $e^{\overline{RD}}$ is negative:[13]

$$
\begin{aligned}
W'(e^{\overline{RD}}) = \int_{c_l}^{c_h} ([1 - F(c|e^{\overline{RD}})]G_e(c|e^{\overline{RD}}) - F_e(c|e^{\overline{RD}})G(c|e^{\overline{RD}}))\ dc - 1 < 0 \\
\Longleftrightarrow + \int_{c_l}^{c_h} [-F(c|e^{\overline{RD}})G_e(c|e^{\overline{RD}}) - F_e(c|e^{\overline{RD}})G(c|e^{\overline{RD}})]\ dc < 0.
\end{aligned}
\tag{I.9}
$$

[12]See Appendix A.1.1 for omitted intermediate steps.

[13]Strict quasi-concavity of W(e) in e ensures that W(e) is single peaked and therefore $W'(e^{\overline{RD}}) < 0$ implies $e^{\overline{RD}} > e^*$.

This is indeed the case for those parameter constellations where the first negative term in the second line of (I.9) is larger in absolute value than the second, positive, term or where the selfish effect of investment is strong relative to the cooperative effect, $G_e(c|e^{\overline{RD}}) >> -F_e(c|e^{\overline{RD}})$.

(iii) In Appendix A.1.1 we show that the seller invests at least $e^{\overline{RD}}$ if a positive price has been specified in the contract. ■

Even though the proof of Proposition I.1 is rather tedious, the intuition behind it is straightforward. We can see from Figure I.2 that if parties set the price very low, say at $p = 0$, the buyer always accepts delivery and, as in Che and Chung (1999), compels the seller to deliver. Thus the seller's payoff is $p - c$ for $v \geq c$ and $p - (1 - \alpha)\, c - \alpha v$ for $v < c$. Hence, his payoff always increases as cost becomes lower, while a benevolent social planner disregards the cost-decreasing effect of investment for $v < c$. It may thus occur that the seller overinvests at price $p = 0$. This is especially likely if the seller's bargaining power α is low and investment mainly affects cost and only has marginal influence on quality. Given this possibility, it suffices to show that a positive price will never induce the seller to invest less. This is true, as increasing the price only makes it more likely that the buyer announces breach.[14] Yet, the seller's payoff in case of breach $\alpha[v - c]^{+} + e - e$ is increasing in e. If the buyer always breached investment incentives would even be indefinitely high. Therefore, investment incentives rise in p.

Hence, the efficiency result derived by Che and Chung (1999) for reliance damages in a setting of purely cooperative investments does not generalize to the hybrid case. However, we will show in the next section that such a generalization is possible for the efficiency result derived for the expectation damages remedy in Stremitzer (2010).

5. Expectation damages

5.1. Expectation damages without renegotiations

In contrast to the case of reliance damages, where it is impossible to achieve ex-post efficiency if renegotiation is ruled out, a standard result of the law and economics literature suggests that the expectation damages remedy induces the ex-post efficient trade decision (see e.g. Posner, 1977; Shavell, 1980; Kornhauser; Craswell, 1988). Hence, it may be possible to derive an efficiency result even without renegotiation.

As mentioned, we assume that the parties write a contract stipulating a fixed price, p, payable by the buyer upon the seller's performance and a quality level $\bar{v}$ which specifies the required quality level under the contract and serves as a baseline for calculating

[14] If the price is smaller than $(1 - \alpha)c_l$, the buyer still always accepts delivery. Then the seller invests the same amount as if a $p = 0$ had been specified in contract.

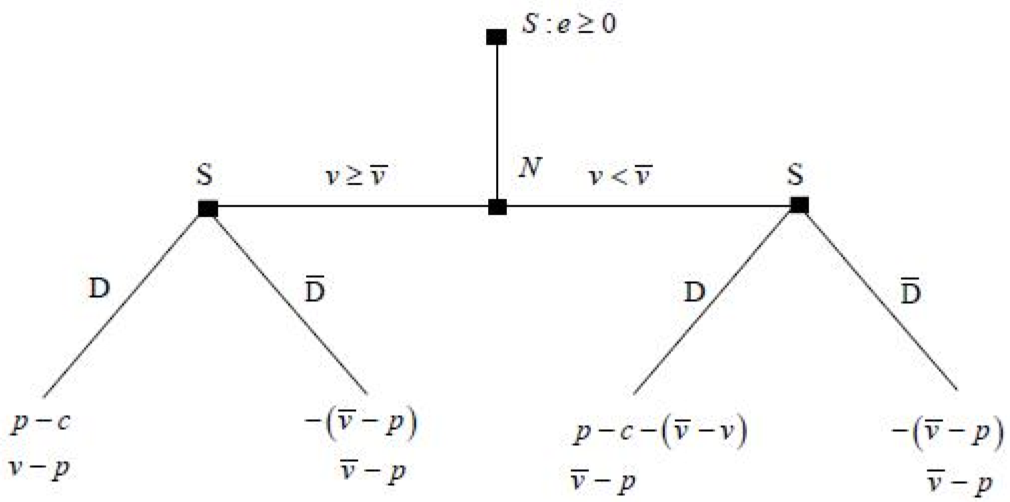

Figure I.3.: Subgame induced by expectation damages.

damages if the seller delivers a non-conforming good.[15] For example, the contract could specify that a motor should not exceed a certain level of fuel consumption. Moreover, the parties can specify a lump sum transfer, t, to split the expected gains from trade (an instrument which we shall show they will not need in order to achieve the first best).

Assuming the buyer never refuses delivery,[16] the seller faces the following decision: If he decides to deliver the good, he receives the trade price but has to incur the costs of production and therefore receives a trade surplus of $p - c$ (see Figure I.3). Under expectation damages, the victim of breach receives a payment that makes him as well off as performance would have. It thus follows that if the good is of inferior quality, $v < \bar{v}$, the seller has to pay damages amounting to $\bar{v} - v$. If the seller refuses to deliver, and assuming $\bar{v} \geq p$,[17] the buyer receives his contractually assured trade surplus of $\bar{v} - p$ regardless of the good's quality.

We will now solve the game by backwards induction. If $v < \bar{v}$, the seller will deliver if and only if it is ex-post efficient to do so ($p - c - (\bar{v} - v) \geq -(\bar{v} - p) \iff v \geq c$). However, if the buyer's valuation turns out to be above the threshold, $v \geq \bar{v}$, the seller will deliver if and only if $p - c \geq -(\bar{v} - p)$, or equivalently $c \leq \bar{v}$. Hence, for $\bar{v} < c < v$,

[15] As is commonly assumed if courts apply expectation damages, the court can perfectly observe the buyers benefit from trade or at least is able to form an unbiased estimate of it.

[16] We show in Appendix A.1.2 that this simplifying assumption does not change the analysis of this and the following subsection.

[17] Note that $\bar{v} < p$ would imply that the seller does not have to pay any damages if he decides not to deliver. One can readily show that it is indeed optimal for the parties to make sure that the price is lower than promised quality.

the seller's trade decision is ex-post inefficient. We can therefore write the following proposition:

Proposition I.2: *If parties specify a threshold below the highest possible realization of quality, $\bar{v} < v_h$, expectation damages fail to generally induce ex-post efficient trade.*

This result is surprising as expectation damages are commonly seen to induce the ex-post efficient breach decision. Given the seller's decision at date 3, he expects the following payoff at date 1:

$$\begin{aligned} U^{ED}(e) = &\int_{c_l}^{\bar{v}} \int_{\bar{v}}^{v_h} (p-c)\ F_v(v|e)\ dv\ G_c(c|e)\ dc \\ &+ \int_{c_l}^{\bar{v}} \int_{c}^{\bar{v}} [(p-c)-(\bar{v}-v)]\ F_v(v|e)\ dv\ G_c(c|e)\ dc \\ &+ \int_{c_l}^{\bar{v}} \int_{0}^{c} -(\bar{v}-p)\ F_v(v|e)\ dv\ G_c(c|e)\ dc \\ &+ \int_{\bar{v}}^{c_h} \int_{0}^{v_h} -(\bar{v}-p)\ F_v(v|e)\ dv\ G_c(c|e)\ dc - e. \end{aligned} \tag{I.10}$$

Integrating by parts and reorganizing allows us to simplify (I.10):

$$U^{ED}(e) = p - \bar{v} - e + \int_{c_l}^{\bar{v}} [1-F(c|e)]G(c|e)\ dc. \tag{I.11}$$

The seller's optimal investment level, e^{ED}, can then be characterized by the following first-order condition:

$$U'^{ED}(e^{ED}) = \int_{c_l}^{\bar{v}} ([1-F(c|e^{ED})]\ G_e(c|e^{ED}) - F_e(c|e^{ED})\ G(c|e^{ED}))\ dc - 1 = 0. \tag{I.12}$$

We can derive the following proposition:

Proposition I.3: *If renegotiation is impossible and parties specify a sufficiently high quality threshold, $\bar{v} \geq v_h$, expectation damages induce the first best.*

Proof. If $\bar{v} \geq v_h = c_h$, we know from Proposition I.2 that the seller's breach decision is ex-post efficient. Comparing expression (I.12) with the benchmark condition (I.2) we also see that $\bar{v} \geq v_h = c_h$ ensures that the seller chooses the socially optimal investment level. ■

The intuition behind Proposition I.3 is that the seller is made a residual claimant. If $\bar{v} \geq c_h$, he receives the entire trade surplus minus a constant term, $(\bar{v} - p)$. He will therefore have incentives to invest at the socially optimal level. As the high quality threshold also induces the ex-post efficient trade decision the contract achieves the first best.[18]

[18]If we relax our simplifying assumption by assuming $v_h \geq c_h$, one can readily show that a contract that specifies a sufficiently high quality threshold, $\bar{v} \geq v_h$, still induces the first best. However, the delivery decision can also be efficient outside the first best. This is for example the case if $v_h > \bar{v} \geq c_h$.

Our result can be contrasted to a related result by Edlin (1996) who analyzes the efficiency of expectation damages if investment is *purely selfish*. In the case of a seller, who invests in order to lower his variable cost of performance, he finds that a contract which specifies the highest possible quantity (a so-called "Cadillac contract") will make the seller a residual claimant if the contract price is set low enough that it will always be the investing seller who breaches the contract. In order to make the seller accept such a low price, the contract also specifies up-front lump sum payment from the buyer to the seller.[19]

Our result differs in two respects. First, we are concerned with inducing hybrid investments as opposed to purely selfish investments. In other words, the seller's investment not only serves to lower the seller's variable cost of delivery but stochastically determines both the seller's cost and the good's quality (and therefore the buyer's valuation for the good).[20] While efficient purely selfish investments, in our setting, could be achieved through a contract that specifies the highest possible quantity (*one* unit in a binary setting) but is silent about quality, parties need to specify the highest possible quantity *and* the highest possible quality level in order to achieve first best hybrid investments. This is because the value increasing effect of investment can only be internalized through the seller's expected damage payments which arise when quality is non-conforming to the contract. The second major difference to Edlin (1996) is that we do not rely on up-front payments as, in equilibrium, our bilateral breach game leads to the same payoff profile for the investing party as if we assumed that only the seller breached the contract. Parties can therefore use the contract price as an instrument to divide the expected gains from trade.

Finally, note that our first-best result holds even if the seller's expected payoff function, $U^{ED}(e)$, is not strictly quasi-concave in e for all $\bar{v}$. To derive results outside the first best, we have to impose stronger assumptions on the seller's expected payoff function. We prove the following lemma:

[19] Already Shavell (1984) had recognized that expectation damages induce the first best if the investing party is the breaching party. Actually, the results are structurally the same, as Shavell (1984) implictly assumes that the contract specifies the highest possible quantity by modelling the trade decision as binary (a contract requiring delivery then automatically specifies the "highest" possible quantity). Shavell (1984) did not, however, describe how up-front payments can be used to contractually manipulate the identity of the breaching party.

[20] Edlin also offers an interpretation of his model, where a Cadillac contract would mean that parties stipulate the highest possible *quality*. Yet, in his model, delivering high or low quality is a choice variable of the seller just as delivering high or low quantity. In our setting, quality is stochastically determined by the cooperative component of the seller's ex-ante investment.

Lemma I.1: *(i) If the contract specifies a low quality level, $\bar{v} < c_h$, and U^{ED} is strictly quasi-concave in e for all $\bar{v}$, the seller underinvests. (ii) If U^{ED} is strictly concave in e for all $\bar{v}$, investment incentives rise in the level of required quality.*

Proof. (i) To see that underinvestment will be the norm recall that $U'^{ED}(e^*) = 0$ if $\bar{v} = c_h$. Fixing $e = e^*$, we consider $U'^{ED}(\cdot)$ as a function of $\bar{v}$. The seller has lower investment incentives relative to the socially optimal level if $U'^{ED}(\bar{v}) < 0$ for all $\bar{v} < c_h$.[21] This is true because, for all $\bar{v} < c_h$

$$\begin{aligned} U'^{ED}(\bar{v}) &= \int_{c_l}^{\bar{v}} ([1 - F(c|e^*)]\ G_e(c|e^*) - F_e(c|e^*)\ G(c|e^*))\ dc - 1 \\ &= \int_{c_l}^{c_h} ([1 - F(c|e^*)]\ G_e(c|e^*) - F_e(c|e^*)\ G(c|e^*))\ dc - 1 \\ &- \int_{\bar{v}}^{c_h} ([1 - F(c|e^*)]\ G_e(c|e^*) - F_e(c|e^*)\ G(c|e^*))\ dc < 0. \end{aligned} \tag{I.13}$$

Note that the term in the second line of (I.13) is equal to zero whereas the term in the third line must be negative by Assumptions I.2 and I.3.

(ii) If $U^{ED}(e)$ is strictly concave in e for all $\bar{v}$, investment incentives rise in the level of required quality. To see this note that investment incentives rise in the threshold if $\frac{de^{ED}}{d\bar{v}} > 0$. Implicitly differentiating (I.12) and rearranging, we have:

$$\frac{de^{ED}}{d\bar{v}} = -\frac{\{[1 - F(\bar{v}|e^{ED})]G_e(\bar{v}|e^{ED}) - F_e(\bar{v}|e^{ED})G(\bar{v}|e^{ED})\}\ dc}{\int_{c_l}^{\bar{v}} \{[1 - F(c|e)]G_{ee}(c|e) - F_{ee}(c|e)G(c|e) - 2F_e(c|e)G_e(c|e)\}\ dc}. \tag{I.14}$$

The numerator of (I.14) must be positive due to Assumptions I.2 and I.3. Strict concavity implies that the denominator of (I.14) must be negative because it is equivalent to U''^{ED}. Hence we can conclude that $\frac{de^{ED}}{d\bar{v}} > 0$. ■

Intuitively, underinvestment occurs for two reasons: If the product is conforming to the contract, $v \geq \bar{v}$, and the seller decides to deliver he receives $p - c$. If $v > c > \bar{v}$, the seller refuses to deliver and pays damages of $-(\bar{v} - p)$ even though it would be socially optimal to trade. In both cases, he does not take into account the value-increasing effect of his investment. Since both sources of inefficiency diminish as $\bar{v}$ approaches v_h, investment incentives increase in the threshold value $\bar{v}$. The result extends the proof of Stremitzer (2010) that it is possible to implement the efficient outcome with expectation damages in a setting of purely cooperative investment to the hybrid case.

[21] Strict quasi-concavity of U^{ED} in e for all $\bar{v}$ ensures that U^{ED} is single peaked and hence the following argument is valid. Note that strict quasi-concavity is a common assumption to ensure a unique equilibrium level.

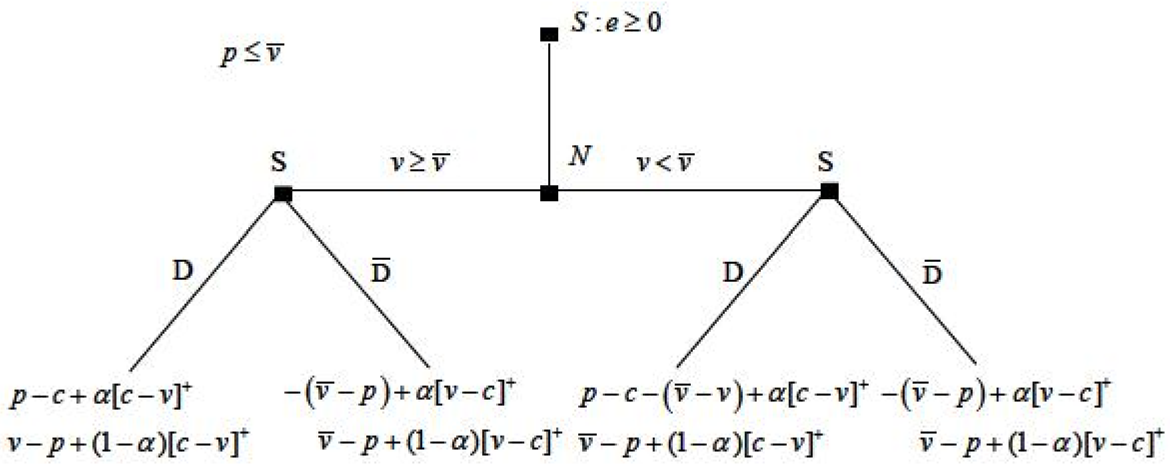

Figure I.4.: Subgame induced by expectation damages if renegotiation is possible.

5.2. Expectation damages with renegotiation

When renegotiation is possible, the parties use the payoff they would receive in the absence of renegotiation as a threat point. Consequently, the payoffs in Figure I.3 must be adjusted to take into account the effect of renegotiation (see Figure I.4).[22] Recall from Proposition I.2 that an optimal contract governed by expectation damages, $\bar{v} \geq v_h = c_h$, induces an efficient ex-post delivery decision. Proposition I.4 directly follows:

Proposition I.4: *If renegotiations are possible and parties specify a sufficiently high quality threshold, $\bar{v} \geq v_h$, expectation damages induce the first best.*

The intuition behind Proposition I.4 is that an efficient ex-post delivery decision renders renegotiations worthless. Hence, payoffs in equilibrium are the same as in the no-renegotiation case and the investment incentives coincide.

6. Conclusion

It is reassuring that expectation damages, the default remedy of common law, not only performs well in a setting of purely cooperative investments but also in the hybrid case. Indeed, the same Cadillac contract which achieves the first best in the purely cooperative setting also achieves the first best in the hybrid case. Under reliance damages, on the other hand, parties must fine-tune the contract price, stipulate up-front payments, and rely on renegotiation to achieve the first best. Even then, they cannot

[22]Note that we assume that $p \leq \bar{v}$ which allows us to simplify payoffs.

achieve the first best when investments are sufficiently selfish. Our analysis therefore suggests that parties should think twice before opting out of default expectation damages for privately stipulated reliance damages, in contrast to the recommendation of Che and Chung (1999). A more troubling result regarding expectation damages is that efficient ex post trade is only guaranteed if parties set the quality threshold sufficiently high. Otherwise - as under reliance damages and specific performance - there are states of the world where parties must rely on renegotiation to achieve the ex-post efficient allocation.

So far, the literature on the incentive effects of different breach remedies has mainly focused on comparing the efficiency of different remedies such as expectation damages, reliance damages or specific performance in varying environments. Yet, even though these settings are usually quite specific, parts of the literature make broader claims to the effect that a certain breach remedy performs well/poorly in general. For instance, Plambeck and Taylor (2007) state that the specific performance remedy is more efficient than expectation damages for inducing optimal relationship-specific investment. They consider a model where N buyers make a selfish investment (innovation) whereas the seller invests to increase capacity such that he or she can supply higher quantities to the buyers after the outcome of the innovation is realized. Since their model is essentially building on Edlin and Reichelstein's (1996) model of bilateral selfish investment they find, like Edlin and Reichelstein, that expectation damages perform poorly in a setting of bilateral selfish investment. However, as Ohlendorf (2009) has pointed out, expectation damages induce efficient bilateral investment if the cost function is not linear, as in Edlin and Reichelstein (1996), but sufficiently concave.[23] This, together with our result on hybrid investments, suggests that properly specified expectation damages perform well in close to any situation given that sufficient information is available to assess them. The main role for alternative regimes such as specific performance or reliance damages therefore is to offer alternative solutions for situations where informational constraints render them easier to assess than expectation damages.

Finally, our analysis illustrates a subtle difference between mechanism design and the economic analysis of real world institutions. As we have already mentioned, the enforcement of reliance damages requires investment to be verifiable. Then, however, parties should theoretically be able to achieve the first best by writing a forcing contract in which they stipulate the efficient investment level. Yet, we show that this does not necessarily imply that reliance damages induce the first best. Indeed, the issue is not

[23]Plambeck and Taylor (2007) actually find that the first best is attainable under bilateral expectation damages if the parties can affect their ex-post bargaining power through renegotiation design. However Ohlendorf's (2009) finding suggests that renegotiation design is not necessary to induce efficient bilateral investment under expectation damages.

whether the information required to operate an institution is in theory sufficient to achieve the first best. It is about how institutions make use of that information.[24]

[24]Both Che and Chung (1999) and Schweizer (2006) prove interesting results, although, by requiring investment to be verifiable, their insights are not surprising from the perspective of contract theory.

II. Expectation Damages and Bilateral Cooperative Investments

We examine the efficiency of the standard breach remedy expectation damages in a setting of bilateral cooperative investment by a buyer and a seller. Contracts may specify a required quality level and an upper bound to the cost of production. We find that it is optimal to write an augmented Cadillac contract that sets one threshold such that it cannot be met with positive probability together with an extreme price. Then, one of the parties becomes a residual claimant of the trade relationship. The other threshold can be used to balance the incentives of the other party.

1. Introduction

In this chapter, we consider a situation where a buyer and a seller, both risk neutral, contract for the future delivery of a good. Between the signing of the contract and production of the good both parties may invest cooperatively to stochastically increase the benefit of their trading partner. After uncertainty is resolved and investments are sunk but before trade is finalized, the parties may renegotiate to reach an ex-post optimal trade decision. Contracts are important to solve the standard hold-up problem that results in underinvestment and arises if trading parties solely rely on ex-post negotiations to induce investment incentives (see e.g. Williamson, 1985; Hart and Moore, 1988).

The earlier literature on the economic analysis of contract law has extensively dealt with and offered solutions for the unilateral investment problem. For selfish investment, Edlin (1996) demonstrates that the classic overreliance result for the standard breach remedy of expectation damages (see e.g. Shavell, 1980, 1984 ; Rogerson, 1984) vanishes if the parties write a so-called Cadillac contract that specifies the highest possible quantity and/or quality combined with a sufficiently low price.[1] The idea behind this commonly-applied legal remedy is that the victim of breach receives a payment that makes him or her as well off as performance would have. In a setting of cooperative investment, Stremitzer (2010) confirms the optimality of Cadillac contracts. In contrast to selfish investment, an optimal Cadillac contract specifies, in his setting, the highest possible quantity and quality.[2] There only exist few results for bilateral investment. Edlin and Reichelstein (1996) analyze selfish investment and consider contracts that specify price and a quantity to be traded. Their main finding is that if the trade decision is continuous the socially optimal solution can be attained under the specific performance remedy whereas expectation damages perform poorly. Ohlendorf (2009), however, points out that the poor performance of expectation damages can be attributed to Edlin and Reichelstein's (1996) assumption of a deterministic and linear cost function: If it is sufficiently concave, expectation damages can indeed induce the first best in Edlin and Reichelstein's (1996) setting. So far, the literature on the economic analysis of contract law has not dealt with bilateral cooperative investment.

[1] An alternative solution is offered by Edlin and Reichelstein (1996) who find that expectation damages and another standard breach remedy, specific performance, can induce the first best if quantity is continuous and can therefore be used as an instrument to balance the overinvestment effect of Shavell (1980) against the hold-up effect that arises in absence of contractual protection.

[2] Several alternative solutions to the cooperative investment problem have been proposed in the literature. For example, Che and Chung (1999) and Schweizer (2006) allow the parties to specify a required investment level. They show that the first best can be attained by a contract that is governed by reliance damages and expectation damages, respectively.

This may be due to Che and Hausch's (1999) pessimistic view about the value of contracting in such an environment. Under the strict assumption that courts are not able to verify any direct or indirect signal about investment and the state of the world, they demonstrate that contracting becomes irrelevant if investment is of a sufficiently cooperative nature. Even though the economic analysis of contract law generally makes less strict assumptions, Che and Hausch's (1999) result suggests that it may be difficult to balance both parties' investment incentives in a setting of purely cooperative investment. Bilateral cooperative investment is, however, highly relevant in practise. Consider, for example, a situation where a manufacturer with a fixed train of machines invests to custom tailor the product to the wishes of his buyer. The buyer, in turn, may exert effort to improve coordination between both parties. Dyer and Ouchi (1993) mention Japanese automakers that sent consultants to their suppliers to help decrease cost of production.

The aim of this chapter is twofold. First, we demonstrate that the bilateral holdup problem that often arises under cooperative investment can be solved by a combination between a Cadillac and a balancing contract, henceforth augmented Cadillac contract. To obtain this result, we do not impose stronger informational requirements on courts than in Edlin and Reichelstein (1996). All that is needed is that the court is able to unbiasedly estimate the buyer's benefit from trade and the seller's cost of production. Second, we do so using a generally applicable machinery that does not require differentiability. The contracts we consider are governed by expectation damages. They may specify, besides price and quantity, a required quality level that serves as a baseline for calculating damages if the seller delivers one or more goods of non-conforming quality. Similarly, the contracting parties may stipulate an upper bound for the seller's cost of production such that all cost above this threshold are born by the buyer. A standard Cadillac contract specifies a single threshold and sets it at an extreme level such that it cannot be met with positive probability. Together with either a very low or a very high price this ensures that one of the parties accepts/delivers the quantity specified in contract whereas the other party breaches to the socially efficient quantity. Consequently, the breaching party is a residual claimant of the trade relationship and thus has efficient incentives to invest. What is crucial here is that the parties may freely specify a second threshold without disturbing the incentives of the residual claimant. Thus, it can be used to balance the incentives of the non-breaching party. Our result challenges the viewpoint expressed in Edlin (1996) and Edlin and Reichelstein (1996) that expectation damages are poorly suited to solve problems of bilateral investment. Moreover, in contrast to Ohlendorf (2009), this chapter also suggests that it may not be necessary that both parties face the risk of ex-post breach.[3]

The chapter is organized as follows. Section 2 introduces the model before we discuss the legal consequences of breach in section 3. In Sections 4, 5 and 6, we consider binary trade. Section 4 assumes that the buyer takes the performance decision whereas the seller takes it in Section 5. We demonstrate that in both cases a standard Cadillac contract can be augmented such that the first best is induced. Section 6 considers the ex-post breach game induced by expectation damages. We show that the first-best contracts of Sections 4 and 5 induce the parties to behave as if the buyer or as if the seller takes the performance decision, respectively. In Section 7, we extend, under the assumption that contracts are divisible, our first best result to non-binary trade. Section 8 concludes.

[3]If, similar to the literature, both parties make a purely selfish investment, one can readily show that the first best can be achieved by a contract that specifies an extreme price together with an intermediate cost or quality threshold. Similar to a standard Cadillac contract, this contract determines the breaching party. The result is available upon request.

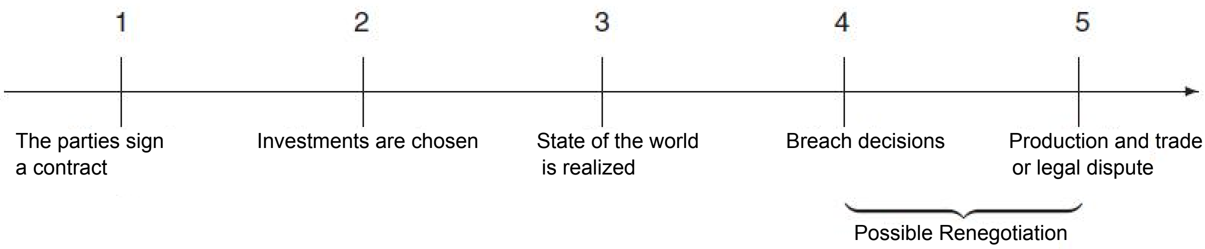

Figure II.1.: Timeline of the model.

2. The model

Consider a situation where a buyer and a seller, both risk neutral, have to incur relationship-specific investments before they potentially trade a quantity q of some good. At date 1, the parties sign a contract to induce an efficient outcome (see Figure II.1). The contract, which is governed by expectation damages, specifies a fixed price p and a quantity $\bar{q}$ to be traded. Furthermore, it may stipulate an upper bound for the seller's cost of production $\bar{c}$, a required quality $\bar{v}$ and an upfront transfer t, where the latter is used to divide the expected gains from trade after price and thresholds have been chosen to maximize joint surplus. The legal implications of this type of contract are discussed in Section 3. At date 2, the buyer invests to decrease the seller's expected cost of production whereas the seller invests to increase the buyer's expected benefit from trade. We denote the cost of their investments by $\beta \in [0, \beta^{max}]$ and $\sigma \in [0, \sigma^{max}]$, respectively, and assume that the investment decisions are not contractible. Then, at date 3, the state of the world $\omega \in \Omega$ is realized and hence the potential level of the seller's cost of production and the buyer's benefit from trade become commonly known.

At date 4, the parties play an extensive form breach game, which is described in detail in Section 3 and results in a quantity $q \in Q$ to be traded at date 5. In Sections 3 to 6 the trade choice is binary. W.l.o.g., we consider $Q = \{0, 1\}$. If it is non-binary, as in Section 7, we consider $Q = \{0, 1, 2, ..., q^{max}\}$. The payoffs determined by expectation damages serve as a disagreement point in subsequent renegotiations, which are costless and can take place anywhere between date 4 and date 5. The parties split the potential renegotiation surplus at an exogenously given ratio with the seller receiving a share of $\alpha \in [0, 1]$.[4] Let us denote the seller's cost of producing q units by $C(\beta, \omega, q)$ and the buyer's benefit of obtaining q units by $V(\sigma, \omega, q)$. To identify cost and and benefit associated with each single unit, we denote them, for the ith unit, by $C_i(\beta, \omega)$ and $V_i(\sigma, \omega)$, respectively. Let us assume that they are additive separable: For any unit

[4]This is, for example, the case if the parties play a bargaining game that results in the generalized Nash bargaining solution.

$i \in \{1, 2, ..., N\}$, the seller's cost of production and the buyer's benefit do not depend on whether the remaining units are produced or not. Finally, the following technical assumptions apply throughout:

Assumption II.1 For any $\beta \in [0, \beta^{max}]$, $\sigma \in [0, \sigma^{max}]$ and $\omega \in \Omega$, $C(\beta, \omega, q)$ and $V(\sigma, \omega, q)$ are monotonically increasing in q and $C(\beta, \omega, 0) = V(\sigma, \omega, 0) = 0$.

Assumption II.2 For any $\omega \in \Omega$ and $q > 0$, $V(\sigma, \omega, q)$ is monotonically increasing in σ and $C(\beta, \omega, q)$ is monotonically decreasing in β.

Assumption II.3 There exist c_l and c_h s.t. for any unit $i \in \{1, 2, ..., N\}$ and for all $\beta \in [0, \beta^{max}]$ and $\omega \in \Omega$, $0 \leq c_l \leq C_i(\beta, \omega) \leq c_h < \infty$. Moreover, there exist v_l and v_h s.t. for any unit $i \in \{1, 2, ..., N\}$ and for all $\sigma \in [0, \sigma^{max}]$ and $\omega \in \Omega$, $0 \leq v_l \leq V_i(\sigma, \omega) \leq v_h < \infty$.

Assumption II.1 establishes that, ex-post, the total cost of production and the buyer's benefit are increasing in the quantity to be traded. Assumption II.2 represents that investment is beneficial and of a purely cooperative nature. It directly follows that the expected value of the buyer's benefit and of the seller's cost is increasing in the other parties' investment. Assumption II.3 establishes that for any unit to be potentially traded the cost of production and the buyer's benefit lie within a bounded interval. The ex-post social surplus of the transaction,

$$W(\beta, \sigma, \omega, q) = V(\sigma, \omega, q) - C(\beta, \omega, q),$$

is maximized at the socially efficient quantity

$$Q^*(\beta, \sigma, \omega) \in \arg\max_{q \in [0, q^{max}]} W(\beta, \sigma, \omega, q).$$

The efficient investment levels, denoted by (β^*, σ^*), maximize the expected welfare gains from trade

$$E[W(\beta, \sigma, \omega, Q^*(\beta, \sigma, \omega))] - \beta - \sigma$$

in $[0, \beta^{max}] \times [0, \sigma^{max}]$ contingent on an efficient trade decision. We assume that β^* and σ^* are unique maximizers.[5]

[5]This assumption is not required to establish any of our results. It makes, however, the proofs considerably less tedious.

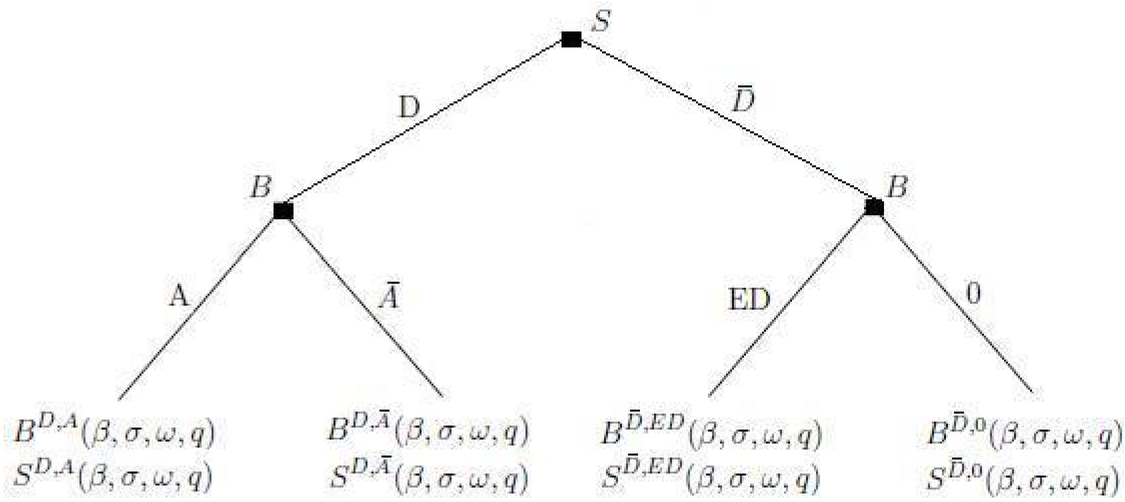

Figure II.2.: Breachgame induced by expectation damages.

3. Ex-post payoff

In this section, we work out the parties' ex-post payoffs induced by expectation damages when the buyer's benefit and the seller's cost of production are observable by the contracting parties and the court. For clarity of exposition, we first tackle the case where trade is binary, $Q \equiv \{0, 1\}$.[6] To simplify notation, let us denote cost of production and quality of the good by $c := C(\beta, \omega, 1)$ and $v := V(\sigma, \omega, 1)$, respectively.[7]

In absence of breach, the buyer has to pay the contracted price and receives the good whereas the seller receives the price but has to incur production costs. These payoffs are given by $v - p$ and $p - c$, respectively. The idea of the expectation damage rule is that the victim of breach has to be compensated such that he or she is in as good a position as if the contract had been fulfilled. This rule is, however, not applied literally if breach is advantageous for the breached-against party. In that case damage payments are zero.

As mentioned, we assume that the parties may stipulate a required quality level $\bar{v}$. This quality threshold serves as a baseline for calculating damages if the seller delivers a non-conforming good. Suppose that the seller announces his delivery decision followed by the buyer's announcement of whether she accepts the good (see Figure II.2).[8] If the seller delivers a non-conforming good and the buyer accepts, the buyer may claim

[6] Alternatively, we consider non-binary trade in Section 7.

[7] For simplicity, we do not distinguish between the buyer's benefit from trade and the quality of the good. For our results to go through it is only required that the court's perception of quality is an unbiased estimate of the buyer's true benefit from trade. See Edlin (1996) for a detailed discussion of imperfectly informed courts.

[8] The order of announcements does not affect any of our results.

compensation amounting to $\bar{v} - v$. Similarly, the parties may specify a cost threshold $\bar{c}$ which is defined such that any additional cost above $\bar{c}$ are borne by the buyer. Thus, the contract guarantees $\bar{v} - p$ to the buyer and $p - \bar{c}$ to the seller.

If the seller delivers (D) and the buyer accepts (A), the latter's ex-post payoff amounts to

$$B^{D,A}(\beta, \sigma, \omega, q) = \ max[v, \bar{v}] - p - \ max[c - \bar{c}, 0] + (1 - \alpha) \ max[c - v, 0] \qquad \text{(II.1)}$$

where $(1{-}\alpha)\ max[c{-}v, 0]$ represents the Buyer's potential bargaining surplus. Likewise, the Seller's ex-post payoff corresponds to

$$S^{D,A}(\beta, \sigma, \omega, q) = p - \ min[c, \bar{c}] - \ max[\bar{v} - v, 0] + \alpha \ max[c - v, 0]. \qquad \text{(II.2)}$$

Suppose that the seller announces to deliver (D) but the buyer refuses to accept ($\bar{A}$). If the good is conforming to the contract $v \geq \bar{v}$, the seller receives, as compensation, his contractually ensured trade surplus $p - \bar{c}$. However, if quality is inferior $v < \bar{v}$, we assume, as in Edlin (1996), that the parties have a broad duty to mitigate damages. The buyer is obliged to accept performance whether the good is conforming to the contract or not and may only collect $max[\bar{v} - v, 0]$ in damages. This prevents her from threatening to reject performance unless the seller agrees to pay larger damages. If she decides despite of her obligation to refuse performance, the seller may claim damages. Total damages amount to the seller's contractually guaranteed surplus $p - \bar{c}$ minus the damages he would have to pay to the buyer had she accepted.[9] Consequently, the buyer's ex-post payoff amounts to

$$B^{D,\bar{A}}(\beta, \sigma, \omega, q) = - \ max[p - \bar{c} - \ max[\bar{v} - v, 0], 0] + (1 - \alpha) \ max[v - c, 0] \qquad \text{(II.3)}$$

whereas the seller receives

$$S^{D,\bar{A}}(\beta, \sigma, \omega, q) = \ max[p - \bar{c} - \ max[\bar{v} - v, 0], 0] + \alpha \ max[v - c, 0]. \qquad \text{(II.4)}$$

If the seller refuses to deliver ($\bar{D}$) the buyer may sue for damages (ED). Then, her payoff is given by

$$B^{\bar{D},ED}(\beta, \sigma, \omega, q) = \ max[\bar{v} - p - \ max[c - \bar{c}, 0], 0] + (1 - \alpha) \ max[v - c, 0] \qquad \text{(II.5)}$$

whereas the seller receives

$$S^{\bar{D},ED}(\beta, \sigma, \omega, q) = - \ max[\bar{v} - p - \ max[c - \bar{c}, 0], 0] + \alpha \ max[v - c, 0]. \qquad \text{(II.6)}$$

[9] If total damages were equivalent to the seller's contractually assured trade surplus $p - \bar{c}$, he would be, in contrast to the aim of expectation damages, in a better position as if the contract had been fulfilled. As mentioned, the buyer cannot sue for a reward if total damages are negative. The case where the seller does not claim damages is equivalent to the one where total damages are zero. In both situations, the parties' ex-post payoff is identical to their respective bargaining shares.

In contrast, suppose the buyer does not sue for damages (0). In that case, neither party has to pay damages and both parties' ex-post payoff

$$B^{\bar{D},0}(\beta, \sigma, \omega, q) = (1 - \alpha)\ max[v - c, 0] \tag{II.7}$$

and

$$S^{\bar{D},0}(\beta, \sigma, \omega, q) = \alpha\ max[v - c, 0] \tag{II.8}$$

is identical to their respective bargaining shares.[10]

4. Buyer takes the performance decision

In this section, we assume that the buyer takes the performance decision, i.e. the seller always announces to deliver.[11] We find that it is optimal for the parties to write an augmented Cadillac contract that combines aspects from Cadillac and balancing contracts. Edlin (1996) defines a Cadillac contract as a contract that stipulates the highest possible quantity and/or quality. A balancing contract, in contrast, sets the contractual parameters at an intermediate level. For example, Chung (1991) and Edlin and Reichelstein (1996) consider contracts where the parties stipulate an intermediate quantity such that the investors sometimes receive more and sometimes less than the marginal social return of their investment. The contracts we consider in this section stipulate the lowest possible cost of production $\bar{c} = c_l$, some intermediate quality threshold $\bar{v} \in [v_l, v_h]$, a high price $p \geq v_h + max[c_l - v_l, 0]$ and that the good has to be traded $\bar{q} = 1$. In Section 6, we consider the ex-post breach game induced by expectation damages and demonstrate that the combination of a low cost threshold and a high price induces the parties to behave as if the buyer takes the performance decision.

In Lemma II.1, we show that the buyer performs whenever it is socially desirable to do so. Thus, the efficient breach property of expectation damages continues to hold.[12] This property is desirable because it ensures that there is no scope for renegotiation. Given

[10] Note that the buyer's decision is trivial in the sense that she is always weakly better off if she claims damages.

[11] Even though we assume that the buyer takes the performance decision, the parties may renegotiate her decision.

[12] It is a well known standard result of the literature that expectation damages induce an efficient ex-post trade decision (see e.g. Posner, 1977; Shavell, 1980; Kornhauser, 1986; Craswell, 1988). However, Göller and Stremitzer (2009) explain that a contract that specifies a quality threshold may induce expectation damages to lose its efficient breach property. Even though in the present chapter the parties may specify a quality threshold, this problem does not occur because the contracts we consider specify a sufficiently low or high price.

that a contract is optimal in absence of renegotiation, it must also be optimal if costless renegotiation is possible. After having derived the buyer's performance decision, we summarize the parties' expected payoffs. Let us denote the buyer's expected payoff, at date 1, by $B^{\bar{c}\bar{v}}(\beta,\sigma)$ and the seller's by $S^{\bar{c}\bar{v}}(\beta,\sigma)$, respectively. Here, $\bar{c} \in [c_l, c_h]$ and $\bar{v} \in [v_l, v_h]$ indicate which cost and quality thresholds are specified in contract.

Lemma II.1: *Any contract of the form ($\bar{c} = c_l,\ \bar{v} \in [v_l, v_h],\ p \geq v_h + max[c_l - v_l, 0]$, $\bar{q} = 1$) induces the buyer to accept the good whenever $v \geq c$ and to reject otherwise. The buyer's expected payoff is given by*

$$B^{c_l\bar{v}}(\beta,\sigma) = E[W(\beta,\sigma,\omega,Q^*(\beta,\sigma,\omega))] + E[max[\bar{v} - v, 0]] - (p - c_l) - \beta$$

whereas the seller receives

$$S^{c_l\bar{v}}(\beta,\sigma) = p - c_l - E[max[\bar{v} - v, 0] - \sigma.$$

PROOF: See the Appendix.

Let us define the buyer's best response to investment of the seller as

$$\beta_B(\bar{c},\bar{v},p,\bar{q}) := \arg\max_{\beta} B^{\bar{c}\bar{v}}(\beta,\sigma)$$

and the seller's best response to investment of the buyer as

$$\sigma_S(\bar{c},\bar{v},p,\bar{q}) := \arg\max_{\sigma} S^{\bar{c}\bar{v}}(\beta,\sigma).$$

Having derived the parties' expected payoffs in Lemma II.1, the following proposition describes their investment incentives for different levels of the quality threshold.

Proposition II.1: *For any $p \geq v_h + max[c_l - v_l, 0]$ and $\bar{q} = 1$, it holds for any $\sigma \in [0, \sigma^{max}]$ that*

$$\arg\max_{\beta} B^{c_l\bar{v}}(\beta,\sigma) = \arg\max_{\beta} E[W(\beta,\sigma,\omega,Q^*(\beta,\sigma,\omega))] - \beta$$

and for any $\beta \in [0, \beta^{max}]$ that

$$\sigma_S(c_l, v_l, p, 1) = 0.$$

Moreover, for $\beta = \beta^*$, any

$$\sigma \in \sigma_S(c_l, v_h, p, 1) \geq \sigma^*.$$

Proof. The first statement is true because for all quality thresholds $\bar{v} \in [v_l, v_h]$ the buyer's expected payoff

$$B^{c_l\bar{v}}(\beta,\sigma) = E[W(\beta,\sigma,\omega,Q^*(\beta,\sigma,\omega))] + E[max[\bar{v}-v,0] - (p-c_l) - \beta$$

is equivalent to expected social surplus plus or minus a constant term. Moreover, the second statement is true because the seller's expected payoff

$$S^{c_l v_l}(\beta,\sigma) = p - c_l - \sigma$$

is strictly decreasing in σ. To prove statement three observe that, given that the buyer invests efficiently, the difference between the seller's expected surplus and expected social surplus

$$\begin{aligned} S^{c_l v_h}(\beta^*,\sigma) - [E[W(\beta^*,\sigma,\omega,Q^*(\beta^*,\sigma,\omega))] - \beta^* - \sigma] \\ = p - v_h - c_l + E[min[C(\beta^*,\omega,1),V(\sigma,\omega,1)] + \beta^* \end{aligned}$$

is monotonically increasing in σ due to Assumption II.2. Therefore it must hold for any $\sigma < \sigma^*$ that

$$\begin{aligned} S^{c_l v_h}(\beta^*,\sigma) - [E[W(\beta^*,\sigma,\omega,Q^*(\beta^*,\sigma,\omega))] - \beta^* - \sigma] \leq \\ S^{c_l v_h}(\beta^*,\sigma^*) - [E[W(\beta^*,\sigma^*,\omega,Q^*(\beta^*,\sigma^*,\omega))] - \beta^* - \sigma^*] \end{aligned}$$

or equivalently

$$\begin{aligned} [E[W(\beta^*,\sigma^*,\omega,Q^*(\beta^*,\sigma^*,\omega))] - \beta^* - \sigma^*] - [E[W(\beta^*,\sigma,\omega,Q^*(\beta^*,\sigma,\omega))] - \beta^* - \sigma] \\ \leq S^{c_l v_h}(\beta^*,\sigma^*) - S^{c_l v_h}(\beta^*,\sigma). \end{aligned} \tag{II.9}$$

Because social welfare is uniquely maximized by (β^*,σ^*), the term in the first line of (II.9) is positive and consequently $S^{c_l v_h}(\beta^*,\sigma) < S^{c_l v_h}(\beta^*,\sigma^*)$ for all $\sigma \in [0,\sigma^*)$. ■

From Proposition II.1, we can deduce how different levels of the quality threshold influence the parties' best responses to efficient investment of the other party. The first statement tells us that for a low cost threshold $\bar{c} = c_l$ and a sufficiently high price $p \geq v_h + max[c_l - v_l, 0]$, it holds for any quality threshold $\bar{v} \in [v_l, v_h]$ that the buyer's best response is equivalent to the socially best response. Thus, if the seller invests efficiently, it is a best response for the buyer to invest efficiently herself. Under these contractual parameters, the seller's best response to efficient investment of the buyer is to not invest at all for $\bar{v} = v_l$ and to overinvest for $\bar{v} = v_h$. Figure II.3 illustrates that continuity of the buyer's and the seller's best response is a sufficient condition for Theorem II.1 to hold.

We can now sum up our main result:

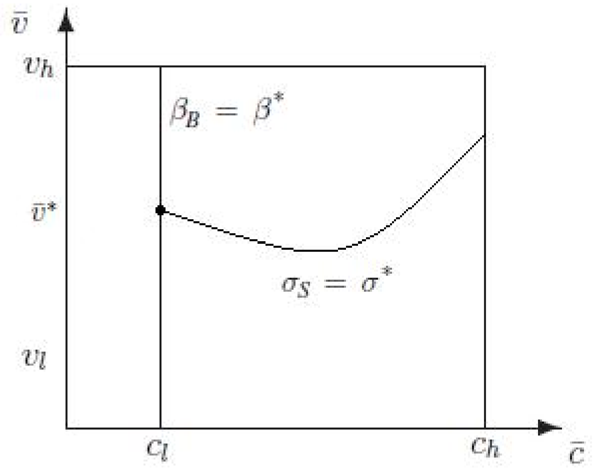

Figure II.3.: Best responses to efficient investment of the other party for any $p \geq v_h + max[c_l - v_l, 0]$. Note that we did not derive the exact shape of the seller's best response.

Theorem II.1: *If the parties' best responses are continuous and the contract specifies a sufficiently high price* $p \geq v_h + max[c_l - v_l, 0]$, $\bar{c} = c_l$ *and* $\bar{q} = 1$, *there exists a quality threshold* $\bar{v}^* \in (v_l, v_h]$ *such that the first-best investment levels* (β^*, σ^*) *constitute a subgame-perfect equilibrium of the induced game.*

As mentioned, the first-best contract of Theorem II.1 combines aspects from Cadillac- and balancing contracts. It is a Cadillac contract because, as in Edlin (1996), it stipulates a combination of an extreme price and an extreme threshold. The buyer has efficient incentives to invest for two reasons. First, because the efficient breach property of expectation damages ensures that she accepts the good whenever it is socially desirable to do so. Second, because the low cost threshold ensures that she has to pay damages in any state of the world. Thus, she internalizes the full benefit of her investment indirectly through the damages she has to pay to the seller. Because the buyer is a residual claimant of the trade relationship for any level of specified quality $\bar{v} \in [v_l, v_h]$, the quality threshold can be used as an instrument to balance the seller's incentives.

5. Seller takes the performance decision

In contrast to the previous section, let us assume that the seller takes the performance decision. As before, we find that it is optimal for the parties to write an augmented Cadillac contract. The contracts we consider in this section stipulate an intermediate cost threshold $\bar{c} \in [c_l, c_h]$, the highest possible quality $\bar{v} = v_h$, a considerably low price

$p \leq c_l - max[c_h - v_h, 0]$ and that the good has to be traded $\bar{q} = 1$. Next section, where we consider the ex-post breach game induced by expectation damages, we demonstrate that the combination of a high quality threshold and a low price induces the parties to behave as if the seller takes the performance decision.

In the following lemma, we show that the seller's performance decision is efficient and summarize the parties' expected payoffs.

Lemma II.2: *Any contract of the form* ($\bar{c} \in [c_l, c_h]$, $\bar{v} = v_h$, $p \leq c_l - max[c_h - v_h, 0]$, $\bar{q} = 1$) *induces the seller to deliver the good whenever* $v \geq c$. *The buyer's expected payoff is given by*

$$B^{\bar{c}v_h}(\beta, \sigma) = v_h - p - E[max[c - \bar{c}, 0] - \beta$$

whereas the seller receives

$$S^{\bar{c}v_h}(\beta, \sigma) = E[W(\beta, \sigma, \omega, Q^*(\beta, \sigma, \omega))] + E[max[c - \bar{c}, 0] - (v_h - p) - \sigma.$$

PROOF: See the Appendix.

Having derived the parties' expected payoffs in Lemma II.2, the following proposition describes their investment incentives for different levels of the cost threshold.

Proposition II.2: *For any* $p \leq c_l - max[c_h - v_h, 0]$ *and* $\bar{q} = 1$, *it holds for any* $\beta \in [0, \beta^{max}]$ *that*

$$\arg\max_{\sigma} S^{\bar{c},v_h}(\beta, \sigma) = \arg\max_{\sigma} E[W(\beta, \sigma, \omega, Q^*(\beta, \sigma, \omega))] - \sigma$$

and for any $\sigma \in [0, \sigma^{max}]$ *that*

$$\beta_B(c_h, v_h, p, 1) = 0.$$

Moreover, for $\sigma = \sigma^*$, *any*

$$\beta \in \beta_B(c_l, v_h, p, 1) \geq \beta^*.$$

Proof. The first statement is true, because, for all cost thresholds $\bar{c}$, the seller's expected payoff

$$S^{\bar{c},v_h}(\beta, \sigma) = E[W(\beta, \sigma, \omega, Q^*(\beta, \sigma, \omega))] + E[max[c - \bar{c}, 0] - (v_h - p) - \sigma$$

is equivalent to expected social surplus plus or minus a constant term. Moreover, the second statement is true because the buyer's expected payoff

$$B^{c_h,v_h}(\beta, \sigma) = v_h - p - \beta$$

is strictly decreasing in β.

To prove statement three observe that, given that the seller invests efficiently, the difference between the buyer's expected surplus and expected social surplus

$$\begin{aligned}&B^{c_l v_h}(\beta,\sigma^*) - [E[W(\beta,\sigma^*,\omega,Q^*(\beta,\sigma^*,\omega))] - \beta - \sigma^*] \\ &\qquad = v_h - p + c_l - E[min[C(\beta,\omega,1),V(\sigma^*,\omega,1)] + \sigma^*\end{aligned}$$

is monotonically increasing in β due to Assumption II.2. Therefore it must hold for any $\beta < \beta^*$ that

$$\begin{aligned}&B^{c_l v_h}(\beta,\sigma^*) - [E[W(\beta,\sigma^*,\omega,Q^*(\beta,\sigma^*,\omega))] - \beta - \sigma^*] \leq \\ &B^{c_l v_h}(\beta^*,\sigma^*) - [E[W(\beta^*,\sigma^*,\omega,Q^*(\beta^*,\sigma^*,\omega))] - \beta^* - \sigma^*]\end{aligned}$$

or equivalently

$$\begin{aligned}&[E[W(\beta^*,\sigma^*,\omega,Q^*(\beta^*,\sigma^*,\omega))] - \beta^* - \sigma^*] - [E[W(\beta,\sigma^*,\omega,Q^*(\beta,\sigma^*,\omega))] - \beta - \sigma^*] \\ &\leq B^{c_l v_h}(\beta^*,\sigma^*) - B^{c_l v_h}(\beta,\sigma^*). \qquad \text{(II.10)}\end{aligned}$$

Because social welfare is uniquely maximized by (β^*,σ^*), the term in the first line of (II.10) is positive and consequently $B^{c_l v_h}(\beta,\sigma^*) < B^{c_l v_h}(\beta^*,\sigma^*)$ for all $\beta \in [0,\beta^*)$. ■

If the seller takes the performance decision, the combination of a high quality threshold $\bar{v} = v_h$ and a sufficiently low price $p \leq c_l - max[c_h - v_h, 0]$ ensures that, for any level of the cost threshold $\bar{c} \in [c_l, c_h]$, the seller's best response is equivalent to the socially best response. The buyer's best response to efficient investment of the seller is to not invest at all for $\bar{c} = c_h$ and to overinvest for $\bar{c} = c_l$. We can establish the following theorem:

Theorem II.2: *If the parties' best responses are continuous and the contract specifies a sufficiently low price $p \leq c_l - max[c_h - v_h, 0]$, $\bar{v} = v_h$ and $\bar{q} = 1$, there exists a cost threshold $\bar{c}^* \in [c_l, c_h)$ such that the first-best investment levels (β^*,σ^*) constitute a subgame-perfect equilibrium of the induced game.*

The intuition behind Theorem II.2 and Theorem II.1 is closely related. The combination of an extremely low price and a sufficiently high quality threshold ensures that the seller is a residual claimant of the trade relationship. Because this is the case for any cost threshold $\bar{c} \in [c_l, c_h]$, it can be used as an instrument to fine tune the buyer's incentives. The residual claimant argument also is the driving force behind the efficiency result of Stremitzer (2010). He considers a situation where only the seller makes a purely cooperative investment and finds that a contract that is governed by expectation damages and specifies $\bar{v} = v_h$ induces the first best. We can, however, deduce from Proposition II.2 that such a pure cadillac contract performs poorly if both parties invest. The buyer receives, in all states of the world, a fixed payoff amounting to promised quality minus price and therefore has no incentive to invest.[13]

6. Ex-post breach game

So far, we assumed that either the buyer (Section 4) or the seller (Section 5) takes the performance decision. In this section, we consider the ex-post breach game and show that a contract of the form $(\bar{c} = c_l,\ \bar{v} \in [v_l, v_h],\ p \geq v_h + max[c_l - v_l, 0],\ \bar{q} = 1)$ induces the parties to behave as if the buyer takes the performance decision whereas a contract of the form $(\bar{c} \in [c_l, c_h],\ \bar{v} = v_h,\ p \leq c_l - max[c_h - v_h, 0],\ \bar{q} = 1)$ induces them to behave as if the seller takes the performance decision. We prove the following lemma.

Lemma II.3: *(i) Any contract of the form* $(\bar{c} = c_l, \bar{v} \in [v_l, v_h], p \geq v_h + max[c_l - v_l, 0], \bar{q} = 1)$ *induces the following behavior on the equilibrium path. The seller always announces to deliver the good. The buyer accepts whenever* $v \geq c$ *and rejects otherwise. (ii) Under any contract of the form* $(\bar{c} \in [c_l, c_h], \bar{v} = v_h, p \leq c_l - max[c_h - v_h, 0], \bar{q} = 1)$ *the behavior on the equilibrium path is as follows. The seller announces to deliver if and only if* $v \geq c$ *whereas the buyer always accepts delivery.*

PROOF: See the Appendix.

From Lemma II.3 we can deduce that the combination of an an extreme price and an extreme threshold determines the breaching party. Next section, we use this finding to extend our first-best result to the case of non-binary trade.

7. Divisible contracts

As a matter of real world contracting, parties are often interested to trade several units of the same good, $Q = \{0, 1, 2, ..., q^{max}\}$. In this section, we demonstrate that our first-best results continue to hold if contracts are divisible and specify maximum quantity $\bar{q} = q^{max}$. Divisible contracts are specified such that each unit together with the per-unit price can be breached independently. Cost and quality threshold then serve as a baseline for calculating damages for every single unit. The buyer's benefit of consuming q units is given by $V(\sigma, \omega, q) - pq$ and the seller's profit by $pq - C(\beta, \omega, q)$. It may frequently occur that some but not all units violate a threshold. Let us denote the quantity of units that is non-conforming to stipulated cost or quality threshold by

[13] The first best contract of Stremitzer (2010) does not specify any cost threshold. Technically, this situation is similar to a contract that specifies a cost threshold that is never violated, $\bar{c} = c_h$.

$q^{\bar{c}}$ or $q^{\bar{v}}$, respectively.[14] The seller's cost of producing $q^{\bar{c}}$ units can then be written as $C(\beta, \omega, q^{\bar{c}})$ whereas the buyer's benefit of consuming $q^{\bar{v}}$ units is denoted by $V(\sigma, \omega, q^{\bar{v}})$.

As before, to establish the first best, it is crucial that the parties have a broad duty to mitigate damages. Each party is obliged to accept inferior and/or partial performance and may only collect the difference between contractually assured and actual performance as damages. Since contracts are divisible, the parties may breach each single unit independently. The legal implications of breach are then, for each unit, the same as discussed in Section 3.[15] In the following lemma, we solve the ex-post breach-game induced by expectation damages.

Lemma II.4: *(i) Any contract of the form ($\bar{c} = c_l, \bar{v} \in [v_l, v_h], p \geq v_h + max[c_l - v_l, 0]$, $\bar{q} = q^{max}$) induces the following behavior on the equilibrium path. The seller announces to deliver q^{max} units and the buyer breaches to the socially efficient quantity $Q^*(\beta, \sigma, \omega)$.* *(ii) Under any contract of the form ($\bar{c} \in [c_l, c_h], \bar{v} = v_h, p \leq c_l - max[c_h - v_h, 0]$, $\bar{q} = q^{max}$) the behavior on the equilibrium path is as follows. The seller announces to deliver the socially efficient quantity $Q^*(\beta, \sigma, \omega)$ which is then accepted by the buyer.*

Proof. Because cost of production and quality are additive separable, the parties have a brought duty to mitigate damages and contracts are divisible, we can consider each single unit separately to check if the parties trade it or not. (i) From Lemma II.3, we can deduce that the combination of a high price $p \geq v_h + max[c_l - v_l, 0]$ and a low cost threshold $\bar{c} = c_l$ induces the seller to deliver all units whereas the buyer accepts all units that yield a positive net joint benefit.

(ii) Moreover, from Lemma II.3 we can also deduce that the combination of a low price $p \leq c_l - max[c_h - v_h, 0]$ and a high quality threshold $\bar{v} = v_h$ induces the seller to deliver all units that are socially desirable to trade which are then accepted by the buyer.

Hence, in both cases, the efficient breach property of expectation damages continues to hold and the parties trade the socially efficient quantity $Q^*(\beta, \sigma, \omega)$. ■

Let us summarize the parties' expected payoffs in the following lemma.

[14] These quantities depend on investments and the state of the world. For our analysis, it is only important that $q^{\bar{c}}$ does not depend on the seller's and that $q^{\bar{v}}$ does not depend on the buyer's investment. Hence, we write $q^{\bar{c}}$ instead of $q^{\bar{c}}(\beta, \omega)$.

[15] As an example, suppose the parties write a contract that stipulates some required quality and a quantity of 10 units. The seller announces to deliver 9 units from which one is non-conforming to the contract. Due to her broad duty to mitigate damages, the buyer is obliged to accept all 9 units. She may, however, claim damages. Suppose the buyer refuses to accept all 9 units. Then, the seller may claim compensation amounting to price minus cost for all 9 units he was willing to deliver minus the damages he would have to pay if the buyer had accepted the ninth unit.

Lemma II.5: *(i) For any* $p \geq v_h + max[c_l - v_l, 0]$ *and* $q = q^{max}$*, the expected payoffs under subgame-perfect equilibrium amount to*

$$B^{c_l\bar{v}}(\beta,\sigma) = E[W(\beta,\sigma,\omega,Q^*(\beta,\sigma,\omega))] + E[q^{\bar{v}}\bar{v} - V(\sigma,\omega,q^{\bar{v}})] - q^{max}(p - c_l) - \beta$$

and

$$S^{c_l\bar{v}}(\beta,\sigma) = q^{max}(p - c_l) - E[q^{\bar{v}}\bar{v} - V(\sigma,\omega,q^{\bar{v}})] - \sigma.$$

Specifically,

$$B^{c_lv_h}(\beta,\sigma) = E[W(\beta,\sigma,\omega,Q^*(\beta,\sigma,\omega))] + E[q^{max}v_h - V(\sigma,\omega,q^{max})] - q^{max}(p - c_l) - \beta$$

and

$$S^{c_lv_h}(\beta,\sigma) = q^{max}(p - c_l) - E[q^{max}v_h - V(\sigma,\omega,q^{max})] - \sigma.$$

(ii) For any $p \leq c_l - max[c_h - v_h, 0]$ *and* $q = q^{max}$*, the expected payoffs under subgame-perfect equilibrium amount to*

$$B^{\bar{c}v_h}(\beta,\sigma) = q^{max}(v_h - p) - E[C(\beta,\omega,q^{\bar{c}}) - q^{\bar{c}}\bar{c}] - \beta$$

and

$$S^{\bar{c}v_h}(\beta,\sigma) = E[W(\beta,\sigma,\omega,Q^*(\beta,\sigma,\omega))] + E[C(\beta,\omega,q^{\bar{c}}) - q^{\bar{c}}\bar{c}] - q^{max}(v_h - p) - \sigma.$$

Specifically,

$$B^{c_lv_h}(\beta,\sigma) = q^{max}(v_h - p) - E[C(\beta,\omega,q^{max}) - q^{max}c_l] - \beta.$$

and

$$S^{c_lv_h}(\beta,\sigma) = E[W(\beta,\sigma,\omega,Q^*(\beta,\sigma,\omega))] + E[C(\beta,\omega,q^{max}) - q^{max}c_l] - q^{max}(v_h - p) - \sigma.$$

PROOF: See the Appendix.

Having derived the parties' expected payoffs, we analyze in the following proposition their investment incentives for different levels of the cost and quality thresholds.

Proposition II.3: *(i) For any* $p \geq v_h + max[c_l - v_l, 0]$ *and* $q = q^{max}$*, it holds for any* $\sigma \in [0, \sigma^{max}]$ *that*

$$\arg\max_\beta B^{c_l\bar{v}}(\beta,\sigma) = \arg\max_\beta E[W(\beta,\sigma,\omega,Q^*(\beta,\sigma,\omega))] - \beta$$

and for any $\beta \in [0, \beta^{max}]$ *that*

$$\sigma_S(c_l, v_l, p, q^{max}) = 0.$$

Moreover, for $\beta = \beta^*$, any

$$\sigma \in \sigma_S(c_l, v_h, p, q^{max}) \geq \sigma^*.$$

(ii) For any $p \leq c_l - max[c_h - v_h, 0]$ and $q = q^{max}$, it holds for any $\beta \in [0, \beta^{max}]$ that

$$\arg\max_{\sigma} S^{\bar{c}v_h}(\beta, \sigma) = \arg\max_{\sigma} E[W(\beta, \sigma, \omega, Q^*(\beta, \sigma, \omega))] - \sigma$$

and for any $\sigma \in [0, \sigma^{max}]$ that

$$\beta_B(c_h, v_h, p, q^{max}) = 0.$$

Moreover, for $\sigma = \sigma^*$, any

$$\beta \in \beta_B(c_l, v_h, p, q^{max}) \geq \beta^*.$$

PROOF: See the Appendix.

The intuition behind Proposition II.3 is closely related to Proposition II.1 and II.2. The combination of an extreme price and an extreme threshold ensures that one of the parties is a residual claimant of the trade relationship. Because this holds true regardless how the remaining threshold is set, it can be used to balance the incentives of the other party.

Theorem II.3: *If the parties' best responses are continuous and the contract specifies a sufficiently high price $p \geq v_h + max[c_l - v_l, 0]$, $\bar{c} = c_l$ and $\bar{q} = q^{max}$, there exists a quality threshold $\bar{v}^* \in (v_l, v_h]$ such that the first-best investment levels (β^*, σ^*) constitute a subgame-perfect equilibrium of the induced game. Moreover, if the parties' best responses are continuous and the contract specifies a sufficiently low price $p \leq c_l - max[c_h - v_h, 0]$, $\bar{v} = v_h$ and $\bar{q} = q^{max}$, there exists a cost threshold $\bar{c}^* \in [c_l, c_h)$ such that the first-best investment levels (β^*, σ^*) constitute a subgame-perfect equilibrium of the induced game.*

If the parties trade several units from the same good and contracts are divisible, they have an additional instrument, the quantity, at hand. This cannot destroy the optimality result obtained under binary trade. Our first-best contracts induce that one party is interested to trade all units stipulated in contract. The other party then breaches to the socially efficient quantity. To obtain the first best it is not necessary to specify $\bar{q} = q^{max}$ in contract. In theory, it is sufficient to set quantity such that it is at least as high as the highest possible realization of the socially efficient quantity.

8. Conclusion

We have shown that expectation damages, the default remedy of common law, can achieve the first best in an environment of bilateral cooperative investment. In contrast to selfish investment, where Ohlendorf (2009) has demonstrated that it is sufficient to specify price and quantity to achieve the first best, cooperative investment requires better contractual protection. We found that it is optimal to write a contract that protects the contracting parties by stipulating a cost and a quality threshold that guarantee both parties a fixed payoff in bad states of the world. The parties set one threshold at an extreme level such that one of them becomes a residual claimant of the trade relationship whereas the incentives of the remaining party can be balanced by setting the remaining threshold at an intermediate level.

Similarly to a pure Cadillac contract, our first-best contracts determine which party may have an incentive to ex-post breach the contract. Hence, our optimality result stands in contrast to the opinion expressed in Ohlendorf (2009) that in a setting of bilateral investment it is important that both parties face the risk of ex-post breach. For the breaching party to sign the contract, it must receive a substantial transfer up-front. If one believes, however, that the parties are truly sophisticated, they could theoretically divide the ex-ante expected gains from trade by stipulating a lottery between both types of optimal contracts.

From a legal perspective, the assumption that damages in case of non-delivery are equivalent to specified quality minus price may seem questionable. Indeed, courts may be inclined to use true quality instead of specified quality as a baseline for calculating damages. Our optimality result may suggest that this is not the right way to measure expectation damages. Also, this chapter supports the viewpoint that courts should be ready to enforce contracts that request a broader view to mitigate damages. If courts do not, expectation damages may lose the efficient breach property in our setting.

This chapter also contributes to the viewpoint that to judge the performance of a breach remedy it is important to consider the interplay between breach remedy and contract. As an example, consider Che and Chung (1999) who argue that expectation damages perform poorly in an environment of unilateral cooperative investment. This viewpoint has been refuted by Schweizer (2006) and Stremitzer (2009) who have shown that it is possible to augment the contracts considered in Che and Chung (1999) such that expectation damages can indeed induce the first best.

III. Economic Analysis of Taking Rules: the Bilateral Case

Our analysis focuses on a situation where a landowner and the government invest prior to the government's taking decision. When the government suffers from budgetary "fiscal illusion", optimal compensation amounts to the hypothetical value of the landowner's property had she invested efficiently. In contrast, under a government that maximizes social welfare, the only regime to induce the first best grants as compensation the social benefit of the taking. Consequently, if the government can only raise capital up to a certain amount, society may be better off under a non-benevolent government.

1. Introduction

The Fifth Amendment to the United States Constitution states that "[...]nor shall private property be taken for public use, without just compensation". In the same vein, Art. 14 of the German Constitution (Grundgesetz) allows a taking only in "public interest" and requires compensation to be determined under "just consideration of interests". These and corresponding clauses in other legal systems, referred to as eminent domain, expropriations or takings, have not only generated an enormous amount of legal cases, but have also been examined by economists. They emphasize that, from an economic perspective, "a taking" not only captures physical acquisitions. So called regulatory takings, e.g. modifying approach paths of an airport, must also be considered as a taking insofar as they may lower the value of property.[1] Besides the basic question about the justification for eminent domain[2], economists and legal scholars have argued how optimal compensation should look like. Whereas legal scholars often point out justice arguments[3], the economic literature focuses on the investment incentives of the victim of a taking, often a landowner. In a provocative article, Blume et al. (1984) assume that the government acts to maximize social welfare and show that zero compensation often leads to efficient investment incentives for the landowner. Fair market value compensation induces, however, ex-ante overinvestment in private property. The intuition is that the potential victim is fully insured and does not take those states of the world into account where a taking is socially desirable. Scholars have, since then, challenged the result that no compensation outperforms fair market value compensation. A straightforward argument is that risk averse individuals are not able to insure themselves against takings due to market failure. Consequently, the government has to provide insurance in the form of compensation (see e.g. Blume and Rubinfeld, 1984,

[1] Hermalin (1995), pp. 64 f., Kaplow (1986), for an overview of cases, cf. Miceli and Segerson (1994).

[2] The common justification for this form of compulsory exchange can be found in the hold-out problem (see Cohen, 1991; Goldberg et al., 1986; Miceli and Segerson, 2007, pp. 286-293). Consider, as an example, that several parcels of land are required for a public project. In absence of eminent domain, owners have an incentive to delay their sale in order to extract parts of the project's social surplus. Munch (1976) challenges the desirability of eminent domain, claiming that it may cause increased transaction costs. Shavell (2010) finds, however, that eminent domain is socially desirable if the quantity of parcels is sufficiently large and the government does not know their private value.

[3] Many scholars have argued that, even if a government exercises its power of eminent domain to maximize social welfare, it is necessary to compensate for the loss suffered by the taking (see e.g. Michelman, 1967). This is connected to the *Sonderopfertheorie* (Maunz and Dürig, Art. 14, No. 366 ff.) in German law. According to it, the motive behind compensation is to ensure that all citizens are treated equally. A taking without compensation would therefore constitute a sacrifice that would only be levied on the owner but not on other members of the society.

pp. 582 ff. and Calandrillo, 2005). Other articles point out "demoralization costs" that accrue to potential losers "from the realization that no compensation is offered" (Fischel and Shapiro, 1988 ; Michelman, 1967, p. 1214).

An important branch of the literature assumes that the government suffers from "fiscal illusion", i.e. the perceived cost of a taking is identical to compensation.[4] In such frameworks, an important motive behind compensation is to influence the government's behavior. As a noteworthy example, consider Hermalin (1995). He demonstrates in a setting where only the landowner invests that compensation should amount to the social benefit of the taking. Alternatively, related to the famous Coase (1960) theorem, the first best can also be achieved if the landowner has to compensate the government in absence of a taking. In both situations, the landowner maximizes expected social welfare and therefore has efficient incentives to invest. A large branch of the literature considers the so called constitutional choice approach to eminent domain (cf. Fischel and Shapiro, 1989; Innes, 1997; Miceli, 2008; Nosal, 2001). Individual landowners, acting from behind a veil of ignorance, choose compensation law without knowing which parcels of land will be taken. Compensation is financed by a tax levied onto the property value. The main insight gained by this approach is that the overinvestment incentives generated by most common compensation regimes are often canceled out because tax makes investment in property less attractive.

This chapter goes one step further than Hermalin (1995). If the government suffers from fiscal illusion and therefore has non-benevolent motives, it makes sense to consider a situation where not only the landowner but also the government may invest ex-ante. Whereas the landowner invests to increase the value of her property, the government invests to increase the expected social benefit of the taking. As an example, the landowner may invest in a new fodder silo or storehouse whereas the government may invest to gather information on how to use the landowner's property as a disposal site for nuclear waste. If the government is non-benevolent, compensation regimes thus influence both investment decisions and also the ex-post taking decision of the government. Suffering from fiscal illusion, it initiates a taking whenever the amount of compensation it has to pay is less or equal than the social benefit of the taking.

We find, as our main result, that compensation should be based on the hypothetical value of the landowner's property had she invested efficiently. Under this regime, the common problem that the landowner overinvests to reduce the probability of a taking or to increase compensation does not occur. Consequently, the landowner has an

[4]This may be the case if the government's behavior is driven by lobbyism. Bell (2009) argues that the economic analysis of eminent domain also applies to situations where the state is not even involved.

incentive to choose the socially best response to the investment of the government. The government, in turn, internalizes the benefit of its investment in exactly the same states as in the social optimum and thus is a residual claimant of the bilateral relationship. In equilibrium, both parties have efficient incentives to invest. This result can be related to the economic analysis of contract law where it is well known that the legal breach remedy of expectation damages, if based on socially optimal investment, induces an efficient breach decision and efficient investment incentives (Cooter, 1985, p. 18; Schweizer, 2005, pp. 250 ff.). In contrast, the most commonly proposed compensation regimes perform poorly. If no compensation is paid, the government initiates too many takings and, hence, the landowner underinvests in her property. This result stands in contrast to Blume et al. (1984) where, if the taking decision depends on the landowner's investment, the no compensation regime induces overinvestment. The compensation regime proposed by Hermalin (1995) that grants as compensation the social benefit of the taking, henceforth social benefit compensation regime, induces the government to not invest at all because it does not internalize any benefit of its investment.

As a benchmark, we consider the situation that the government acts benevolently, i.e., maximizes expected social welfare. We establish, under plausible assumptions, that the social benefit compensation regime is the only regime to generally induce the first best. This result leads to an interesting implication. If the government can only raise capital up to an amount below the social benefit, no optimal compensation regime may be available. Consequently, society may be better off if the government suffers from fiscal illusion.

The chapter is organized as follows. In section 2, we introduce our model of bilateral investment. We then analyze under the assumption that the government is non-benevolent the efficiency of different compensation regimes in section 3. In section 4, we consider, as a benchmark, the situation that the government is benevolent. Section 5 concludes.

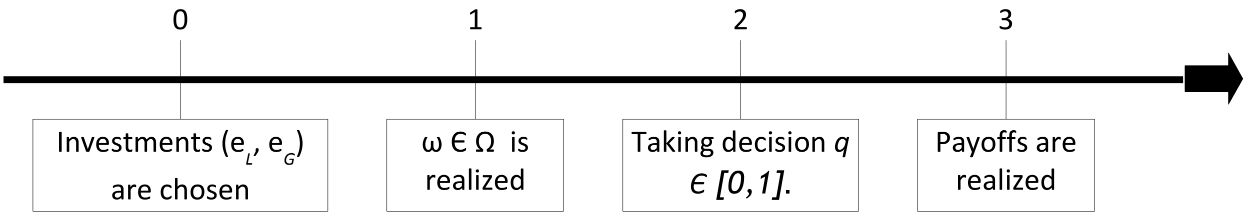

Figure III.1.: Timeline of the model.

2. The model

We consider a model with two risk-neutral parties. A landowner, also referred to as "she", faces the risk that in the future the government or "it" may take her property in order to provide a public good[5] (see Figure III.1). At date 0, before it is known whether a taking occurs, the landowner may invest to increase the expected private value of her property. Likewise, the government invests to increase the expected social value of the public good. We denote the cost of their investments by $e_L \in [0, e_L^{max}]$ and $e_G \in [0, e_G^{max}]$, respectively, and assume that investment is asset-specific. If the government does not take the landowner's property, its investment is lost whereas the landowner's investment is beneficial only in absence of a taking. As an example, consider a farmer who may invest in a new fodder silo or a storehouse. The government may consider using the farmer's land to construct a repository for nuclear waste. Here, the government invests to obtain information about the nature of the ground and to tailor the repository to the geologic conditions of the area.

At date 1, the state of the world $\omega \in \Omega$ is realized. Hence, the landowner's private valuation of her property $(1-q)V(e_L, \omega)$, the social value of the public good $qS(e_G, \omega)$ and the amount of compensation to be paid $qC(e_L, e_G, \omega)$, values that depend on the government's taking decision $q \in \{0, 1\}$, become commonly known. In this decision, to be made at date 2, $q = 0$ means that the landowner keeps her property whereas $q = 1$ implies that it is taken and the public good is supplied. Thus, the property can either be used by the landowner or the government, but not by both at the same time. We assume that the landowner does not draw utility from the provision of the public good.[6] In the next section, we consider the case that the government initiates a taking

[5] The two defining properties of a public good, non-rivalry and non-excludability, are not crucial for our analysis. Therefore, the term "public good" must not be understood in a narrow sense, but describes any good provided by public authorities.

[6] The potential value of the public good to society, $S(e_G, \omega)$, can also be understood as the social benefit of the taking. This expression should not be confused with the social net benefit, $qS(e_G, \omega) - (1-q)V(e_L, \omega)$.

if the amount of compensation it has to pay does not exceed the potential social value of the public good. In contrast, we assume in section 4 that the government takes the property whenever it is socially desirable to do so.

Finally, at date 3, the payoffs are realized. We discuss them in detail in section 3 and 4, for both the non-benevolent and the benevolent government, respectively. Throughout this chapter, we assume that all information but investment is common knowledge and use the following notation and assumptions:

Assumption III.1 For any $e_L \in [0, e_L^{max}]$, $e_G \in [0, e_G^{max}]$ and $\omega \in \Omega$, $V(e_L, \omega) > 0$ and $S(e_G, \omega) > 0$.

Assumption III.2 For any $\omega \in \Omega$, $V(e_L, \omega)$ is monotonically increasing in e_L and $S(e_G, \omega)$ is monotonically increasing in e_G.

It directly follows from Assumption III.2 that the probability that the value of the public good exceeds the landowner's private valuation of her property is increasing in e_G and decreasing in e_L. Let us denote the ex-post social surplus minus investment by

$$W(e_L, e_G, \omega, q) = qS(e_G, \omega) + (1 - q)V(e_L, \omega) - e_L - e_G.$$

For given investments e_L, e_G and state of the world ω, it is maximized by the socially efficient taking decision

$$Q^*(e_L, e_G, \omega) \in \arg\max_{q \in \{0,1\}} W(e_L, e_G, \omega, q).$$

We assume that the efficient investment levels, denoted (e_L^*,e_G^*), uniquely maximize the expected social surplus

$$E[W(e_L, e_G, \omega, Q^*(e_L, e_G, \omega))]$$

in $[0, e_L^{max}] \times [0, e_G^{max}]$ contingent on an efficient taking decision. Let us consider two more benchmarks that will prove useful for our analysis. First, we are interested in the landowner's optimal investment in absence of the risk of a potential taking. This private optimal level, denoted e_L^p, uniquely maximizes

$$E[V(e_L, \omega)] - e_L \tag{III.1}$$

in $[0, e_L^{max}]$. Second, let us consider the case that a taking is always desirable from a social perspective. Then, the government's socially optimal investment level, denoted e_G^p, uniquely maximizes

$$E[S(e_G, \omega)] - e_G \tag{III.2}$$

in $[0, e_G^{max}]$. It is straightforward to show that $e_L^p \geq e_L^*$ and $e_G^p \geq e_G^*$ (see Appendix A.3.1).

3. Non-benevolent government

As correctly observed by Hermalin (1995), one important motive behind the demand for just compensation is to restrain the government from the tyrannical use of its right of eminent domain. The underlying idea is that a government often acts on behalf of the interest of the majority essentially ignoring the interest of a single property owner.[7] In this section, we analyze how commonly proposed compensation regimes perform with respect to efficiency. A regime is socially optimal if the efficient ex-post taking decision by the government and, contingent on that, efficient bilateral investment can be established as an equilibrium. We find that the first best is attainable by a regime that grants as compensation the potential value of the landowner's property had she invested e_L^* ex-ante.

The non-benevolent government internalizes the benefit of the public good but may have to bear compensation costs.[8] Its ex-post payoff minus investment is given by

$$U_G(e_L, e_G, \omega, q) = q[S(e_G, \omega) - C(e_L, e_G, \omega)] - e_G.$$

For given investments (e_L,e_G) and state of the world ω, the government's taking decision solves

$$Q^G(e_L, e_G, \omega) \in \arg\max_{q\in\{0,1\}} U_G(e_L, e_G, \omega, q).$$

Hence, the government initiates a taking whenever the value of the public good exceeds the amount of compensation it has to pay. If a taking occurs, the landowner receives compensation. If not, she enjoys the benefit of her property. Her ex-post payoff minus investment thus amounts to

$$U_L(e_L, e_G, \omega, q) = (1-q)V(e_L, \omega) + qC(e_L, e_G, \omega) - e_L.$$

We can now define the government's private best response to investment of the landowner as

$$e_G^{BR}(e_L) := \arg\max_{e_G\in[0,e_G^{max}]} E[U_G(e_L, e_G, \omega, Q^G(e_L, e_G, \omega))]$$

and the landowner's private best response to investment of the government as

$$e_L^{BR}(e_G) := \arg\max_{e_L\in[0,e_L^{max}]} E[U_L(e_L, e_G, \omega, Q^G(e_L, e_G, \omega))].$$

[7]As an alternative motivation, consider that the power of eminent domain is often used not in order to provide a public good but in the interest of a private enterprise. In the legal literature, there is a debate whether such takings fulfill the public use requirement, cf. Kelly (2006) and Pritchett (2003).

[8]Recall that the government neglects the landowner's interest and therefore does not take the landowner's benefit of compensation into account.

Moreover, we define the socially best response to investment of the landowner as

$$e_G^{SBR}(e_L) := \underset{e_G \in [0, e_G^{max}]}{\arg\max}\ E[W(e_L, e_G, \omega, Q^G(e_L, e_G, \omega))]$$

and the socially best response to investment of the government as

$$e_L^{SBR}(e_G) := \underset{e_L \in [0, e_L^{max}]}{\arg\max}\ E[W(e_L, e_G, \omega, Q^G(e_L, e_G, \omega))].$$

In United States Case Law, just compensation is usually interpreted as fair market value (Miceli and Segerson, 2007, p. 277). Let us interpret fair market value as the value of the landowner's property in absence of a taking, $C(e_L, e_G, \omega) = V(e_L, \omega)$. Under a regime that grants fair market value, henceforth full compensation regime (see Blume et al. (1984)), the landowner's ex-post payoff minus investment amounts to

$$U_L^{FC}(e_L, e_G, \omega, q) = V(e_L, \omega) - e_L.$$

The government's payoff amounts to ex-post social surplus minus the landowner's payoff. It is given by

$$U_G^{FC}(e_L, e_G, \omega, q) = W(e_L, e_G, \omega, q) - [V(e_L, \omega) - e_L] = q[S(e_G, \omega) - V(e_L, \omega)] - e_G.$$

We can derive the following proposition:

Proposition III.1: *Under the full compensation regime, in any subgame-perfect equilibrium: (i) The government's taking decision is efficient, $Q^G(e_L, e_G, \omega) = Q^*(e_L, e_G, \omega)$. (ii) The landowner invests as if there was no risk of taking and irrespectively of the government's investment, $e_L^{BR}(e_G) = e_L^p \geq e_L^*$ for all $e_G \in [0, e_G^{max}]$. (iii) The government chooses a socially best response to the landowner's investment, $e_G \in e_G^{SBR}(e_L^p)$.*

Proof. (i) The government's taking decision is efficient, $Q^G(e_L, e_G, \omega) = Q^*(e_L, e_G, \omega)$, because it initiates a taking whenever $S(e_G, \omega) \geq V(e_L, \omega)$. (ii) The second statement is true because the landowner's expected payoff

$$E[V(e_L, \omega)] - e_L$$

is equivalent to the one in absence of the risk of a taking (see equation (III.1)). (iii) Taking into account the landowner's investment and its own ex-post taking decision, $Q^G(e_L, e_G, \omega) = Q^*(e_L, e_G, \omega)$, the government's expected payoff is given by

$$E[W(e_L^p, e_G, \omega, Q^*(e_L^p, e_G, \omega))] - E[V(e_L^p, \omega)] + e_L.$$

Since $E[V(e_L^p, \omega)] - e_L$ does not depend on the government's investment, it chooses a socially best response to the landowner's investment. ∎

For the landowner, we get the same overinvestment result as in Blume et al. (1984). She overinvests because she is fully insured and hence does not take those states of the world into account where a taking is socially desirable. The government, however, chooses the efficient ex-post taking decision and even the socially best response to the landowner's investment. This is the case because the government is in the position of a residual claimant of the bilateral relationship. It receives total social surplus minus the value of the landowner's property, a term that is constant with respect to the government's investment. Thus, even though the landowner overinvests, the full compensation regime may not be as undesirable as in Blume et al. (1984).

Perhaps the best known result of Blume et al. (1984) is that if no compensation is paid, the first best can be attained if the landowner's investment does not influence the probability of a taking.

Under the no compensation regime, the landowner's ex-post payoff minus investment amounts to

$$U_L^{NC}(e_L, e_G, \omega, q) = (1-q)V(e_L, \omega) - e_L.$$

Since the government has to pay no compensation and neglects the landowner's interest, its payoff is given by

$$U_G^{NC}(e_L, e_G, \omega, q) = qS(e_G, \omega) - e_G = W(e_L, e_G, \omega, q) - (1-q)V(e_L, \omega) + e_L.$$

We can establish the following proposition:

Proposition III.2: *Under the no compensation regime, in any subgame-perfect equilibrium: (i) The government always initiates a taking, $Q^G(e_L, e_G, \omega) = 1$. (ii) Consequently, the landowner does not invest at all, $e_L^{BR}(e_G) = 0$ for all $e_G \in [0, e_G^{max}]$. (iii) The government chooses a socially best response to the landowner's investment, $e_G \in e_G^{SBR}(0)$.*

Proof. (i) The first claim is true because $S(e_G, \omega) > 0$. (ii) Because the landowner's expected payoff is equivalent to

$$E[U_L^{NC}(e_L, e_G, \omega, 1)] = -e_L,$$

she does not invest at all. (iii) Taking into account the landowner's investment and its own ex-post taking decision, $Q^G(e_L, e_G, \omega) = 1$, the government's expected payoff is given by

$$E[W(0, e_G, \omega, 1)] - E[0V(0, \omega)] + e_L = E[W(0, e_G, \omega, 1)] + e_L.$$

Thus, given that a taking occurs with certainty, the government plays a socially best response. ∎

In contrast to Blume et al. (1984), the no compensation regime performs poorly in our setting. The government always takes the landowner's property and therefore induces her to not invest at all. The government's investment corresponds to our third benchmark where a taking is always socially desirable, $e_G^{BR}(e_L) = e_G^p$. Note that e_G^p is generally not a socially best response to efficient investment of the landowner (see Appendix A.3.1). It is, however, an optimal choice if takings occur with certainty.

Hermalin (1995) shows, in a setting where the state is non-benevolent but only the landowner invests, that the first best can be induced by a regime that grants the landowner as compensation the social benefit of the taking, $C(e_L, e_G, \omega) = S(e_G, \omega)$. Under this regime, henceforth social benefit compensation regime, the landowner's ex-post payoff minus investment amounts to

$$U_L^{SBC}(e_L, e_G, \omega, q) = (1-q)V(e_L, \omega) + qS(e_G, \omega) - e_L = W(e_L, e_G, \omega, q) + e_G.$$

And hence the government's payoff is given by

$$U_G^{SBC}(e_L, e_G, \omega, q) = -e_G.$$

In principle, the government is indifferent between initiating a taking or not. We can then establish the following proposition:

Proposition III.3: *Under the social benefit compensation regime, assuming that the government initiates a taking whenever it is socially desirable, in any subgame-perfect equilibrium: (i) The government does not invest at all,* $e_G^{BR}(e_L) = 0$ *for all* $e_L \in [0, e_L^{max}]$*. (ii) The landowner chooses a socially best response to the government's investment,* $e_L \in e_L^{SBR}(0)$*.*

Proof. (i) Obvious. (ii) The landowner's expected payoff amounts to

$$E[W(e_L, 0, \omega, Q^*(0, e_L, \omega))] + e_G.$$

Hence, she chooses a socially optimal best response. ■

In contrast to Hermalin (1995), the social benefit compensation regime performs poorly in our setting. The government does not internalize any benefit of its investment and thus has no incentive to invest. Suppose that the landowner receives as compensation some fraction $\alpha \in (0, 1)$ from the social benefit of the taking. Because $(1-\alpha)S(e_G, \omega) > 0$, the non-benevolent government always initiates a taking. Since the landowner's investment does not influence the value of the public good, she has no incentive to invest.

We have established that all standard compensation regimes fail to induce the first best. Consider a regime, henceforth referred to as social optimal property value compensation regime, where the landowner receives as compensation the hypothetical value of her property had she invested efficiently, $C(e_L, e_G, \omega) = V(e_L^*, \omega)$. Under this regime, the landowner receives:

$$\begin{aligned} U_L^{SOPVC}(e_L, e_G, \omega, q) &= (1-q)V(e_L, \omega) + qV(e_L^*, \omega) - e_L \\ &= W(e_L, e_G, \omega, q) - qS(e_G, \omega) + qV(e_L^*, \omega) + e_G. \end{aligned}$$

Consequently, the government's payoff is given by

$$\begin{aligned} U_G^{SOPVC}(e_L, e_G, \omega, q) &= q[S(e_G, \omega) - V(e_L^*, \omega)] - e_G \\ &= qS(e_G, \omega) - V(e_L^*, \omega) + (1-q)V(e_L^*, \omega) - e_G \\ &= W(e_L^*, e_G, \omega, q) - V(e_L^*, \omega) + e_L^*. \end{aligned}$$

This allows us to establish the main proposition of this chapter:

Proposition III.4: *Under the social optimal property value compensation regime, the socially efficient investment levels (e_L^*, e_G^*) and the socially efficient ex-post taking decision $Q^G(e_L^*, e_G^*, \omega) = Q^*(e_L^*, e_G^*, \omega)$ constitute the unique subgame-perfect equilibrium outcome.*

Proof. The government initiates a taking whenever $S(e_G, \omega) \geq V(e_L^*, \omega)$. We can therefore write the government's ex-post taking decision as $Q^G(e_L, e_G, \omega) = Q^*(e_L^*, e_G, \omega)$.

Let us establish that $e_G = e_G^*$ is the unique best response to any investment of the landowner. The government's expected payoff is given by

$$E[W(e_L^*, e_G, \omega, Q^*(e_L^*, e_G, \omega))] - E[V(e_L^*, \omega)] + e_L^*$$

Because (e_L^*, e_G^*) uniquely maximize expected welfare and $E[V(e_L^*, \omega)] + e_L^*$ does not depend on the government's investment, e_G^* uniquely maximizes the government's expected payoff.

Given the government's taking decision and investment, the landowner's expected payoff amounts to

$$E[W(e_L, e_G^*, \omega, Q^*(e_L^*, e_G^*, \omega))] - E[Q^*(e_L^*, e_G^*, \omega)(S(e_G^*, \omega) + V(e_L^*, \omega))] + e_G^*.$$

To check that $e_L = e_L^*$ is the unique best response, we show that it maximizes $E[W(e_L, e_G^*, \omega, Q^*(e_L^*, e_G^*, \omega))]$. Take any $e_L \neq e_L^*$, then it must hold that

$$\begin{aligned} &E[W(e_L^*, e_G^*, \omega, Q^*(e_L^*, e_G^*, \omega))] \\ >&E[W(e_L, e_G^*, \omega, Q^*(e_L, e_G^*, \omega))] \\ \geq&E[W(e_L, e_G^*, \omega, Q^*(e_L^*, e_G^*, \omega))]. \end{aligned} \tag{III.3}$$

The first inequality follows from e_L^* and e_G^* being unique welfare maximizers. The second and the third line of (III.3) only differ in the ex-post taking decision. Because the taking decision is socially optimal and conditions on true investment in the second line but on e_L^* in the third line, the second inequality must hold. We have established that e_L^* is the unique best response to e_G^*, which proves the claim. ■

The intuition behind our main result is the following. The government takes the property whenever the compensation it has to pay is less than or equal to the social benefit of the taking. Since compensation is equivalent to the hypothetical value of the landowner's property had she invested e_L^*, the taking decision depends on the government's but not on the landowner's investment. If the government invests $e_G = e_G^*$, it initiates a taking in exactly the same states of the world a benevolent social planner would do so. Consequently, the landowner internalizes the benefit of her investment with exactly the same probability as in the first best. Therefore $e_L = e_L^*$ is the unique best response to efficient investment of the government. If the landowner invests efficiently, the government receives expected social surplus minus the landowner's benefit, a term that is constant with respect to the government's investment. Because e_G^* is the socially best response to e_L^*, it must also be the best response for the government.

Having derived that the social optimal property compensation rule induces the first best, we can establish the following theorem:

Theorem III.1: *The investment levels induced by the compensation regimes discussed in this section can be ranked in the following way:*[9]

$$\forall e_L \in e_L^{SBC} : e_L^{FC} = e_L^p \geq e_L \geq e_L^{SOPVC} = e_L^* \geq e_L^{NC} = 0 \tag{III.4}$$

$$\forall e_G \in e_G^{FC} : e_G^{NC} = e_G^p \geq e_G^{SOPVC} = e_G^* \geq e_G \geq e_G^{SBC} = 0. \tag{III.5}$$

All regimes other than the SOPVC regime, can, however, not be ranked with respect to their welfare properties.

Proof. See Appendix A.3.2. ■

Any regime other than the SOPVC regime fails to induce the first best in different respects. Under different parameter constellations, the size of these inefficiencies may vary greatly. Hence, any of these regimes may outperform the other two.

Our main result suggests that if one believes that the government neglects the interest of the landowner, compensation should not be based on actual but on socially optimal investment. Blume et al. (1984), who assume that the government is benevolent,

[9] Here, the notation is as follows. The landowner's optimal investment level under the full compensation regime is denoted by e_L^{FC}. Because the landowner's optimal investment need not be unique under the social benefit compensation regime, e_L^{SBC} denotes the set of optimal investment levels under this regime. The remaining variables are defined in a similar way, where SOPVC stands for social optimal property value compensation and NC for no compensation.

derive a related result. If the government can commit to initiate a taking whenever the social benefit of the taking is higher than the hypothetical value of the landowner's property had she invested efficiently, any lump sum compensation plan induces the landowner to invest according to the first best. Thus, the benevolent government would like to commit itself to exactly the same ex-post taking decision the non-benevolent government chooses out of its own interest. Next section, we consider the situation that the government is benevolent but cannot commit to any ex-post taking decision.

4. Benevolent government

In this section, the government's interest coincides with those of a benevolent social planner. We consider a wide class of compensation regimes and derive that, under certain plausible assumptions, the social benefit compensation regime is the only one to generally induce the first best. The government's ex-post payoff minus investment is equivalent to ex-post social welfare minus investment. It is given by

$$U_G(e_L, e_G, \omega, q) = qS(e_G, \omega) + (1 - q)V(e_L, \omega) - e_L - e_G.$$

The government uses its right of eminent domain whenever it is socially desirable to do so, $Q^G(e_L, e_G, \omega) = Q^*(e_L, e_G, \omega)$. At the investment stage, it chooses the socially best response to the investment strategy of the landowner contingent on its own ex-post taking decision. Consequently, the first best can be established as an equilibrium whenever the landowner's investment constitutes a socially best response to the government's investment. The landowner's ex-post payoff minus investment is the same as in the previous section. It amounts to

$$U_L(e_L, e_G, \omega, q) = (1 - q)V(e_L, \omega) + qC(e_L, e_G, \omega) - e_L.$$

In the following, we only consider compensation regimes that are non-punishing. In any state of the world $\omega \in \Omega$, the amount of compensation paid to the landowner $C(e_L, e_G, \omega)$, is non-decreasing in e_L. The rationale behind this restriction is that the idea behind compensation is to protect but not to punish the landowner. Moreover, let us assume that compensation may not exceed the social benefit of the taking, $C(e_L, e_G, \omega) \leq S(e_G, \omega)$ for all $\omega \in \Omega$. The government may be wealth-constrained or public pressure may prevent an exceedingly high amount of compensation. We establish the following proposition:

Proposition III.5: *If compensation is non-punishing and may not exceed the social benefit of the taking, only the social benefit compensation regime,* $C(e_L, e_G, \omega) = S(e_G, \omega)$*, generally induces the first best. Any other regime induces that the landowner's best response to efficient investment of the government is to overinvest,* $\forall e_L \in e_L^{BR}(e_G^*)$*,* $e_L \geq e_L^*$*.*

Proof. For ease of notation, let us omit the arguments e_G^* and ω. The landowner's expected payoff is given by

$$\begin{aligned} E[U_L(e_L)] =& E[(1 - Q^*(e_L))V(e_L)] + E[Q^*(e_L)C(e_L)] - e_L \\ =& E[W(e_L, Q^*(e_L))] - \{E[Q^*(e_L)(S - C(e_L))] + e_G^*\}. \end{aligned} \tag{III.6}$$

Under the social benefit compensation regime, (III.6) coincides with expected social welfare. Thus, the landowner has efficient incentives to invest. Let us consider any other compensation regime and assume that there exists some $e_L < e_L^*$ such that $E[U_L(e_L)] \geq E[U_L(e_L^*)]$. Because expected social surplus is uniquely maximized by e_L^* and e_G^*, this can only be the case if

$$-E[Q^*(e_L)(S - C(e_L))] > -E[Q^*(e_L^*)(S - C(e_L^*))].$$

Let us subtract $E[Q^*(e_L^*)C(e_L)]$ from both sides of the inequality. This term represents the hypothetical expected value of compensation if the landowner invests e_L, but the government bases its taking decision on e_L^*. After reorganizing, we get

$$\begin{aligned} & E[Q^*(e_L^*)S] - E[Q^*(e_L)S] + \\ & E[Q^*(e_L)C(e_L)] - E[Q^*(e_L^*)C(e_L)] > E[Q^*(e_L^*)C(e_L^*)] - E[Q^*(e_L^*)C(e_L)]. \end{aligned} \tag{III.7}$$

The right-hand side of (III.7) is greater or equal than zero because the expected amount of compensation is non-decreasing in e_L. After reorganizing, observe that the left hand-side can only be positive if

$$-E[(Q^*(e_L) - Q^*(e_L^*))(S - C(e_L))] > 0. \tag{III.8}$$

In equation (III.8) we consider the expected value of the social benefit of the taking minus compensation in all states of the world where a taking occurs if the decision is based on e_L, but not if it is based on e_L^*. The left-hand side of (III.8) is negative because in any state it must hold that compensation does not exceed the social benefit of the taking. If compensation is equivalent to the social benefit of the taking in all states, the regime must coincide with the social benefit compensation regime. Thus, under any other regime, (III.8) is violated and therefore $\forall e_L \in e_L^{BR}(e_G^*), e_L \geq e_L^*$.[10] ■

[10] For any regime other than the social benefit compensation regime it is always possible to construct an example where $e_L^{BR}(e_G^*) > e_L^*$. In such an example, it must hold that $E[(Q^*(e_L) - Q^*(e_L^*))C(e_L)] << E[(Q^*(e_L) - Q^*(e_L^*))S]$.

The intuition behind Proposition III.5 is straightforward. The landowner has an incentive to overinvest for two reasons. First, in contrast to the objective of a benevolent social planner, the landowner's investment may increase her expected amount of compensation whereas it does not affect the value of the public good. Second, if a taking occurs, the landowner receives an amount of compensation that is generally less than the social benefit of the taking. She thus has an incentive to overinvest to reduce the probability that the government takes her property. Under the social benefit compensation regime both sources of inefficiency do not exist. Consequently, the landowner has efficient incentives to invest.

All rules we examined in the previous section are included in the class of compensation regimes considered in Proposition III.5. The classical Blume et al. (1984) no compensation result is connected to Proposition III.5 in the following way: If the probability of a taking is independent of investment, any compensation regime under which investment does not influence the expected amount of compensation induces the first best. In that case, in equation (III.6) the term in the braces does not depend on the landowner's investment. Hence, her investment incentives coincide with those of a benevolent social planner.

5. Conclusion

This chapter considers a situation where the government has the power to take private property. If due compensation is paid, incentives are often distorted. This literature has begun blooming with the seminal work by Blume et al. (1984).

Perhaps our most interesting finding is that social welfare may be higher under the non-benevolent government. If the government is benevolent, only the social benefit compensation regime is generally able to induce the first best. If, however, the government is wealth-constrained, i.e., can only raise capital up to a certain amount that lies below the social benefit of the taking, the social benefit compensation regime is not available. Thus, there may not exist any compensation regime to induce the first best. If the government is non-benevolent, optimal compensation is equivalent to the hypothetical value of the landowner's property had she invested efficiently. This amount of compensation is, given that a taking occurs, generally less than the social benefit of the taking. Consequently, if the government is wealth constrained, society may be better off if the government disregards the interest of the landowner.

According to U.S. law, one of the main motives behind compensation is that compensation should be just. If the government is non-benevolent, the optimal compensation regime grants to the landowner, in equilibrium, exactly the value of her property. In other words, she is perfectly insured against the government's power of eminent domain. Under the social benefit compensation regime, which is the only regime to be generally optimal if the government is benevolent, the landowner receives the value of the public good. Obviously, this amount may exceed the private value of the landowner's property by far.

It is also important to emphasize that one should distinguish between two forms of public actions. First, law constitutes a set of rules that both the government and the landowner have to follow. Of course, one of the main goals of law should be to maximize social welfare. In contrast, the government's objectives may, as we explained, not coincide with those of a benevolent social planner.

For future research, it seems to be an interesting prospect to consider a setting where the government is non-benevolent but subject to judicial control with respect to the necessity of the taking. Ex-post, the government may only initiate a taking whenever it is socially desirable. Ex-ante, however, the government invests to maximize the difference between the social benefit of the taking and the amount of compensation it has to pay.

A. Appendices

1. Appendix to Chapter I

1.1. Proofs of Propositions and Lemmas

Proof of Proposition I.1 (i).

If the buyer announces acceptance of the good, the parties receive their respective trade surpluses, $p-c$ and $v-p$, and share the potential renegotiation surplus with the seller receiving $\alpha[c-v]^{+}$. If the buyer announces refusal of the good, the seller's investment serves as a threat point during renegotiation. The parties share a potential renegotiation surplus with the seller receiving $\alpha[v-c]^{+}$. Hence the buyer announces breach if

$$-e+(1-\alpha)[v-c]^{+} > v-p+(1-\alpha)[c-v]^{+} \tag{A.1}$$

or equivalently

$$v < \hat{v} \equiv min\ [\frac{p-e-c}{\alpha}+c,\ v_h]. \tag{A.2}$$

Anticipating this, the seller expects to receive the following payoff at date 1:

$$\begin{aligned} U^{RD}(e) &= \int_{c_l}^{c_h}\int_{0}^{\hat{v}}(e+\alpha[v-c]^{+})F_v(v|e)dv\ G_c(c|e)\ dc \\ &+ \int_{c_l}^{c_h}\int_{\hat{v}}^{v_h}(p-c+\alpha[c-v]^{+})F_v(v|e)dv\ G_c(c|e)\ dc - e \\ &= \int_{c_l}^{c_h}\{[p-e-c][1-F(\hat{v}|e)]+\alpha\int_{0}^{\hat{v}}[v-c]^{+}F_v(v|e)\ dv \\ &+ \alpha\int_{\hat{v}}^{v_h}[c-v]^{+}F_v(v|e)dv\}G_c(c|e)\ dc. \end{aligned} \tag{A.3}$$

The term inside {...} can be rewritten as:

$$\alpha \int_0^{\hat{v}} [v-c]^+ F_v(v|e)\ dv + \alpha \int_0^{v_h} [c-v]^+ F_v(v|e)\ dv \tag{A.4}$$

$$- \alpha \int_0^{\hat{v}} [c-v]^+ F_v(v|e)\ dv + [p-e-c][1-F(\hat{v}|e)]$$

$$= \alpha \int_0^{\hat{v}} (v-c) F_v(v|e)\ dv + \alpha \int_0^{v_h} [c-v]^+ F_v(v|e)\ dv + [p-e-c][1-F(\hat{v}|e)]$$

$$= \alpha \int_0^{\hat{v}} (v-c) F_v(v|e)\ dv - \alpha \int_0^{c} (v-c) F_v(v|e)\ dv + [p-e-c][1-F(\hat{v}|e)]$$

$$= \alpha \int_c^{\hat{v}} (v-c) F_v(v|e)\ dv + [p-e-c][1-F(\hat{v}|e)].$$

Integration by parts yields,

$$\alpha(\hat{v}-c)F(\hat{v}|e) - \alpha \int_c^{\hat{v}} F(v|e)\ dv + [p-e-c][1-F(\hat{v}|e)]. \tag{A.5}$$

Using (A.5) we can rewrite (A.3) as

$$U^{RD}(e) = \int_{c_l}^{c_h} \{[p-e-c][1-F(\hat{v}|e)] + \alpha(\hat{v}-c)F(\hat{v}|e) - \alpha \int_c^{\hat{v}} F(v|e)\ dv\} G_c(c|e)\ dc \tag{A.6}$$

$$= \int_{c_l}^{c_h} \{p-e-c + F(\hat{v}|e)\ \alpha[\hat{v} - (\frac{p-e-c}{\alpha} + c)] - \alpha \int_c^{\hat{v}} F(v|e)\ dv\} G_c(c|e)\ dc.$$

Applying integration by parts again yields,

$$U^{RD}(e) = [\{p-e-c-\alpha \int_c^{\hat{v}} F(v|e)\ dv\} G(c|e)]_{c_l}^{c_h} + \int_{c_l}^{c_h} G(c|e)\ dc \tag{A.7}$$

$$- \alpha \int_{c_l}^{c_h} F(c|e)G(c|e)\ dc + \alpha \int_{c_l}^{c_h} \frac{d\hat{v}}{dc}\ F(\hat{v}|e)G(c|e)\ dc$$

$$+ \int_{c_l}^{c_h} F(\hat{v}|e)\ \alpha[\hat{v} - (\frac{p-e-c}{\alpha} + c)]\ G_c(c|e)\ dc.$$

As an intermediate step, we can simplify the term in the last line of (A.7):

$$\int_{c_l}^{c_h} F(\hat{v}|e)\ \alpha[\hat{v} - (\frac{p-e-c}{\alpha} + c)]\ G_c(c|e)\ dc. \tag{A.8}$$

First we define $\hat{c} \equiv \frac{p-e-\alpha v_h}{1-\alpha}$. Note that $c < \hat{c}$ implies $\hat{v} = v_h$, whereas $c > \hat{c}$ implies $\hat{v} = \frac{p-e-c}{\alpha} + c$. In the latter case (A.8) is equal to zero. Thus, we can rewrite (A.8):

$$\int_{c_l}^{\hat{c}} [\alpha v_h - p + e + (1-\alpha)c]\ G_c(c|e)\ dc \tag{A.9}$$

$$= (1-\alpha) \int_{c_l}^{\hat{c}} [\frac{\alpha v_h - p + e}{1-\alpha} + c]\ G_c(c|e)\ dc$$

$$= (1-\alpha) \int_{c_l}^{\hat{c}} (c-\hat{c})\ G_c(c|e)\ dc.$$

Using (A.9) we can rewrite (A.7):

$$
\begin{aligned}
U^{RD}(e) = {} & [\{p-e-c-\alpha \int_{c}^{\hat{v}} F(v|e)\ dv\}G(c|e)]_{c_l}^{c_h} + \int_{c_l}^{c_h} G(c|e)\ dc \\
& - \alpha \int_{c_l}^{c_h} F(c|e)G(c|e)\ dc + \alpha \int_{c_l}^{c_h} \frac{d\hat{v}}{dc}\ F(\hat{v}|e)G(c|e)\ dc \\
& + (1-\alpha)\int_{c_l}^{\hat{c}} (c-\hat{c})\ G_c(c|e)\ dc.
\end{aligned} \tag{A.10}
$$

Let $\tilde{v} \equiv \frac{p-e-c_h}{\alpha} + c_h$ and note that $\frac{d\hat{v}}{dc} = 0$ if $c < \hat{c}$. Then we can rewrite (A.10):

$$
\begin{aligned}
U^{RD}(e) = {} & p-e-c_h-\alpha \int_{c_h}^{\tilde{v}} F(v|e)\ dv + \int_{c_l}^{c_h} G(c|e)\ dc \\
& - \alpha \int_{c_l}^{c_h} F(c|e)G(c|e)\ dc - (1-\alpha)\int_{\hat{c}}^{c_h} F(\hat{v}|e)G(c|e)\ dc \\
& + (1-\alpha)\{[(c-\hat{c})G(c|e)]_{c_l}^{\hat{c}} - \int_{c_l}^{\hat{c}} G(c|e)\ dc\} \\
= {} & p-e-c_h-\alpha \int_{c_h}^{\tilde{v}} F(v|e)\ dv + \int_{c_l}^{c_h} G(c|e)\ dc \\
& - \alpha \int_{c_l}^{c_h} F(c|e)G(c|e)\ dc - (1-\alpha)\int_{\hat{c}}^{c_h} F(\hat{v}|e)G(c|e)\ dc \\
& - (1-\alpha)\int_{c_l}^{\hat{c}} G(c|e)\ dc.
\end{aligned} \tag{A.11}
$$

The seller's optimal investment level, e^{RD}, is represented by the following first-order condition:

$$
\begin{aligned}
U_e'^{RD}(e^{RD}) = {} & F(\tilde{v}|e^{RD}) - \alpha \int_{c_h}^{\tilde{v}} F_e(v|e^{RD})\ dv + \int_{c_l}^{c_h} G_e(c|e^{RD})\ dc \\
& - \alpha \int_{c_l}^{c_h} [F_e(c|e^{RD})G(c|e^{RD}) + F(c|e^{RD})G_e(c|e^{RD})]\ dc \\
& - (1-\alpha)\int_{\hat{c}}^{c_h} [F_e(\hat{v}|e^{RD}) - \frac{1}{\alpha}F_v(\hat{v}|e^{RD})]\ G(c|e^{RD})\ dc \\
& - (1-\alpha)\int_{\hat{c}}^{c_h} F(\hat{v}|e^{RD})G_e(c|e^{RD})\ dc + [1-F(\hat{v}|e^{RD})]G(\hat{c}|e^{RD}) \\
& - (1-\alpha)\int_{c_l}^{\hat{c}} G_e(c|e^{RD})\ dc - 1 = 0.
\end{aligned} \tag{A.12}
$$

■

Proof of Proposition I.1 (iii).

We have already shown in the main text that the seller overinvests relative to the socially optimal level if $p = 0$ has been specified in contract and condition (I.9) holds. We now show that the seller will not invest less than $e^{\overline{RD}}$, if a positive price has been specified in contract. Consider the limit of (I.7) as α goes to zero:

$$\begin{aligned}\lim_{\alpha\to 0} U'^{RD}(e^{RD}) &= F(\tilde{v}|e^{RD}) + \int_{c_l}^{c_h} G_e(c|e^{RD})\ dc \\ &- \int_{\hat{c}}^{c_h} [F_e(\hat{v}|e^{RD}) - \infty F_v(\hat{v}|e^{RD})]\ G(c|e^{RD})\ dc \\ &- \int_{\hat{c}}^{c_h} F(\hat{v}|e^{RD}) G_e(c|e^{RD})\ dc + [1 - F(\hat{v}|e^{RD})]G(\hat{c}|e^{RD}) \\ &- \int_{c_l}^{\hat{c}} G_e(c|e^{RD})\ dc - 1 = 0.\end{aligned} \tag{A.13}$$

Fixing $e = e^{\overline{RD}}$ and considering U'^{RD} as a function of p, the seller will invest at least $e^{\overline{RD}}$ if $U'^{RD}(p) \geq 0$ for all $p > 0$.[1] After reorganizing, $U'^{RD}(p) \geq 0$ for all $p > 0$ is equivalent to the following condition:

$$\begin{aligned}\lim_{\alpha\to 0} U'^{RD}(p) &= F(\tilde{v}|e^{\overline{RD}}) + [1 - F(\hat{v}|e^{\overline{RD}})]G(\hat{c}|e^{\overline{RD}}) \\ &- \int_{\hat{c}}^{c_h} [F_e(\hat{v}|e^{\overline{RD}}) - \infty F_v(\hat{v}|e^{\overline{RD}})]\ G(c|e^{\overline{RD}})\ dc \\ &+ \int_{\hat{c}}^{c_h} [1 - F(\hat{v}|e^{\overline{RD}})]G_e(c|e^{\overline{RD}})\ dc \geq 1 \ \ \forall\, p > 0.\end{aligned} \tag{A.14}$$

Recall that $c \geq \hat{c}$ implies $\hat{v} = \frac{p-e-c}{\alpha} + c \leq v_h$. Then, the term in the second line makes sure that condition (A.14) holds unless $\hat{v} \leq 0$ or $\hat{c} \geq c_h$ for all c. In the latter two cases, the term in the second line is equal to zero. Hence, what is left is to show is that condition (A.14) holds if $\hat{v} \leq 0$ or $\hat{c} \geq c_h$. First, since $\hat{v} \leq 0$ must hold for all c it must in particular hold for $c = c_l$.This implies that

$$\frac{p - e^{\overline{RD}} - c_l}{\alpha} + c_l \leq 0 \Leftrightarrow c_l \geq \frac{p - e^{\overline{RD}}}{(1-\alpha)}. \tag{A.15}$$

Now since $p - e^{\overline{RD}} > p - e^{\overline{RD}} - \alpha v_h$, we can conclude that

$$c_l = \frac{p - e^{\overline{RD}}}{(1-\alpha)} > \frac{p - e^{\overline{RD}} - \alpha v_h}{(1-\alpha)} \equiv \hat{c}. \tag{A.16}$$

Then the last term of (A.14) is equal to 1 and because the other terms are all nonnegative, condition (A.14) must hold. The last step is to prove that condition (A.14) holds if $\hat{c} \geq c_h$. This case directly implies that

$$p \geq e^{\overline{RD}} + c_h. \tag{A.17}$$

[1] Strict quasi-concavity of U^{RD} in e for all p ensures that $U^{RD}$is single peaked. Then $U'^{RD}(p) \geq 0$ ensures that the seller invests at least $e = e^{\overline{RD}}$ for a given p.

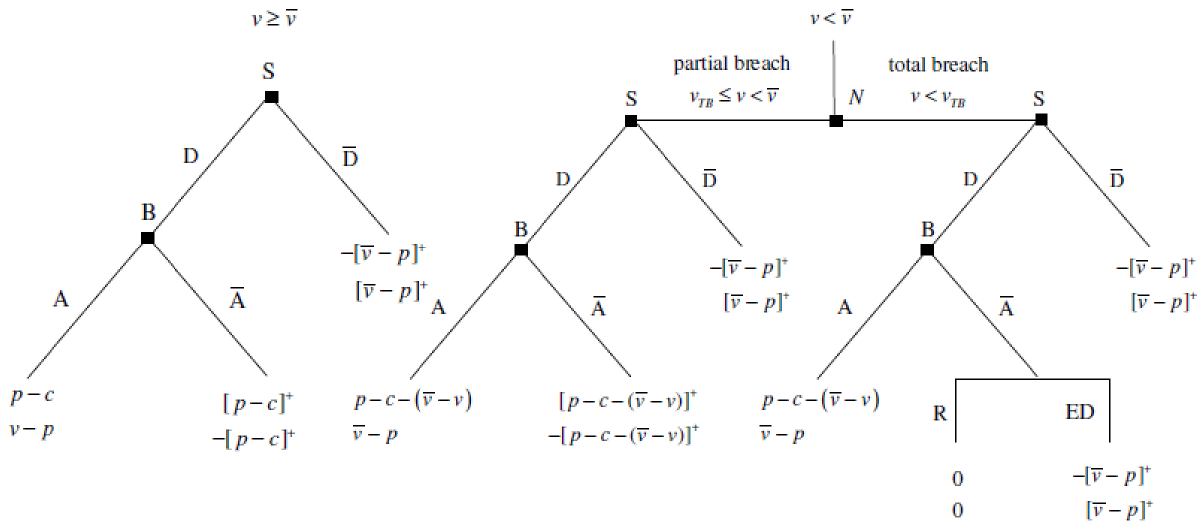

Figure A.1.: Expectation damages without renegotiation if the buyer can breach.

But if (A.17) holds, $F(\tilde{v}|e^{\overline{RD}}) = 1$ must be true. Then again, because all other terms are nonnegative, condition (A.14) must hold. Hence condition (A.14) holds for all $p > 0$ and we have shown that the seller will invest at least $e^{\overline{RD}}$ if $p > 0$ has been specified in the contract. Since $e^{\overline{RD}} > e^*$, the seller will overinvest relative to the socially efficient level for any price. ■

1.2. Allowing for Buyer's breach

Expectation damages without renegotiation

Rather than assuming *ad hoc* that the buyer never breaches the contract under expectation damages, we now show that legal remedies of contract law always induce the buyer to accept delivery.

If quality is conforming, non-acceptance ($\bar{A}$) of the seller's good constitutes breach. Hence, the seller can recover damages of $[p - c]^+$ (Figure A.1). The buyer will accept the good if

$$v - p \geq -[p - c]^+ \Leftrightarrow v \geq \begin{cases} p & \text{if } p \leq c \\ c & \text{otherwise} \end{cases} . \tag{A.18}$$

The natural assumption, $\bar{v} > p$, implies that (A.18) must hold. The first case, $p \leq c$, must hold because $v \geq \bar{v} > p$. The second case can only occur if $p > c$. Then, since $v \geq \bar{v} > p$ it must hold that $v > c$. Hence, the buyer will accept delivery in equilibrium.

If, on the other hand, the seller breaches by either refusing delivery or by delivering a good of non-conforming quality, we need to consider two cases. This is because, under the substantial performance doctrine of common law, different remedies will be available depending on whether the non-conformity is only partial or amounts to total breach. Let us define partial breach as a realization of v which is lower than the quality threshold $\bar{v}$ but greater than or equal to some cut-off value v_{TB}. Similarly, let total breach be defined as a realization of v which is lower than v_{TB} (non-delivery is always considered to be total breach).

Non-conformity constitutes partial breach, $v_{TB} \leq v < \bar{v}$.

If quality is non-conforming but breach due to non-conforming quality is only partial, $v_{TB} \leq v < \bar{v}$, the buyer is only allowed to demand damages for partial breach. Therefore, if the buyer rejects, the supplier can recover damages of $[p - c - (\bar{v} - v)]^+$. For $\bar{v} > p$, we see that $\bar{v} - p > 0 \geq -[p - c - (\bar{v} - v)]^+$. Hence the buyer will accept delivery.

Non-conformity constitutes total breach, $v < v_{TB}$.

If the non-conformity amounts to total breach, $v < v_{TB}$, the buyer can terminate the contract and ask for restitution (R) to recover any progress payment that he might have made to the seller. As the good has no value to the seller, both parties receive zero payoff. Alternatively, the buyer can recover damages for total breach, $[\bar{v} - p]^+$. Hence the buyer will receive $\bar{v} - p$ if he accepts the good and since we assume $\bar{v} > p$, he will also receive $\bar{v} - p$ if he rejects the good. Assuming the buyer accepts if he is indifferent, the buyer will accept delivery in equilibrium.

Expectation damages with renegotiation

If we assume that parties renegotiate towards the ex-post efficient trade decision, adjustments to the payoffs in Figure A.1 need to be made. For example, if the buyer rejects the seller's good when trade is efficient, $v > c$, the parties renegotiate and split the resulting surplus, $v - c$, according to their respective bargaining powers. Similarly, the parties will renegotiate if the buyer accepts the good, even though $c > v$. We make one additional and crucial assumption with respect to v_{TB}, which we did not need in the case where renegotiation was ruled out: Under the substantial performance doctrine of common law, the buyer may only treat the non-conformity as total breach if $v < v_{TB} \leq \bar{v}$. In civil law countries a similar provision requires non-conformity to be "fundamental". One test to determine if non-conformity can be treated as total breach is whether or not the buyer still has an *interest* in the good despite non-conformity (in this case the non-conformity is only partial). We assume that the court will conclude that such an interest exists whenever the parties would freely renegotiate to trade: $v > c$. This implies setting $v_{TB} = c$ (see Figure A.2).[2]

Conforming quality, $v \geq \bar{v} > v_{TB} = c$.

[2]Note that we continue to assume that $p \leq \bar{v}$. This allows us to simplify payoffs.

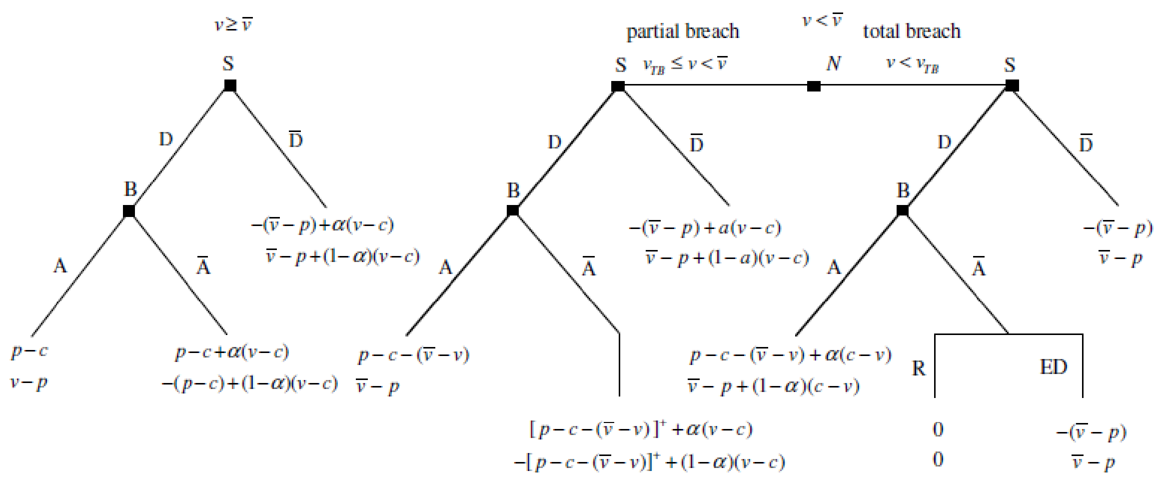

Figure A.2.: Expectation damages with renegotiation if the buyer can breach.

The buyer will accept the good if

$$v - p + (1-\alpha)[c-v]^{+} \geq -[p-c]^{+} + (1-\alpha)[v-c]^{+} \iff \qquad (A.19)$$
$$v - p \geq -[p-c]^{+} + (1-\alpha)(v-c)$$

or

$$v - p \geq \begin{cases} 1-\alpha)(v-c) & \text{if } p < c \\ c-p+(1-\alpha)(v-c) & \text{if } p \geq c \end{cases}. \qquad (A.20)$$

The first case, $p < c$, holds if $v \geq \frac{p-c}{\alpha} + c$. This must be true as $v \geq \bar{v}$ implies $v > c$ and the first case can only occur if $p < c$. The second case holds because $v - c \geq (1-\alpha)(v-c)$. Hence the buyer will accept in equilibrium.

Non-conformity constitutes partial breach, $v_{TB} = c \leq v < \bar{v}$.

The buyer will accept the good if

$$\bar{v} - p + (1-\alpha)[c-v]^{+} \geq -[p-c-(\bar{v}-v)]^{+} + (1-\alpha)[v-c]^{+} \iff \qquad (A.21)$$
$$\bar{v} - p \geq -[p-c-(\bar{v}-v)]^{+} + (1-\alpha)(v-c)$$

or:

$$\bar{v} - p - (1-\alpha)(v-c) \geq \begin{cases} 0 & \text{if } v-c \leq \bar{v}-p \\ \bar{v}-p-(v-c) & \text{if } v-c > \bar{v}-p \end{cases}.$$

In the first case, the condition must hold since $\bar{v} - p \geq v - c \geq (1-\alpha)(v-c)$. In the second case, the condition must hold because $v - c > 0$ and $(1-\alpha) \leq 1$. Hence the buyer will accept in equilibrium.

Non-conformity constitutes total breach, $v < v_{TB} = c$.

As $\bar{v} - p + (1 - \alpha)[v - c]^+ > (1 - \alpha)[v - c]^+$ the buyer chooses ED if he rejects delivery. The buyer will therefore accept if:

$$\begin{aligned} \bar{v} - p + (1 - \alpha)[c - v]^+ &> \bar{v} - p + (1 - \alpha)[v - c]^+ \iff \\ \bar{v} - p + (1 - \alpha)(c - v) &> \bar{v} - p, \end{aligned}$$

which will always hold for $v < c$.

2. Appendix to Chapter II

2.1. Proofs of Propositions and Lemmas

Proof of Lemma II.1

Proof. The buyer announces to accept whenever $B^{D,A}(\beta,\sigma,\omega,q) \geq B^{D,\bar{A}}(\beta,\sigma,\omega,q)$ or equivalently

$$\begin{aligned} & max[v,\bar{v}] - p - (c - c_l) + (1-\alpha)max[c-v,0] \geq \\ & -max[p - c_l - max[\bar{v} - v, 0], 0] + (1-\alpha)max[v-c,0]. \end{aligned} \tag{A.22}$$

Note that the first max operator on the second line of (A.22) can be dropped because $p - c_l - max[\bar{v} - v, 0] \geq 0 \; \forall \; (v,\bar{v}) \in [v_l, v_h]^2$. Consequently, we can simplify (A.22) and conclude that the buyer announces to accept (A) whenever $v \geq c$.

To obtain the seller's expected payoff, we first have to derive his ex-post payoff. Using that the buyer performs whenever $v \geq c$ and inserting the contract terms into (II.2) yields the seller's ex-post payoff for the case that the buyer performs. It amounts to

$$p - c_l - max[\bar{v} - v, 0].$$

Likewise, we get the seller's ex-post payoff for the case that the buyer does not perform by inserting the contract terms into (II.4). In that case, the seller also receives

$$p - c_l - max[\bar{v} - v, 0].$$

Note that all renegotiation terms are equivalent to zero because the buyer's performance decision is efficient. We get the seller's expected payoff by merging both cases, subtracting the seller's investment level and taking expectations. The buyer's expected payoff is equivalent to expected social surplus minus the seller's expected payoff. ■

Proof of Lemma II.2

Proof. The seller announces to deliver whenever $S^{D,A}(\beta,\sigma,\omega,q) \geq S^{\bar{D},ED}(\beta,\sigma,\omega,q)$[3] or equivalently

$$\begin{aligned} & p - min[c, \bar{c}] - (v_h - v) + \alpha\ max[c - v, 0] \geq \\ & -max[v_h - p - max[c - \bar{c}, 0], 0] + \alpha\ max[v - c, 0]. \end{aligned} \tag{A.23}$$

Note that the first max operator on the second line of (A.23) can be dropped because $v_h - p - max[c - \bar{c}, 0] \geq 0\ \forall\ (c, \bar{c}) \in [c_l, c_h]^2$. Consequently, we can simplify (A.23) and conclude that the seller announces to deliver (D) whenever $v \geq c$.

To obtain the buyer's expected payoff, we first have to derive her ex-post payoff. Using that the seller performs whenever $v \geq c$ and inserting the contract terms into (II.1) yields the buyer's ex-post payoff for the case that the seller performs. It amounts to

$$v_h - p - max[c - \bar{c}, 0].$$

Likewise, we get the buyer's ex-post payoff for the case that the seller does not perform by inserting the contract terms into (II.5). In that case, the buyer also receives

$$v_h - p - max[c - \bar{c}, 0].$$

Note that all renegotiation terms are equivalent to zero because the seller's performance decision is efficient. We get the buyer's expected payoff by merging both cases, subtracting the buyer's investment level and taking expectations. The seller's expected payoff is equivalent to expected social surplus minus the buyer's expected payoff. ■

[3] Recall that, after the seller announced not to deliver, the buyer is weakly better off claiming damages than staying passive.

Proof of Lemma II.3

Proof. We proof the first part only. The second part can be proven in a similar way. (i) To proof Lemma II.3, we solve the game depicted in Figure II.2 by backwards induction. If the seller announces not to deliver ($\bar{D}$), the buyer is indifferent between claiming damages (ED) and staying passive (0).[4] In both cases she receives an ex-post payoff of

$$B^{\bar{D},ED}(\beta,\sigma,\omega,q) = (1-\alpha)\ max[v-c,0].$$

If the seller announces to deliver (D), the buyer's best response is to accept (A) if $B^{D,A}(\beta,\sigma,\omega,q) \geq B^{D,\bar{A}}(\beta,\sigma,\omega,q)$ or equivalently

$$\begin{aligned} max[v,\bar{v}] - p - (c-c_l) + (1-\alpha)max[c-v,0] \geq \\ -max[p-c_l-max[\bar{v}-v,0],0] + (1-\alpha)max[v-c,0]. \end{aligned} \tag{A.24}$$

Note that the first max operator on the right-hand side of (A.24) can be dropped because $p-c_l-max[\bar{v}-v,0] \geq 0\ \forall\ (v,\bar{v}) \in [v_l,v_h]^2$. Consequently, we can simplify (A.24) and conclude that the buyer announces to accept (A) whenever $v \geq c$. Anticipating the buyer's decision, the seller always delivers (D). To see this, first consider the case where $v \geq c$. The seller announces to deliver if $S^{D,A}(\beta,\sigma,\omega,q) \geq S^{\bar{D},ED}(\beta,\sigma,\omega,q)$ or equivalently

$$p \geq\ max[\bar{v}-v,0] + c_l + \alpha(v-c).$$

Note that

$$p \geq v_h + c_l - (1-\alpha)v - \alpha c \geq\ max[\bar{v}-v,0] + c_l + \alpha(v-c)$$

for any $\bar{v} \in [v_l,v_h]$. Consequently, the seller delivers. Finally, consider the case where the buyer refuses to accept, $v < c$. Here, the seller announces to deliver (D) because $S^{D,\bar{A}}(\beta,\sigma,\omega,q) \geq S^{\bar{D},ED}(\beta,\sigma,\omega,q)$ or equivalently

$$max[p-c_l-\ max[\bar{v}-v,0],0] \geq 0.$$

■

[4] The buyer receives no damages if she opts for (ED). To see this, insert the contract terms into equation (II.5).

Proof of Lemma II.5

Proof. (i) Recall that divisibility allows us to treat each unit as a separate contract. We know from Lemma II.1 that the seller's payoff per unit does not depend on whether the buyer accepts the unit or not. Thus, ex-post, the seller receives a payoff amounting to $p - c_l - max[\bar{v} - V_i(\sigma, \omega)]$ for each of the q^{max} units the parties stipulated in contract. Because $q^{\bar{v}}$ of the q^{max} units are non-conforming to the contract, the seller's ex-post payoff amounts to $q^{max}(p - c_l) - [q^{\bar{v}}\bar{v} - V(\sigma, \omega, q^{\bar{v}})]$. Taking expectations and subtracting the seller's investment level then yields the seller's expected payoff. The buyer's expected payoff is equivalent to total social surplus minus the seller's expected payoff. If the contract specifies $\bar{v} = v_h$, all units are non-conforming to the contract. Thus, the seller's ex-post payoff is given by $q^{max}(p - c_l) - [q^{max}v_h - V(\sigma, \omega, q^{max})]$. The parties' expected payoff can be derived as before.

(ii) The second part of the proof can be performed in a similar way and is left to the reader. ■

Proof of Proposition II.3

Proof of Proposition II.3. (i) The first statement is true, because, for all quality thresholds $\bar{v}$, the buyer's expected payoff is equivalent to expected social surplus plus or minus a constant term. Moreover, the second statement must also be true because the seller's expected payoff $S_{c_l v_l}(\beta, \sigma) = q^{max}(p - c_l) - \sigma$ is strictly decreasing in σ. To prove statement three, we first show that given the buyer invests efficiently the difference of the seller's expected surplus and expected social surplus

$$
\begin{aligned}
S^{c_l v_h}(\beta^*, \sigma) - {} & [E[W(\beta^*, \sigma, \omega, Q^*(\beta^*, \sigma, \omega))] - \beta^* - \sigma] \\
&= q^{max}(p - c_l) - E[q^{max}v_h - V(\sigma, \omega, q^{max})] - E[W(\beta^*, \sigma, \omega, Q^*(\beta^*, \sigma, \omega))] + \beta^* \\
&= q^{max}(p - c_l - v_h) + E[V(\sigma, \omega, q^{max})] - E[C(\beta^*, \omega, q^{max})] \\
&\quad - E[W(\beta^*, \sigma, \omega, Q^*(\beta^*, \sigma, \omega))] + E[C(\beta^*, \omega, q^{max})] + \beta^* \\
&= q^{max}(p - c_l - v_h) + E[W(\beta^*, \sigma, \omega, q^{max})] - E[W(\beta^*, \sigma, \omega, Q^*(\beta^*, \sigma, \omega))] + \beta^* \\
&= q^{max}(p - c_l - v_h) + E[W(\beta^*, \sigma, \omega, q^{max} - Q^*(\beta^*, \sigma, \omega))] + \beta^*
\end{aligned}
$$

is monotonically increasing in σ. To see this, take any pair (σ', σ'') with $\sigma' < \sigma''$ and note that

$$
\begin{aligned}
& E[W(\beta^*, \sigma', \omega, q^{max} - Q^*(\beta^*, \sigma', \omega))] \\
& \leq E[W(\beta^*, \sigma', \omega, q^{max} - Q^*(\beta^*, \sigma'', \omega))] \\
& \leq E[W(\beta^*, \sigma'', \omega, q^{max} - Q^*(\beta^*, \sigma'', \omega))].
\end{aligned}
$$

The first inequality follows because, for β^*, $\sigma^{'}$ and ω the quantity $q^{max} - Q^*(\beta^*, \sigma^{'}, \omega)$ represents all units that yield a negative net joint profit. Thus, this quantity minimizes ex-post social welfare. The second inequality follows from Assumption II.2. To see this, recall that Assumption II.2 implies that expected welfare is increasing in σ for any fixed quantity $q > 0$. Consider some state $\omega^{'} \in \Omega$. Ex-post, together with β^* and $\sigma^{'}$ this state determines how many units are associated with a negative net joint profit. Therefore, due to Assumption II.2, for quantity $q^{max} - Q^*(\beta^*, \sigma^{''}, \omega^{'})$ it must hold that

$$E[W(\beta^*, \sigma^{'}, \omega^{'}, q^{max} - Q^*(\beta^*, \sigma^{''}, \omega^{'}))] \leq E[W(\beta^*, \sigma^{''}, \omega^{'}, q^{max} - Q^*(\beta^*, \sigma^{''}, \omega^{'}))]. \tag{A.25}$$

Because (A.25) holds for any state, it must also hold for the expected value over all states.

We have established that the difference between the seller's expected surplus and expected social welfare is increasing, hence it must hold for any $\sigma < \sigma^*$ that

$$\begin{aligned} &S^{c_l v_h}(\beta^*, \sigma) - [E[W(\beta^*, \sigma, \omega, Q^*(\beta^*, \sigma, \omega))] - \beta^* - \sigma] \leq \\ &S^{c_l v_h}(\beta^*, \sigma^*) - [E[W(\beta^*, \sigma^*, \omega, Q^*(\beta^*, \sigma^*, \omega))] - \beta^* - \sigma^*] \end{aligned}$$

or equivalently

$$\begin{aligned} &[E[W(\beta^*, \sigma^*, \omega, Q^*(\beta^*, \sigma^*, \omega))] - \beta^* - \sigma^*] - [E[W(\beta^*, \sigma, \omega, Q^*(\beta^*, \sigma, \omega))] - \beta^* - \sigma] \\ &\leq S^{c_l v_h}(\beta^*, \sigma^*) - S^{c_l v_h}(\beta^*, \sigma). \end{aligned} \tag{A.26}$$

Because social welfare is uniquely maximized by (β^*, σ^*), the term in the first line of (A.26) is positive and consequently $S^{c_l v_h}(\beta^*, \sigma) < S^{c_l v_h}(\beta^*, \sigma^*)$ for all $\sigma \in [0, \sigma^*)$. (ii) The second part of the proof can be performed in a similar way and is left to the reader.

■

3. Appendix to Chapter III

3.1. Comparison between private and efficient investment

Proof. Let us compare the landowner's privately optimal investment level in absence of the risk of a taking with the socially best response to the government's investment in the general case where a taking may occur. We prove that e_L^p is, for any investment of the government, at least as high as any $e_L \in e_L^{SBR}(e_G)$. In absence of the risk of a taking, the landowner's optimal investment maximizes

$$e_L^p \in \arg\max_{e \in [0, e_L^{max}]} E[U_L^p(e_L, \omega, q)] = E[V(e_L, \omega)] - e_L.$$

Take any $e_G \in [0, e_G^{max}]$ and note that

$$E[U_L^p(e_L, \omega, q)] - E[W(e_L, e_G, \omega, Q^*(e_L, e_G, \omega))] = E[min[V(e_L, \omega) - S(e_G, \omega), 0] + e_G$$

is increasing in e_L due to Assumption III.2. Let us denote the greatest element of $e_L^{SBR}(e_G)$ by $e_L^{max}(e_G)$. Take any $e_L < e_L^{max}(e_G)$ that is not a socially best response itself. Then it must hold that

$$E[U_L^p(e_L, \omega, q)] - E[W(e_L, e_G, \omega, Q^*(e_L, e_G, \omega))] \leq$$
$$E[U_L^p(e_L^{max}(e_G), \omega, q)] - E[W(e_L^{max}(e_G), e_G, \omega, Q^*(e_L^{max}(e_G), e_G, \omega))].$$

Because

$$E[W(e_L^{max}(e_G), e_G, \omega, Q^*(e_L^{max}(e_G), e_G, \omega))] > E[W(e_L, e_G, \omega, Q^*(e_L, e_G, \omega))]$$

it must hold that

$$E[U_L^p(e_L, \omega, q)] < E[U_L^p(e_L^{max}(e_G)\omega, q)]$$

and consequently $e_L^p \geq e_L^{max}(e_G)$. ■

Note that this directly implies $e_L^p \geq e_L^*$. In a similar way one can show that the government's privately optimal investment level exceeds the socially best response to any investment of the landowner. This directly implies $e_G^p \geq e_G^*$.

3.2. Proofs of Propositions and Lemmas

Proof of Theorem III.1

Proof. Let us prove that the landowner's investment incentives, under the compensation regimes we considered in Chapter 3.3, can be ranked in the following way:

$$\forall e_L \in e_L^{SBC} : e_L^{FC} = e_L^p \geq e_L \geq e_L^{SOPVC} = e_L^* \geq e_L^{NC} = 0. \tag{III.4}$$

In Appendix A.3.1, we explained that e_L^p is, for any e_G, at least as high as the greatest element of $e_L^{SBR}(e_G)$. Because $e_L^{FC} = e_L^p$ and the landowner's best response under the social benefit compensation regime is equivalent to the social best response, the first claim directly follows. Let us establish that *any* $e_L \in e_L^{SBC} \geq e_L^{SOPVC} = e_L^*$. To do so, we consider the difference between the landowner's expected payoff under the social benefit compensation regime and expected social surplus. It is given by

$$\begin{aligned}
&E[U_L^{SBC}(e_L, 0, \omega, Q^*(e_L, 0, \omega))] - E[W(e_L, e_G^*, \omega, Q^*(e_L, e_G^*, \omega))] = \\
&E[W(e_L, 0, \omega, Q^*(e_L, 0, \omega))] - E[W(e_L, e_G^*, \omega, Q^*(e_L, e_G^*, \omega))] = \\
&E[min[max[V(e_L, \omega), S(0, \omega)] - S(e_G^*, \omega), 0]]
\end{aligned}$$

which is increasing in e_L due to Assumption III.2. Note that we used that the government invests zero under the SBC regime and that the socially best response to e_L^* is e_G^*. Take any $e_L < e_L^*$, then

$$\begin{aligned}
&E[U_L^{SBC}(e_L, 0, \omega, Q^*(e_L, 0, \omega))] - E[W(e_L, e_G^*, \omega, Q^*(e_L, e_G^*, \omega))] \leq \\
&E[U_L^{SBC}(e_L^*, 0, \omega, Q^*(e_L^*, 0, \omega))] - E[W(e_L^*, e_G^*, \omega, Q^*(e_L^*, e_G^*, \omega))].
\end{aligned}$$

Because expected welfare is uniquely maximized by (e_L^*, e_G^*), this implies

$$E[U_L^{SBC}(e_L, 0, \omega, Q^*(e_L, 0, \omega))] < E[U_L^{SBC}(e_L^*, 0, \omega, Q^*(e_L^*, 0, \omega))]$$

and consequently *any* $e_L \in e_L^{SBC} \geq e_L^{SOPVC} = e_L^*$. Since $e_L^{NC} = 0$, it is clear that $e_L^{SOPVC} > e_L^{NC}$. Similarly, we can rank the government's investment incentives:

$$\forall e_G \in e_G^{FC} : e_G^{NC} = e_G^p \geq e_G^{SOPVC} = e_G^* \geq e_G \geq e_G^{SBC} = 0.$$

In Appendix A.3.1, we explained that $e_G^p \geq e_G^*$. Because $e_G^{NC} = e_G^p$ and $e_G^{SOPVC} = e_G^*$, it directly follows that $e_G^{NC} \geq e_G^{SOPVC}$. The proof that e_L^{SOPVC} is at least as high as *any* $e_G \in e_G^{FC}$ can be done the same way we proved that *any* $e_L \in e_L^{SBC} \geq e_L^{SOPVC}$ and is left to the reader. Finally, *any* $e_G \in e_G^{FC} \geq e_G^{SBC}$, because $e_G^{SBC} = 0$. ■

Bibliography

[1] P. Aghion, M. Dewatripont, and P. Rey. Renegotiation design with unverifiable information. *Econometrica: Journal of the Econometric Society*, pages 257–282, 1994.

[2] A. Bell. Private takings. *U. Chi. L. Rev.*, 76:517, 2009.

[3] B.D. Bernheim and M.D. Whinston. Incomplete contracts and strategic ambiguity. *American Economic Review*, pages 902–932, 1998.

[4] L. Blume and D.L. Rubinfeld. Compensation for takings: an economic analysis. *California Law Review*, 72(4):569–628, 1984.

[5] L. Blume, D.L. Rubinfeld, and P. Shapiro. The taking of land: When should compensation be paid? *The Quarterly Journal of Economics*, 99(1):71, 1984.

[6] S.P. Calandrillo. Eminent domain economics: Should" just compensation" be abolished, and would" takings insurance" work instead? In *American Law & Economics Association Annual Meetings*, page 1. bepress, 2005.

[7] Y.K. Che and T.Y. Chung. Contract damages and cooperative investments. *The Rand Journal of Economics*, pages 84–105, 1999.

[8] Y.K. Che and D.B. Hausch. Cooperative investments and the value of contracting. *American Economic Review*, 89:125–147, 1999.

[9] T.Y. Chung. Incomplete contracts, specific investments, and risk sharing. *The Review of Economic Studies*, 58(5):1031, 1991.

[10] R.H. Coase. The problem of social cost. *Economic Analysis of the Law*, pages 1–13, 1960.

[11] L. Cohen. Holdouts and free riders. *J. Legal Stud.*, 20:351, 1991.

[12] R. Cooter. Unity in tort, contract, and property: The model of precaution. *California Law Review*, 73(1):pp. 1–51, 1985.

[13] R. Craswell. Contract remedies, renegotiation, and the theory of efficient breach. *Southern California Law Review*, 61:630–670, 1988.

[14] G. De Fraja. After you sir. hold-up, direct externalities, and sequential invesments. *Games and Economic Behavior*, 26:22–39, 1999.

[15] J.H. Dyer and W.G. Ouchi. Japanese style partnership: giving companies a competitive edge. *Sloan Management Review*, 35(1):51–63, 1993.

[16] A. S. Edlin and S. Reichelstein. Holdups, standard breach remedies, and optimal investment. *American Economic Review*, 86(3):478–501, 1996.

[17] A.S. Edlin. Cadillac contracts and up-front payments: Efficient investment under expectation damages. *Journal of Law, Economics, and Organization*, 12(1):98–118, 1996.

[18] W.A. Fischel and P. Shapiro. Takings, insurance, and michelman: Comments on economic interpretations of" just compensation" law. *The Journal of Legal Studies*, 17(2):269–293, 1988.

[19] W.A. Fischel and P. Shapiro. A constitutional choice model of compensation for takings. *International Review of Law and Economics*, 9(2):115–128, 1989.

[20] V.P. Goldberg, T.W. Merrill, and D. Unumb. Bargaining in the shadow of eminent domain: Valuing and apportioning condemnation awards between landlord and tenant. *UCLA L. Rev.*, 34:1083, 1986.

[21] D. Göller and A. Stremitzer. Breach remedies inducing hybrid investments. *Yale Economics Department Working Paper No. 72, Yale Law & Economics Research Paper No. 395*, 2009.

[22] S. J. Grossman and O. D. Hart. The costs and benefits of ownership - a theory of vertical and lateral integration. *Journal of Political Economy*, 94(4):691–719, 1986.

[23] P. Grout. Investment and wages in the absence of binding contracts: A nash bargaining approach. *Econometrica*, 52 (2):449–460, 1984.

[24] S. Guriev. Incomplete contracts with cross-investments. *Contributions to Theoretical Economics*, 3 (1) Article 5, 2003.

[25] O. Hart and J. Moore. Incomplete contracts and renegotiation. *Econometrica*, 56(4):755–785, 1988.

[26] B.E. Hermalin. An economic analysis of takings. *Journal of Law, Economics, & Organization*, 11(1):64–86, 1995.

[27] R. Innes. Takings, compensation, and equal treatment for owners of developed and underdeveloped property. *JL & Econ.*, 40:403, 1997.

[28] L. Kaplow. An economic analysis of legal transitions. *Harvard Law Review*, pages 509–617, 1986.

[29] D.B. Kelly. The" Public Use" Requirement in Eminent Domain Law: A Rationale Based on Secret Purchases and Private Influence. *Cornell Law Review*, 92(1):1, 2006.

[30] L. A. Kornhauser. An introduction to the economic analysis of contract remedies. *University of Colorado Law Review*, 57:683–725, 1986.

[31] N. Kumar. The power of trust in manufacturer-retailer relationships. *Harvard Business Review*, 74(6):92–106, 1996.

[32] T. Lyon and E. Rasmusen. Buyer-option contracts, renegotiation, and the hold-up problem. *Journal of Law, Economics, and Organization*, 20(1):148–169, 2004.

[33] W. B. MacLeod and J. M. Malcomson. Investments, holdup, and the form of market contracts. *American Economic Review*, 83(4):811–837, 1993.

[34] E. Maskin and J. Moore. Implementation and renegotiation. *Review of Economic Studies*, 66(1):39–56, 1999.

[35] T. Maunz and G. Dürig. *Grundgesetz, Band III, Art. 17-27, 50.* 2007.

[36] T.J. Miceli. Public goods, taxes, and takings. *International Review of Law and Economics*, 28(4):287–293, 2008.

[37] T.J. Miceli and K. Segerson. Regulatory takings: When should compensation be paid? *The Journal of Legal Studies*, 23(2):749–776, 1994.

[38] T.J. Miceli and K. Segerson. *The economics of eminent domain: private property, public use, and just compensation.* Now Publishers Inc, 2007.

[39] F.I. Michelman. Property, utility, and fairness: Comments on the ethical foundations of" just compensation" law. *Harvard Law Review*, pages 1165–1258, 1967.

[40] P. Munch. An economic analysis of eminent domain. *The Journal of Political Economy*, pages 473–497, 1976.

[41] G. Nöldeke and K. M. Schmidt. Option contracts and renegotiation - a solution to the hold-up problem. *RAND Journal of Economics*, 26(2):163–179, 1995.

[42] E. Nosal. The taking of land: Market value compensation should be paid. *Journal of Public Economics*, 82(3):431–443, 2001.

[43] S. Ohlendorf. Expectation damages, divisible contracts, and bilateral investment. *The American Economic Review*, 99(4):1608–1618, 2009.

[44] E.L. Plambeck and T.A. Taylor. Implications of renegotiation for optimal contract flexibility and investment. *Management Science*, 53(12):1872–1886, 2007.

[45] R. Posner. *Economic Analysis of Law 2nd Ed.* Little Brown, Boston, 1977.

[46] W.E. Pritchett. Public Menace of Blight: Urban Renewal and the Private Uses of Eminent Domain, The. *Yale L. & Pol'y Rev.*, 21:1, 2003.

[47] W. P. Rogerson. Efficient reliance and damage measures for breach of contract. *RAND Journal of Economics*, 15(1):37–53, 1984.

[48] A. Roider. Asset ownership and contractibility of interaction. *RAND Journal of Economics*, 35(4):787–802, 2004.

[49] S. Rosenkranz and P. Schmitz. Know-how disclosure and incomplete contracts. *Economics Letters*, 63(2):181–185, 1999.

[50] U. Schweizer. The pure theory of multilateral obligations. *Journal of Institutional and Theoretical Economics JITE*, 161(2):239–254, 2005.

[51] U. Schweizer. Cooperative investments induced by contract law. *RAND Journal of Economics*, Spring 37-1:134–145, 2006.

[52] S. Shavell. Damage measures for breach of contract. *Bell Journal of Economics*, 11:466–490, 1980.

[53] S. Shavell. Eminent domain versus government purchase of land given imperfect information about owners' valuations. *Journal of Law & Economics*, 53(1):1–27, 02 2010.

[54] Steven Shavell. The design of contracts and remedies for breach. *Quarterly Journal of Economics*, 94:121–148, 1984.

[55] A. Stremitzer. Standard breach remedies, quality thresholds, and cooperative investments. *Journal of Law, Economics, and Organization*, 2010.

[56] J. Watson. Contract, mechanism design, and technological detail. *Econometrica*, 75:55–81, 2007.

[57] O. E. Williamson. Transaction-cost economics: The governance of contractual relations. *Journal of Law and Economics*, 22:233–61, 1979.

[58] O. E. Williamson. *The Economic Institutions of Capitalism.* Free Press, New York, 1985.