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Opportunistic Termination

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Abstract

If a seller delivers a good non-conforming to the contract, Article 2 of the UCC as well as European warranty law allows consumers to choose between some money transfer and termination. Termination rights are, however, widely criticized, mainly for fear that the buyer resorts to "opportunistic termination", i.e. takes non-conformity as a pretext to get rid of a contract he no longer wants. We show that the possibility of opportunistic termination might actually have positive effects. Under some circumstances, it will lead to redistribution in favour of the buyer without any loss of efficiency. Moreover, by curbing the monopoly power of the seller, a regime involving termination increases welfare by enabling a more efficient output level in a setting with multiple buyers.

Keywords: contract law, warranties, breach remedies, termination, harmonization

JEL-Classification: K12, C7, L40, D30

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1 Introduction

It is quite common that a buyer does not get what he has contracted for: The seam of a dress may become unstitched shortly after purchase, the new DVD player may start to stagger after one year, the construction firm may not build according to the architect's plan or the travel agency informs you that you will be accommodated in a hotel different from the one you booked.

The remedies available to the buyer in such situations are governed by warranty law as laid down in Article 2 of the Uniform Commercial Code (Priest (1978)) and Directive 1999/44 of the European Community on the sale of consumer goods (Parisi (2004)). It basically gives the victim of non-conforming delivery the right to choose between expectation damages and termination (hereafter EDT regime).[1] If the buyer chooses expectation damages he receives a monetary compensation so that in terms of utility he is in the same position as if the contract had been duly performed.[2] If the buyer chooses termination this will lead to restitution, i.e. he will return the good to the seller and recover the price.[3]

It is quite common that contract law provides the non-breaching party with the option to choose between two or more remedies. Yet, the existing economic literature, with the noteworthy exception of Ayres and Madison (2000) and Avraham (2006), has so far largely focused on *exclusive* regimes, i.e. regimes where only *one* legal remedy is available to the victim of breach.[4] As warranty law is of huge practical relevance and happens to be governed by largely the same *optional* legal regime in both the United States and the European Community, there is a gap to fill. We therefore analyze the properties of the EDT regime by comparing it to a prominent exclusive regime, namely pure expectation damages (hereafter ED-regime).[5] ED is the default remedy in common law and was shown to perform reasonably well under many different circumstances.[6]

Our analysis allows us to expose a function of warranty law that has so far gone unnoticed. It is commonly held (e.g. Parisi (2004)) that there are three main functions

[1] The regime applies if the delivered goods are non-conforming to the contract and cannot be restored to conformity by either repair or replacement.

[2] Note that Article 3 (5) of EC Directive 1999/44 does not speak of "expectation damages" but of "appropriate reduction of the price". In our paper we will use "expectation damages" as a benchmark largely in order to make the paper comparable to the existing literature. Moreover, using "price reduction" will not qualitatively alter the insights of this paper. A discussion of this claim is available from the author upon request.

[3] EC Directive 1999/44 uses the term "rescission" instead of "termination". We do not want to enter into the niceties of legal terminology (Farnsworth (2004) §8.15 n. 2) and will use "termination" synonymous with "cancellation" and "rescission".

[4] See e.g. Shavell (1980), Shavell (1984), Rogerson (1984), Edlin and Reichelstein (1996), Che and Chung (1999) who explore the relative performance of different exclusive remedy regimes under various assumptions about the nature of investment, the nature of the breach decision and the possibility of renegotiaion.

[5] We are only aware of one other model (Avraham (2006)) which - like ours - compares a regime of optional remedies with an exclusive remedy.

[6] See Schweizer (2006) and the literature cited there.

of legal warranties: Brown (1974) has shown that warranties can be used to efficiently allocate the risk of product defect, given the parties' risk attitudes (insurance function), Spence (1974) and Grossman (1981) pointed to the revelation of private information about product quality (signalling function) and Priest (1981) argued that warranties provide incentives for the production and preservation of quality (incentive function). In our paper we want to argue that warranties also serve an *antitrust function.*

We consider a setting where, at the outset, both the buyer's valuation and the seller's ability to deliver the good in conforming quality are uncertain. While the buyer's valuation is modelled as an exogenous random variable the probability of conforming delivery is determined by an investment decision of the seller. Both buyer and seller are risk neutral and symmetrically informed. Even if the buyer's valuation is low and quality is non-conforming, the buyer values the good more than the seller, so that trade is always efficient ex post. The contracting problem, therefore, is to induce efficient investment incentives and to make sure that parties trade ex post.

It is well known that a contract stipulating price and quality $[P, q]$ and a legal regime which requires the breaching party to pay expectation damages will achieve first best if - as in our case - it is the investing party who breaches (Shavell (1980)). This is so because ED makes the investing seller a residual claimant of the trade surplus and induces the efficient ex-post trade decision. [7]

It is, however, far from obvious that we should be able to achieve first best with the EDT regime. If, for some reason, the buyer's valuation for the good decreases below the contracted price the buyer will have the incentive to terminate the contract if he is given the right to do so (e.g. Priest (1978), Parisi (2004), Wehrt (1995), Schlechtriem and Schmidt-Kessel (2005), Para 534). This phenomenon of *opportunistic termination* may give rise to *ex post inefficiency* if renegotiation is (prohibitively) costly.[8] Moreover, we will see that the seller is strictly worse off if the buyer chooses termination rather than expectation damages. He may therefore *overinvest* into quality in order to reduce the probability of the buyer choosing termination. Yet, a trivial first best solution can indeed be achieved under the EDT regime, with a contract $[P, q, T]$ where T is an lump sum side payment from the buyer to the seller. Parties could simply set a price low enough to prevent the buyer from choosing termination and compensate the seller by raising the lump sum payment.[9]

In a way, however, this result makes our attempt to expose the virtues of the EDT regime an uphill battle: Why should we be interested in a regime if the best we can achieve can be had much easier with a pure ED regime? Indeed, we can find two arguments why EDT differs from ED in an interesting way: First, the possibility of opportunistic

[7]The result can also be interpreted as a polar case of Priest's "investment theory" (Priest (1981)).

[8]We consider the renegotiation case in another paper.

[9]See Edlin (1996) for the general idea of using lump sum side payments in order to achieve first best solutions in the context of contract remedies.

termination under the EDT regime can lead to a *redistribution* of welfare in favour of the buyer *without sacrificing first best*. This redistribution effect has the special property that it leaves the payoff of sellers in fairly competitive markets unaffected while putting a ceiling on the extent that a monopolistic seller can take advantage of his monopoly power.[10] Second, by extending our model to a setting with multiple buyers, it can be shown that the EDT regime can improve on the ED regime in *efficiency terms*. It turns out, that EDT acts as a substitute to price regulation in cases which are below the radar screen of antitrust authorities.

An important feature of our model is that we do not allow for lump sum payments. This assumption is usually motivated by citing wealth constraints (e.g. Aghion and Bolton (1992) and Aghion and Tirole (1994)). In our case, it captures a crucial legal property of the EDT regime: If a party terminates the contract all payments made under the contract - including any lump sum payment - are reversed as a matter of law.[11] This eliminates an often used instrument to split the ex ante gains of trade without affecting incentives. Parties might therefore be forced to simultaneously determine incentives and distribution such that "ex ante bargaining power influences not only the distribution of the pie, but also its size"(Aghion and Tirole (1994)).

Under ED it makes no difference whether side payments are possible or not as the damage measure sets the right incentives independent of the price. So price can be used as an instrument to distribute the ex ante expected surplus according to the parties' bargaining power. Yet, a problem potentially arises under the EDT regime: For first best, price has to be set low enough in order to prevent the buyer from choosing termination. Absent lump sum payments, we would expect the seller not to be willing to set such a low price, especially if his bargaining power is high. Yet, we will see that he will frequently go along with the low price nevertheless. This result is driven by a *discontinuity* in the seller's payoff function. As he sets the price higher than a certain threshold, termination will be part of the buyer's equilibrium strategy. If, as assumed, renegotiation is prohibitively costly, this will make his expected payoff jump down. The seller will therefore often refrain from pushing the price beyond that threshold. He prefers a *smaller share of a larger pie to a bigger share of a smaller pie.* This vindicates our first claim that EDT can lead to a redistribution in favour of the buyer without sacrificing first best.

Given this result, our second claim, that switching from the ED to the EDT regime

[10] We therefore present an exception to the general rule that it is not possible to redistribute income with contractual remedies as parties will always adjust the contract price such that payoffs reflect their respective bargaining power (e.g. Craswell (1991) or Polinsky (1983), p. 108).

[11] See e.g. Schlechtriem and Schmidt-Kessel (2005), AT Para. 525. As it is often legally impossible to promise the exchange of payments in a separate agreement which is shielded from the main contract there is no easy legal way to circumvent this. Yet, Edlin (1996) suggests, that under the consideration doctrine of common law this would be possible by setting up a separate contract with a separate consideration. Still, for our purposes, it is hard to imagine that consumers will resort to this technique in their everyday shopping activity. Note that an example of a lump sum side payment that could not be reversed is advisory service prior to the sale. Yet, for our purposes, this transfer would go into the wrong direction.

can increase welfare in a setting with multiple buyers by breaking the monopoly power of the seller is not particularly surprising. In order to illustrate this fact, we will construct a simple example where this is the case. We consider two customers with identical valuation but different wealth constraints which are potential consumers of a single unit of the good. It is assumed that the seller cannot distinguish between the two types so that he cannot engage in discriminatory pricing. From a welfare perspective it is always desirable to trade with both customers if the expected valuation of the consumers exceeds the producer's cost. Yet, for the seller it will only be attractive to set the price low enough for the low wealth customer if the extra profit he makes by gaining the additional customer outweighs the loss of profit he incurs by also reducing the price for the customer who is willing and able to pay the high price. As switching from the ED to the EDT regime lowers the seller's margin, the profit on the high wealth customer that the seller has to sacrifice in order to accommodate the low wealth customer is lower under EDT than under ED. Therefore he is more likely to lower the price under EDT, enabling a more efficient volume of trade.

Our analysis sheds light on some issues of practical importance: We will argue that the scepticism of many legal scholars towards generous termination rights might be overblown. Our model offers no justification for the fact that the law tends to disallow termination unless non-conformity passes a certain threshold level. We also find an argument in favor of mandatory termination rights for consumer buyers as stipulated in Directive 1999/44 of the European Community. Such a mandatory regime can have an antitrust effect by acting as a substitute to price regulation. For the United States the policy implication would be to consider making Article 2 of the UCC mandatory for consumer buyers.

The paper is organized as follows: Section 2 describes our model. After working out the benchmark case in section 3 we compare the ED and EDT regime in section 4. Section 5 states our main results. An extension in section 6 shows that EDT might increase welfare in a setting with multiple buyers. In section 7, we conduct comparative statics exercises and further discuss our findings. Section 8 concludes.

2 The Model

We consider a seller and a buyer who can trade one unit of a good of a certain quality.[12] Both the buyer's valuation and the seller's ability to deliver the good in conforming quality are uncertain. The buyer's valuation $\widetilde{V}$ is exogenous. It will be either high ($\overline{V}$) with probability λ or low ($\underline{V}$) with probability $1-\lambda$.[13] While the buyer's valuation

[12] Quality is either standard quality which courts would assume by default or specified in the contract.

[13] Note that $\widetilde{V}$ does not depend on whether delivery will be conforming or not. Rather it captures the possibility that circumstances relevant for the buyer's valuation change between the conclusion of the contract and the time when the he can invoke non-conformity. If, for example, somebody buys furniture which is tailored to his house the value of these goods to him will be much lower if he has to move somewhere else.

is strictly positive ($\underline{V} > 0$), we assume that the good has zero value to the seller.[14] Probability γ that the seller is able to deliver in conforming quality is endogenously determined by the seller's investment c: It will be $\overline{\gamma} \in (0,1)$ if the seller invests $\bar{c}$ and 0 otherwise.[15] We further assume that, if the delivered good is non-conforming, the buyer's valuation, whether low or high, is reduced by a factor $\delta \in (0,\ 1]$.[16] All parameters are observable and verifiable except of c which is not verifiable.

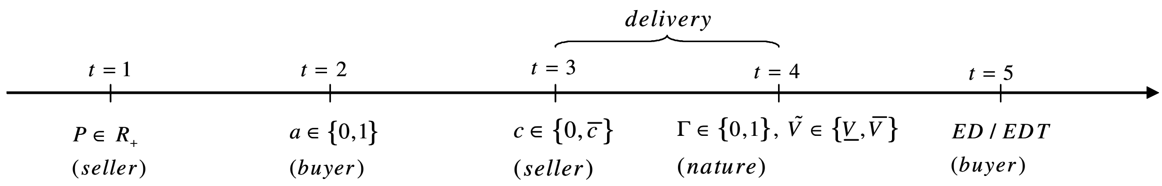

Figure 1: Timeline.

In the first period (see Figure 1), the seller makes a take-it-or-leave-it price offer P.[17] If the buyer rejects (a=0) he will earn his reservation utility u and the seller will get 0. If the buyer accepts (a=1), the seller chooses c and delivers the good. Subsequently, the buyer's valuation and the quality of the good are realized.[18] If the good is conforming to the quality specified in the contract ($\Gamma = 1$) the buyer receives the good and pays the contracted price. If the good is non-conforming ($\Gamma = 0$) the buyer can choose the legal remedies available under either the ED or the EDT regime. In Section 4 we will explain in detail how these remedies affect payoffs.

The negotiation set-up in stage 1 and 2 can be motivated by assuming that each seller has monopoly power over his specific good but an imperfect substitute is available to the consumer from which he can derive expected utility u. Note, that u can be interpreted as a parameter for market structure. High u can be associated with highly competitive markets where the consumer always has a close substitute at hand. Low u capture the case of uncompetitive markets where no or only very imperfect substitutes for the seller's product are available.[19]

[14] Very often, it will be difficult for the seller to resell defective goods which have already been used e.g. because it is too expensive to repackage them.

[15] Modelling $\gamma(\cdot)$ is an increasing and convex twice differentiable function would not change results qualitatively but unnecessarily complicates comparative statics.

[16] This implies that the value of the non-conforming good is strictly positive, i.e. we exclude the possibility that the loss due to non-conforming delivery exceeds the value of the conforming good.

[17] We assume that it is not possible to write a contingent contract $P(\tilde{V})$. Indeed, such a contract might not hold before the court, because it would circumvent mandatory termination rights of consumer law.

[18] We assume that a possible defect is hidden to both the buyer and the seller and only surfaces after delivery. Therefore the seller cannot wait until quality is realized and then set the price.

[19] The necessity to explicitly model the negotiation stage follows directly from ruling out lump sum side payments. If the buyer chooses termination, the law requires that all payments made under the contract be reversed. Of course, lump sum side payments would still be effective if the buyer chooses ED. Yet, as can be seen in Figure 2, this is already captured in our model as we can reinterpret P as a net price which equals $P^* + T$ where P^* would be the contract price and T the up-front payment.

The timing of our model assumes that the contract is made before the seller makes his investment. This will e.g. be the case if the consumer orders a tailor made suit. Often, however, the seller will first produce the good and then conclude the contract. If we assume that investments become relationship specific only after the investment decision - say at the time of delivery - we can show that the results of our model will still hold. This assumption is rather plausible as the resale value will often decrease as the good is unpacked and starts to be used.

3 Benchmark

First, as a benchmark, we work out the decisions that maximize social welfare. As, by assumption, the buyer's valuation of the good will always be higher than the valuation of the seller, it is socially optimal that parties always trade ex post. The socially optimal investment decision c_0 maximizes expected social payoff:

$$c_0 \in \arg\max_c \Pi^0_{Total}(c) = \arg\max_c E\widetilde{V} - c - (1-\gamma)\,\delta E\widetilde{V}. \tag{1}$$

Note that, expected social payoff equals the buyer's expected valuation minus investment cost and expected devaluation due to non-conforming delivery. As the probability of conforming delivery is $\bar{\gamma}$ if the seller invests $\bar{c}$ and 0 otherwise it follows that it is socially optimal for the seller to invest if and only if:

$$E\widetilde{V} - \delta E\widetilde{V} < E\widetilde{V} - \overline{c} - (1-\overline{\gamma})\,\delta E\widetilde{V}. \tag{2}$$

Therefore, the socially optimal investment level is:

$$c_0 = \begin{cases} \overline{c} & \text{if } \overline{c} < \overline{\gamma}\delta E\widetilde{V} \\ 0 & otherwise \end{cases}. \tag{3}$$

In the following we will consider the effect of introducing legal regimes. In particular, we will compare the ED and the EDT regime.

4 Legal Regimes

4.1 Payoffs

If the buyer rejects the seller's offer (a=0) he will earn his reservation utility u and the seller's payoff will be zero. If the buyer accepts the offer (a=1) and chooses ED in the case of non-conformity his utility will be the value of the conforming good minus price, $\widetilde{V} - P$ (see Figure 2). This is so because he will receive damages from the seller that will fully compensate him in terms of utility if delivery is non-conforming. The seller's payoff will be price minus investment cost and the damage payment in the event of non-conforming delivery, $P - c - (1-\Gamma)\,\delta\widetilde{V}$.

If the buyer accepts the offer and chooses termination (T) in the case of non–conformity his payoff will be zero and the seller will loose his investment c.[20]

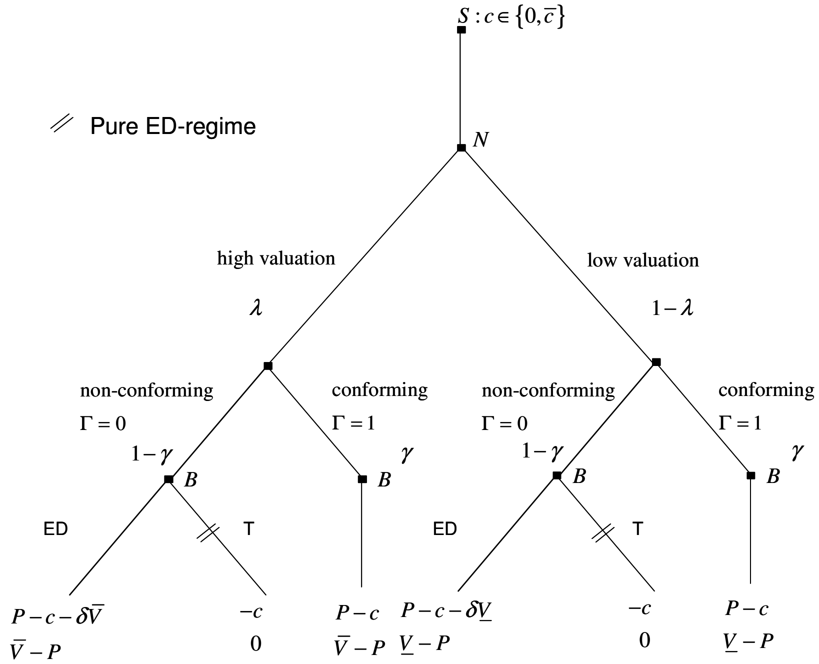

Figure 2: Subgame starting from the seller's investment decision.

4.2 ED regime

We are solving the game by backwards induction. The seller's expected payoff under ED is given by:

$$\Pi_S^{ED}(c) = P - c - (1-\gamma)\,\delta E\widetilde{V}. \tag{4}$$

Comparing (4) with (1) we see that it differs from expected social payoff by $E\widetilde{V} - P$ which is independent of the investment decision. Therefore, ED always induces the first best investment level:

$$c_{ED} = \arg\max_c \Pi_S^{ED}(c) = \arg\max_c \Pi_{Total}^0(c) = c_0. \tag{5}$$

The buyer accepts the offer whenever his expected payoff exceeds reservation utility:

$$\Pi_B^{ED} = E\widetilde{V} - P \geq u. \tag{6}$$

As the seller's payoff increases in P it is optimal for him to offer a price for which the buyer's PC is binding:

$$P_{ED}(u) = E\widetilde{V} - u \tag{7}$$

[20]Remember that we assumed that the good has no resale or scrap value.

provided that his own participation constraint is satisfied. Inserting (7) into (4) it can be seen that:

$$\Pi_S^{ED}(P_{ED}) \geq 0 \iff \Pi_{Total}^0 \geq u \tag{8}$$

which means that the seller's participation constraint is satisfied whenever there are potential gains of trade. The subgame perfect equilibrium under ED can therefore be characterized by the following lemma:

Lemma 1 *The ED regime achieves first-best allocation, price will be set at $E\widetilde{V} - u$ and the buyer earns his reservation utility.*

4.3 EDT regime

Suppose that the good is delivered in non-conforming quality. Then, under EDT, the buyer chooses between expectation damages and termination at stage 5. Termination will only be optimal for him if his valuation turns out to be lower than the price:

$$\widetilde{V} - P < 0 \iff \widetilde{V} < P. \tag{9}$$

Yet, in order for termination to occur in equilibrium it is not sufficient that the buyer *wants* to terminate. He must also have the legal opportunity to do so, i.e. performance has to be non-conforming ($\Gamma = 0$). The probability of termination thus increases in the seller's price offer and decreases in his investment into quality:

$$\pi_T = prob\left\{\widetilde{V} < P\right\}(1 - \gamma(c)). \tag{10}$$

The seller's expected payoff under EDT can then be written as:

$$\Pi_S^{EDT} = P - c - (1 - \gamma)\,\delta E\widetilde{V} - \pi_T\left(P - \delta E\left[\widetilde{V}\,\middle|\,\widetilde{V} < P\right]\right). \tag{11}$$

It equals the seller's payoff under ED (4) minus the expected effect of termination: If the buyer chooses termination the seller will not get the price but neither will he have to pay any damages. Note that this term will always be non-negative. Total payoff under EDT is:

$$\Pi_{Total}^{EDT} = E\widetilde{V} - c - (1 - \gamma)\,\delta E\widetilde{V} - \pi_T(1 - \delta)\,E\left[\widetilde{V}\,\middle|\,\widetilde{V} < P\right] \tag{12}$$

where $(1 - \delta)\,E\left[\widetilde{V}\,\middle|\,\widetilde{V} < P\right]$ is the expected loss whenever the buyer terminates. As we assume that valuation can either be $\underline{V}$ or $\overline{V}$ with $\overline{V} > \underline{V} > 0$, three cases can be distinguished depending on the contract price. It is obvious that the buyer would never accept a price $P > \overline{V}$ in equilibrium. We will therefore consider the two remaining cases $P \leq \overline{V}$ and $\underline{V} < P \leq \overline{V}$:

a) Case P $\leq \underline{V}$: If P is smaller than $\underline{V}$, which is the lowest possible realization of $\widetilde{V}$, the buyer's valuation *always* exceeds the price. Probability of termination will therefore be zero (10). Inserting $\pi_T = 0$ into equation (11) gives us:

$$\Pi_S^a(P,c) = P - c - (1-\gamma)\,\delta E\widetilde{V} = \Pi_S^{ED}(c)\,.^{21} \tag{13}$$

Thus, conditional on $P < \underline{V}$, payoffs under EDT are just the same as under ED (see 4). It immediately follows that $c_a = c_0$ i.e. it is optimal for the seller to choose first best investment levels at stage 3. Finally, total expected payoff is:

$$\Pi_{Total}^a(c) = E\widetilde{V} - c - (1-\gamma)\,\delta E\widetilde{V} = \Pi_{Total}^0(c)\,. \tag{14}$$

b) Case $\underline{V}<$ P $\leq \overline{V}$: In this case, P will be higher than $\widetilde{V}$ if the low state $\underline{V}$ is realized. The probability of termination will therefore be:

$$\pi_T = (1-\lambda)(1-\gamma)\,, \tag{15}$$

the expression for the seller's expected payoff simplifies to:

$$\Pi_S^b(c) = P - c - (1-\gamma)\,\delta E\widetilde{V} - \pi_T\left(P - \delta\underline{V}\right) \tag{16}$$

and total expected payoff is given by:

$$\Pi_{Total}^b(c) = E\widetilde{V} - c - (1-\gamma)\,\delta E\widetilde{V} - \pi_T(1-\delta)\,\underline{V}. \tag{17}$$

Note that

$$\phi_P \equiv \pi_T(1-\delta)\,\underline{V} \tag{18}$$

measures expected ex post inefficiency due to termination. The seller will choose investment c_b at stage 3 which maximizes his expected payoff Π_S^b:[22]

$$c_b = \arg\max_c \Pi_S^b(c)\,. \tag{19}$$

If $c_b \neq c_0$ this gives rise to ex-ante inefficiency due to distortion of investment incentives:

$$\phi_A \equiv (c_b - c_0) + [\gamma_0 - \gamma_b]\,\delta E\widetilde{V}. \tag{20}$$

where $\gamma_0 \equiv \gamma(c_0)$ and $\gamma_b \equiv \gamma(c_b)$. Summarizing cases a) and b) the seller's payoff under EDT can be written as:

$$\Pi_S^{EDT} = \begin{cases} \Pi_S^a = \Pi_S^{ED}(c_0) = P - c_0 - (1-\gamma_0)\,\delta E\widetilde{V} & \text{if } P \leq \underline{V} \\ \Pi_S^b = \Pi_S^{ED}(c_0) - \phi_A - \pi_T\left(P - \delta\underline{V}\right) & \text{if } P > \underline{V} \end{cases}. \tag{21}$$

This payoff function exposes an interesting feature of the EDT regime. For $P \leq \underline{V}$ the seller's payoffs under ED and EDT are identical and increasing in price. However, as P is raised above $\underline{V}$, termination occurs with positive probability under EDT and the

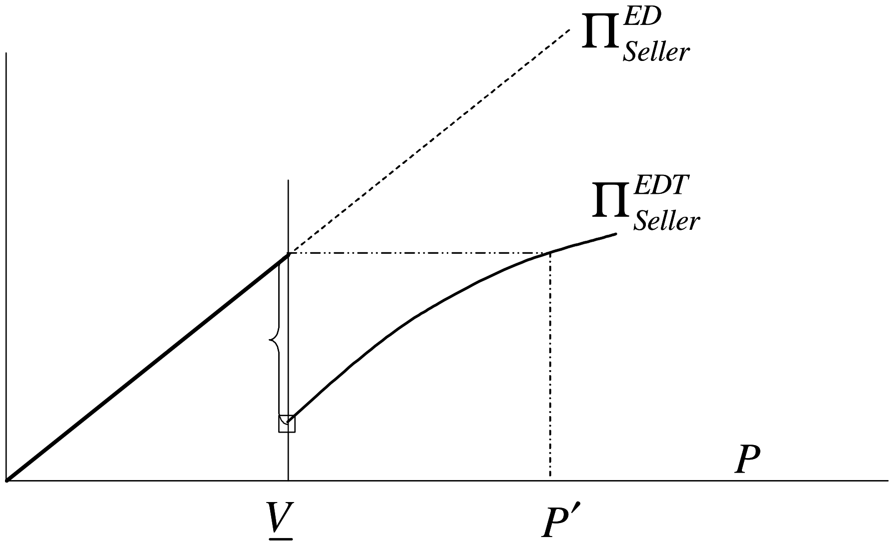

Figure 3: Seller's payoff under ED and EDT depending on price.

seller's payoff jumps down. Payoff under ED, however, continues to rise smoothly in P (see Figure 3).

Therefore, whereas under ED the seller always chooses the highest price that satisfies the buyer's PC (see Lemma 1) this can be different under EDT. Indeed, it might be in the seller's interest to set the price at $\underline{V}$, which is the highest price for which he can avoid termination, rather than at $P_{EDT}(u)$, which sets the buyer's utility to his reservation level.[23] In Figure 3 this happens for $P_{EDT}(u) \in (\underline{V}, P']$.

5 Main Result

In the previous section we solved the subgames induced by ED and EDT starting from the seller's investment decision. We showed that EDT leads to a discontinuity in the seller's payoff function which might have a moderating effect on the seller's price offer. This provides the intuition for our main result which we will derive in the remainder of this section by solving the game through stages 2 and 1. In essence, we will show that switching from ED to EDT may lead to redistribution from the seller to the buyer without sacrificing first best. Although increasing the consumer's welfare is often seen as desirable in its own right[24] we will also be concerned with overall welfare improvement.

[21] The superscript in Π^a_S reminds us that this is conditional on case a).

[22] We will later prove that the seller has the incentive to overinvest into quality.

[23] Price may not exceed valuation in the low case in order to always induce ex post trade. In the model the seller can influence the ex post trade decision by lowering the price. However, if the seller is able to directly influence the valuation of the seller through cooperative investments (which he cannot in our model) EDT would provide incentives for cooperative investments (see Che and Hausch (1999) and Che and Chung (1999)).

[24] See e.g. Recital 29 of the EC Merger Regulation 139/2004.

By a simple extension in section 6 we show that it is also possible to raise social welfare in a setting with multiple buyers.

Proposition 1 *If the devaluation due to non-conforming delivery is small, switching from ED to EDT has the following effect: For an intermediate range of market structures prices decrease and distribution of surplus changes in favour of the buyer, while preserving first best investment incentives. For highly competitive markets changing the regime has strictly no effect. For very uncompetitive markets, it may lead to higher prices and inefficient investment while putting the onus of the efficiency loss exclusively on the seller. Trade level remains unchanged. If the devaluation due to non-conforming delivery is high, inefficiency occurs in uncompetitive markets. In competitive markets there will even be loss of trade volume.*

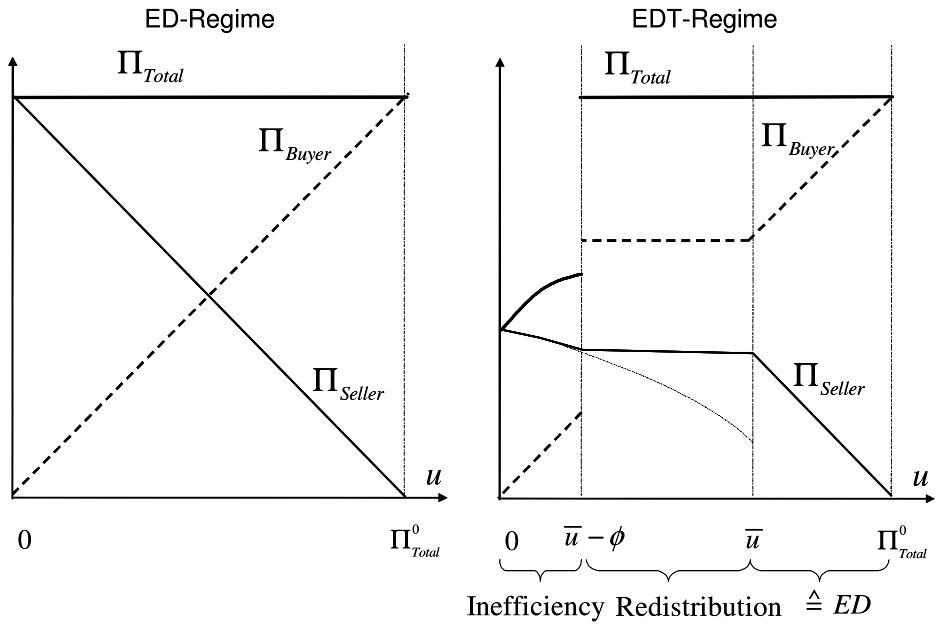

Figure 4: Payoff under ED and EDT depending on buyer's reservation utility u.

Figure 4 presents a leading case that illustrates the proposition. Note, that for very low devaluation due to non-conformity (very low δ) it may be the case that inefficiency disappears and redistribution even occurs for small u. For high devaluation due to non-conformity (high δ), switching from EDT to ED leads to inefficient investment, inefficient ex post trade decisions and loss of ex ante trade volume. For an illustration of all possible cases see Figure 9 in Appendix A.

5.1 Discussion

For low devaluation due to non-conforming delivery, switching from ED to EDT has an attractive feature: It curbs the monopoly power of the seller for an intermediate range of market structures without sacrificing any welfare. If, however, markets are highly competitive, neither efficiency nor distribution will be affected. Yet, failure to limit the seller's share in the gains of trade will be largely irrelevant under such circumstances. For markets which are close to outright monopoly, changing from ED to EDT will decrease welfare. This, however, should not be of too much concern as these markets are likely to be under the scrutiny of antitrust authorities. Prices will therefore often be regulated or set under the threat of regulation. Moreover, consistent with our findings, Article 1 (2b) of the EC Directive 1999/44 exempts from its scope classical monopolies like water, gas and electricity. Similar provisions existed for public transport. Therefore, the attractiveness of the EDT regime lies in its capability to limit the monopoly power of sellers in markets which traditionally are below the radar screen of antitrust authorities. Moreover, this is achieved without creating distortive effects on competitive markets.

For high levels of δ, switching from ED to EDT is much less attractive. It may lead to major distortions and even loss of trade volume. This inefficiency, however, may be empirically negligible as we will argue on the basis of the comparative statics exercises in section 7. In the remainder of this section we will continue to solve the game induced by EDT through the negotiation stages 2 and 1.

5.2 Negotiation Stage

a) Case P $\leq$V: The buyer accepts the seller's offer in stage 2 if he earns at least his reservation utility u. We can write this condition using equations (13) and (14):

$$\Pi_B^a(c_0) \geq u \iff \Pi_{Total}^a(c_0) - \Pi_S^a(c_0) = E\widetilde{V} - P_a \geq u. \tag{22}$$

The seller's payoff increases in price. Provided that his PC is satisfied, he therefore sets equilibrium price P_a such that the buyer's PC is binding unless this price would exceed $\underline{V}$ (which is the highest price for which case a) applies):

$$P_a = \min\left[E\widetilde{V} - u, \underline{V}\right] = \begin{cases} E\widetilde{V} - u & \text{for } u > \bar{u} \equiv E\widetilde{V} - \underline{V} \\ \underline{V} & \text{for } u \leq \bar{u} \end{cases}. \tag{23}$$

i) u $>$ ū. Inserting $P_a = E\widetilde{V} - u$ into (22) we get:

$$\Pi_S^a(c_0) = \Pi_{Total}^0(c_0) - u \geq 0. \tag{24}$$

for the seller's PC which is satisfied whenever there are potential gains of trade. This gives us the following lemma:

Lemma 2 *If total payoff exceeds cut-off value $\bar{u}$ ($\Pi_{Total}^0(c_0) > \overline{u}$) and the market is highly competitive ($u \in [\overline{u},\ \Pi_{Total}^0(c_0)]$) the following allocation is a candidate for subgame perfect equilibrium under EDT: The seller sets the price at the same level as under ED, the buyer never chooses termination, total payoff is socially optimal and the buyer earns his reservation utility u.*

ii) $\mathbf{u} \leq \bar{\mathbf{u}}$. Inserting $P_a = \underline{V}$ into (22) it follows from $u \leq \bar{u}$ that the buyer will earn a non-negative rent. Using (13) the seller's participation constraint is given by:

$$\Pi_S^a\left(\underline{V}, c_0\right) = \underline{V} - c_0 - (1-\gamma)\,\delta E\widetilde{V} \geq 0. \tag{25}$$

Rewriting this condition using $\bar{u} = E\widetilde{V} - \underline{V}$ gives us:

$$\Pi_{Total}^0\left(c_0\right) \geq \bar{u}. \tag{26}$$

We can therefore write the following lemma:

Lemma 3 *If total payoff exceeds cut-off value $\bar{u}$ ($\Pi_{Total}^0\left(c_0\right) > \overline{u}$) and the market is not too competitive ($u \in [0,\ \overline{u})$), the following allocation is a candidate for subgame perfect equilibrium under EDT: The seller sets price at $\underline{V}$, the buyer never chooses termination, total payoff is socially optimal and the buyer earns a non-negative rent.*

b) Case $\underline{\mathbf{V}}< \mathbf{P} \leq \overline{\mathbf{V}}$: At stage 2 it is optimal for the buyer to accept any offer that gives him at least his reservation utility u:

$$\Pi_{Total}^b\left(c_b\right) - \Pi_S^b\left(c_b\right) = E\widetilde{V} - P + \pi_T\left(P - \underline{V}\right) \geq u. \tag{27}$$

One can see from equation (16) that the seller's payoff Π_S^b is increasing in P. Therefore, in equilibrium, the seller will offer a price P_b at stage 1 such that condition (27) is binding:

$$P_b = \frac{E\widetilde{V} - u - \pi_T\underline{V}}{1-\pi_T} \tag{28}$$

provided that his participation constraint:

$$\Pi_S^b\left(c_b\right) = \Pi_{Total}^b\left(c_b\right) - u \geq 0 \iff \Pi_{Total}^b\left(c_b\right) \geq u \tag{29}$$

is satisfied. Rewriting this condition using equations (14) and (17) gives us:

$$\Pi_{Total}^0\left(c_0\right) - \phi_A - \phi_P \geq u. \tag{30}$$

We can therefore write the following lemma:

Lemma 4 *If the market is not too competitive ($u \leq \Pi_{Total}^0\left(c_0\right) - \phi_A - \phi_P$) the following allocation is a candidate for equilibrium: The seller sets price at P_b and two kinds of inefficiencies arise: 1) Ex post inefficiency ϕ_P because the good sometimes ends up with the seller. 2)Ex ante inefficiency ϕ_A due to overinvestment into quality because the seller anticipates opportunistic termination by the buyer. The buyer earns his reservation utility u.*

Proof. See Appendix A for the proof of the overinvestment result. The intuition of the proof is easy to understand: As the buyer gets his reservation utility, the entire expected loss of welfare due to termination is absorbed by the seller. This provides excessive investment incentives to the seller as, by increasing investment, he can lower the probability of termination. ■

We can now characterize the subgame perfect equilibrium in our leading case as illustrated in Figure 4:

Lemma 5 *If $\Pi^0_{Total} > \overline{u}$ and $\overline{u} - \phi > 0$, where $\phi \equiv \phi_A - \phi_P$, the seller's price offer under the EDT regime will be:*

$$P_{EDT} = \begin{cases} E\widetilde{V} - u & \text{for } u \geq \overline{u} \equiv E\widetilde{V} - \underline{V} \\ \underline{V} & \text{for } u \in [\overline{u} - \phi,\ \overline{u}) \\ P_b = \frac{E\widetilde{V} - u - \pi_T \underline{V}}{[1 - \pi_T]} & \text{for } u \in [0, \overline{u} - \phi) \end{cases} .$$

If the seller offers $\underline{V}$ the buyer will earn a positive rent. Otherwise he gets his reservation utility. Total payoff achieves first best unless the seller chooses P_b.

Proof. For $\Pi^0_{Total} > \overline{u}$ and $u > \bar{u}$ Lemma 2 describes the only feasible equilibrium candidate. This is because Lemma 3 requires $u \leq \bar{u}$ and Lemma 4 requires a parameter constellation that implies $u < \bar{u}$. The latter claim can be seen by using the fact that condition (27) holds with equality:

$$u = E\widetilde{V} - P + \pi_t (P - \underline{V}) < E\widetilde{V} - P + (P - \underline{V}) = \bar{u}. \tag{31}$$

Therefore Lemma 2 characterizes the subgame perfect equilibrium for $\Pi^0_{Total} > \overline{u}$ and $u > \bar{u}$.

For $\Pi^0_{Total} > \overline{u}$ and $u \leq \bar{u}$ Lemma 3 describes a candidate for equilibrium. It will be the subgame perfect equilibrium of the game if it is optimal for the seller to offer $\underline{V}$ instead of P_b:

$$\Pi^a_S (\underline{V}, c_0) \geq \Pi^b_S (P_b) = \Pi^b_{Total} (c_b) - u. \tag{32}$$

Using equations (25) and (17) and rearranging gives us:

$$u \geq E\widetilde{V} - \underline{V} - \left[(c_b - c_0) + (\gamma_0 - \gamma_b) \delta E\widetilde{V} \right] - [\pi_T (1 - \delta) \underline{V}] . \tag{33}$$

Substituting $\bar{u} = E\widetilde{V} - \underline{V}$ and $\phi \equiv \phi_A + \phi_P$ (see expressions (20) and (18)) we can rewrite the condition as follows:

$$u \geq \bar{u} - \phi. \tag{34}$$

Therefore the equilibrium characterized by Lemma 3 will be the subgame perfect equilibrium of the EDT game if $\Pi^0_{Total} > \overline{u}$ and $u \in [\overline{u} - \phi,\ \overline{u})$. Moreover, it follows that for $u < \bar{u} - \phi$ Lemma 4 characterizes the subgame perfect equilibrium of the EDT game, provided that the seller's participation constraint (30) is satisfied. Using $\phi < \bar{u} - u$ and $\Pi^0_{Total} > \overline{u}$ we can write:

$$\Pi^0_{Total}(c_0) - \phi > \Pi^0_{Total}(c_0) - \bar{u} + u > u \tag{35}$$

which means that the seller's PC will always be satisfied. The remaining parts of the lemma follow directly form Lemmas 2-4. ■

5.3 Comparing Prices

Comparing ED and EDT with respect to the seller's price offer, we can derive the following lemma:

Lemma 6 *i) If the seller sets the price at $E\widetilde{V} - u$ under EDT, it will be the same as under ED. ii) If the seller offers price $\underline{V}$ under EDT it will be lower than under ED. iii) If under EDT the seller offers P_b it will be higher than under ED.*[25]

Proof. Part i) follows immediately from (7). Whenever the seller offers $\underline{V}$ under EDT, $u < \overline{u}$ must hold by Lemma 5. Inserting $\overline{u} = E\widetilde{V} - \underline{V}$ we get $\underline{V} < E\widetilde{V} - u$ which vindicates part ii). $P_b > E\widetilde{V} - u$ is equivalent to $\pi_T \left(E\widetilde{V} - u - \underline{V}\right) > 0$. Substituting $\overline{u} = E\widetilde{V} - \underline{V}$ we can write $\pi_T(\overline{u} - u) > 0$. This will always hold for $u < \overline{u} - \phi$, which by Lemma 5 is true whenever the seller offers P_b under EDT. This gives us part iii). ■

Our main result in Proposition 1 largely summarizes the lemmas of this section but drops the assumption of Lemma 5 that $\Pi^0_{Total} > \overline{u}$ and $\overline{u} - \phi > 0$. This creates considerable complication without helping intuition. We will therefore relegate the proof to Appendix B. The main problem is that we have to make a case distinction which does not yield to an intuitive interpretation until we rewrite the conditions in terms of quality parameter δ. We also make use of the structure imposed by the seller's investment decision.

6 Efficiency

It is not surprising that curbing the monopoly power of the seller is also likely to lead to efficiency gains. In order to illustrate this fact, we will present an example where this is the case. Let us imagine two consumers $i = 1, 2$ with identical valuation but different wealth constraints $w_1 > w_2 > c_0$ who are potential consumers of a single unit of the good.[26] We assume that valuation is high enough such that trade is socially desirable.

[25] The third part of this lemma may seem counter-intuitive. If the seller offers P_b the buyer earns his reservation utility just as under ED. So, one could ask why the price can rise if at the same time joint payoff is lower due to inefficiency. The reason is that the option to terminate increases the buyer's expected payoff by more than the amount of the inefficiency.

[26] Assuming identical valuation has the advantage that we do not have to change the above benchmark for efficient investment. Otherwise a seller who cannot distinguish types would adjust quality investments to the valuation of the average customer. This is the reason why we construct the downward sloping demand curve by assuming wealth constraints.

The highest price that the seller can set under the ED regime is still given by $P = E\widetilde{V} - u$. Now, let us assume that $w_1 > E\widetilde{V} - u > w_2$. Then, the seller knows that if he sets the price below or at w_2 he can win over an additional customer. From a welfare perspective it is always desirable to trade with both customers. Yet, for the seller this will only be attractive if the extra profit he makes by gaining the additional customer, outweighs the loss of profit he incurs by also reducing the price for the customer who is able to pay the high price. This resonates with standard monopoly theory which predicts that a non-discriminating monopolist tends to produce a smaller output than socially optimal because he takes into account the effect of price reduction owing to an increase in output on *all* the units sold. The seller will therefore set the price in the following way:

$$P = \begin{cases} w_2 & if\ 2\left[w_2 - c_0 - (1-\gamma_0)\,\delta E\widetilde{V}\right] > E\widetilde{V} - c_0 - (1-\gamma_0)\,\delta E\widetilde{V} - u \\ E\widetilde{V} - u & otherwise \end{cases} \quad (36)$$

The condition for lowering the price in order to serve the low wealth customer under the ED regime is therefore:

$$w_2 > \bar{w}_{ED} \equiv \frac{[1 + (1-\gamma_0)\,\delta]\,E\widetilde{V} + c_0 - u}{2}. \quad (37)$$

Now, we turn to the EDT regime. For simplicity, we assume that Case A applies (see Figure 7 in Appendix B). Then, if there is only one consumer, we have shown that the seller will set the price at $\underline{V}$ which is the highest price for which no termination occurs. Of course, trade with the low wealth consumer occurs if $\underline{V} < w_2$. However, this is not a necessary condition for increased output under EDT. Indeed, if $\underline{V} > w_2$, the seller will set the price as follows:

$$P = \begin{cases} w_2 & if\ \ 2\left[w_2 - c_0 - (1-\gamma_0)\,\delta E\widetilde{V}\right] > \underline{V} - c_0 - (1-\gamma_0)\,\delta E\widetilde{V} \\ \underline{V} & otherwise \end{cases} \quad (38)$$

The condition for lowering the price in order to serve the low wealth customer under the EDT regime is therefore:

$$w_2 > \bar{w}_{EDT} \equiv \frac{\underline{V} + (1-\gamma_0)\,\delta E\widetilde{V} + c_0}{2} = \frac{[1 + (1-\gamma_0)\,\delta]\,E\widetilde{V} + c_0 - (E\widetilde{V} - \underline{V})}{2} \quad (39)$$

We can derive the following proposition:

Proposition 2 *If $w_2 \in [\bar{w}_{EDT},\ \bar{w}_{ED}]$ the seller will not lower the price in order to serve the low wealth customer under the ED regime but will do so under the EDT regime. Therefore introducing the EDT regime increases efficiency by enabling a more efficient volume of trade.*

Proof. Remember from Figure 7 that if Case A applies, the seller will set the price at $\underline{V}$ for $u \in [0,\ \bar{u})$ and at the same level as under ED if $u \in [\bar{u},\ \Pi^0_{Total}]$. Thus it can be seen from expressions (39) and (37) that $\bar{w}_{EDT} < \bar{w}_{ED}$ as $u < \bar{u} = E\widetilde{V} - \underline{V}$ for all $u \in [0,\ \bar{u})$. ■

The intuition is that, as the price under EDT is lower anyway, the margin that the seller has to sacrifice in order to accommodate the low wealth customer is smaller than under ED.[27] He will therefore produce a higher output under EDT. Thus, we have shown that EDT serves as a functional substitute to price regulation, which might, however, be less prone to the latter's informational problems (e.g. Sheshinski (1976)). This makes EDT especially attractive for an intermediate range of market structures.

7 Comparative Statics

7.1 Devaluation due to non-conformity (δ)

Casual empiricism suggests that the distribution of δ may be double-peaked at relatively modest and very high δ. Quite often, non-conformity will consist in little defects which will reduce the value of the good by only a fraction: A software program may work well most of the time but some features may be bugged. Or, the weave of clothes may be flawed at some barely visible spot. On the other hand, it seems to be frequent that non-conforming goods have no use at all. There is very little value to a TV set that does not work. Such binary quality is common for most electronic devices. If this description of reality is approximately correct, it would vindicate our earlier claim that the theoretical inefficiency associated with the EDT regime are empirically negligible. Indeed, we know from Proposition (1) that for high devaluation due to non-conformity inefficient investment and ex post trade decisions may arise in uncompetitive markets. In competitive markets there will even be loss of trade volume. Yet, for $\delta \longrightarrow 1$ this inefficiency tends to zero as is implied by the following proposition.

Proposition 3 *The higher δ the lower the inefficiency in the event of trade. Moreover, the no trade interval shrinks for ever higher u. In the limit case, were $\delta = 1$, there will be no loss of trade volume under EDT and the seller will always choose P_b. Therefore, although price increases, there will be no redistribution effect and joint surplus does not deviate from first-best.*

Proof. Appendix C. ■

Another implication of the proposition is that product groups with high δ_{II} are likely to benefit from EDT. Not only will the redistribution effect occur for a large interval of

[27] A negative effect on trade volume can occur in this setting, if there is a positive probability of termination under the EDT regime. This is because the contract price increases (e.g. for low u in Case B). It is, however, straightforward to see that this problem is due to modelling the downward sloping demand curve by assuming wealth constraints. As mentioned earlier, this assumption was adopted for expositional reasons. The direction of the effect is unambigously positive if the downward sloping demand curve is due to different valuations. Indeed, the consumer will receive the same value as under ED because the higher price is compensated by the higher value due to the option to terminate.

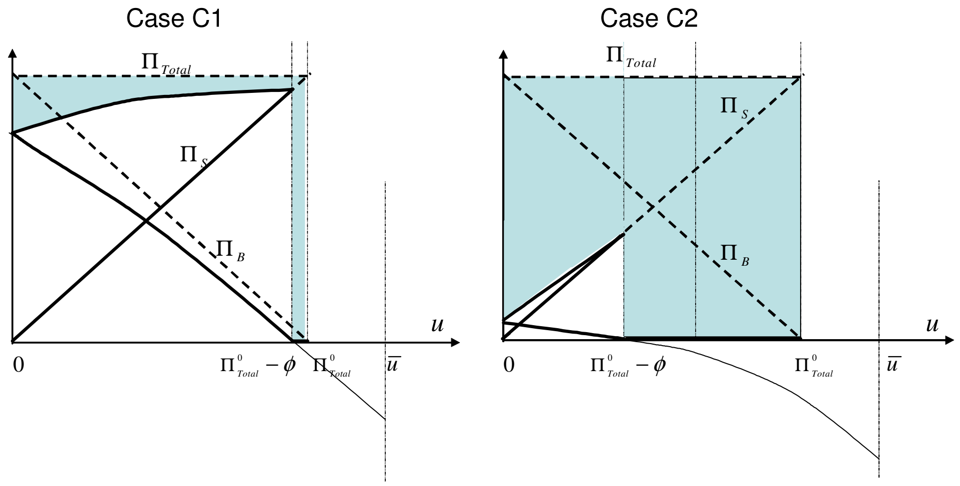

Figure 5:

u in this case but also inefficiency, if it arises at all, will be low. Figure (5) illustrates this fact. C1 depicts the situation for high δ_{II}, while C2 shows the effect for low δ_{II}. The shaded area shows the amount of inefficiency. Threshold value δ_{II} will be high if the buyer's valuation in the low state $\underline{V}$ is not too small and the probability $1-\lambda$ that the buyer changes his mind about the product is high (See Appendix C).

7.2 Consistency of valuation (λ)

When parties enter into a contract it is often not clear what the value of the good will be at the time when the buyer may invoke lack of conformity. If, for example, somebody buys furniture or household equipment which is tailored to his house the value of these goods to him will be much lower if he has to move somewhere else. Yet, even less drastic events can bring this about. The buyer might as well discover that he does not like the good as much as he thought. Or, he discovers another good which he likes even more (Shavell (1980) p. 470). In any such case the buyer will be delighted to be able to reverse the transaction if delivery turns out to be non-conforming.

It is difficult to imagine a situation where it is certain that the valuation of the buyer will decrease ($\lambda = 0$). Maybe the best examples are cases of deception or mental black out for which special provisions exist in the law which are not the focus of our analysis. Also the opposite case ($\lambda = 1$), where we can be absolutely sure that the valuation stays the same will be rare. Maybe this would be the case for life saving medicine. Generally, cases will lie in between. The following proposition looks on how results vary for different levels of λ:

Proposition 4 *(a) If valuation is unlikely to stay high (low λ) the relative importance of the redistribution effect increases in λ. In the limit case, where it is sure that valuation will be low ($\lambda = 0$), EDT will produce the same result as under ED. (b) For intermediate*

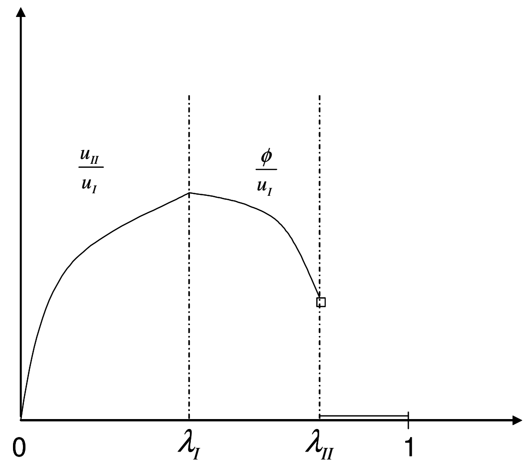

Figure 6:

probabilities the relative importance of the effect will decrease in λ. (c) For high probability that valuation stays the same (high λ) we know from Proposition 1 that parties will trade for low u, but inefficient investment and ex post trade decisions may arise. For high u there will be no trade despite ex ante gains of trade. Yet, as λ increases, this inefficiency decreases and the no-trade interval shrinks to ever higher u. In the limit case $\lambda = 1$, the effect of EDT and ED is the same.

Proof. Appendix D. ■

Relevant factors determining the consistency of the valuation may be buyer characteristics or the industry's pace of product innovation. Moreover, the marketing literature has identified products where "cognitive dissonance" is likely to be high. This may induce buyers to regret their buying decision.[28]

The main legal instrument influencing consistency of valuation is the time limit for invoking lack of conformity. With time, the probability that parameters relevant for the valuation change is likely to increase. European warranty law is rather generous: It does not require the consumer to invoke lack of conformity at the time of delivery, as very often defects are hidden and will become apparent much later. And, even if the consumer discovers it right away, the law in many European countries still allows him to invoke non-conformity for at least two years after the good has been delivered.[29] Especially this latter provision has been criticized by lawyers on the ground that a buyer who does not invoke his right immediately no longer deserves the protection of the law. If he continues to have the right to terminate the law merely supports "speculation at the cost of the

[28] This is said to be the case for "high involvement products" (e.g. Kaish (1967) and Solomon (2004) p. 233 and the literature cited there). Cognitive Dissonance is one of the reasons why luxury brands not only direct advertisment to prospective but also to existing customers.

[29] Recital 19 of the Preamble of the EC Directive 1999/44 allows countries to introduce a two month term of decadence within which the buyer must inform the seller of the lack of conformity. Many countries did not make use of this provision.

debtor" (Schlechtriem and Schmidt-Kessel (2005) AT Para 534).[30] The only remaining justification would therefore be some consumer protection argument, e.g. that the legally inexperienced consumer might otherwise not have enough time to pursue his right. We offer an alternative argument which justifies rather generous time limits precisely because they enable opportunistic termination. While it is correct that opportunistic termination is bad if actually exercised it may serve as a threat (not carried out in equilibrium) that helps to curb monopoly power. Yet, there are limits to the blessings of opportunistic termination: As can be seen from Proposition 4, the positive effect due to EDT will subside if valuation is almost certain to be low at the time the consumer may invoke lack of conformity (λ close to 0). Curiously, however, the least favorable outcome is to be expected of a regime, which allows termination in principle, but tries to keep the probability of opportunistic termination at fairly low levels ($\lambda \in [\lambda_{II}, 1]$).

8 Conclusion

We have shown that the consumer does not pay the bill for the expansion of his rights from ED to EDT. Quite the opposite, his share of the trade surplus may actually increase. Moreover, by curbing the monopoly power of the seller, the redistribution effect can also improve welfare. Namely, it enables more efficient trade volume in a setting with multiple buyers. Thus private law can have an antitrust effect in cases which are below the radar screen of antitrust authorities. This provides an argument for mandatory termination rights as stipulated in the EC directive 1999/44. Indeed, as the effect is to curb monopoly power of the seller, the EDT regime would never be the outcome of free negotiations in uncompetitive markets. For the United States the policy implication would be to consider making Article 2 of the UCC mandatory.

We have also shown that the scepticism of many legal scholars towards generous termination rights is overblown. In particular, our model offers no justification for the fact that the law tends to disallow termination unless non-conformity passes a certain threshold level.[31] Quite the opposite, the EDT regime seems to perform rather well for small defects.[32]

Finally, our analysis also has an interesting implication for contracting even if EDT is not mandatory. One could easily imagine that two companies making a deal have a commercial team which bargains over the price, a technical team which works out the exact specification of the good to be traded and legal team which agrees on the legal

[30] Traditionally there are two techniques that the law uses to restrict the possibility of opportunistic termination: One is to introduce a notification requirement, the other is to require the buyer to inspect the goods upon delivery. Failure to do either of these would entail forfeiture of termination rights (e.g. the German Commercial Code §377 HBG).

[31] Article 3 (6) of the EC Directive 1999/44 disallows termination if the non-conformity is "minor". In common law the prerequisite for termination is "material breach" (see Farnsworth (2004) § 8.15)

[32] This will, however, not be true if renegotiations are possible.

remedies which govern the transaction. Our analysis suggests that given a package of product characteristics and legal remedies parties cannot just freely bargain about the price. We have shown, that inserting a termination clause into the contract will restrict the set of prices that reasonable parties are able to agree upon. This effect depends on the probability of non-conformity which in turn is determined by the technical specification of the good. We therefore predict that contract renegotiations in uncompetitive markets will be a integrated process which comprehensively deals with commercial, technical and legal issues. Another - empirically testable - implication would be that retail companies who either by firm policy or law are required to offer the same termination rights for all of their products will earn lower mark-ups on goods which are likely to become defective (e.g. clothes) than on goods where this is not the case (e.g. cosmetics). This difference should be more pronounced as termination rights become more generous. We leave testing these empirical hypotheses to further research.

9 Appendix

9.1 Appendix A

in order to say more about the seller's investment decision c_b. Using (29) and (16) it follows for the seller's optimal investment decision c_b that:

$$\begin{aligned} c_b &\in \arg\max_c \Pi_S^b = \arg\max_c \Pi_{Total}^b - u \\ &= \arg\max_c E\widetilde{V} - c - (1-\gamma)\,\delta E\widetilde{V} - \pi_T\,(1-\delta)\,\underline{V} - u. \end{aligned} \quad (40)$$

As the probability of conforming delivery is $\bar{\gamma}$ if the seller invest $\bar{c}$, and 0 otherwise, it follows that the seller will invest only if:

$$\begin{aligned} & E\widetilde{V} - \delta E\widetilde{V} - (1-\lambda)\,(1-\delta)\,\underline{V} - u \\ < \; & E\widetilde{V} - \bar{c} - (1-\overline{\gamma})\,\delta E\widetilde{V} - (1-\lambda)\,(1-\overline{\gamma})\,(1-\delta)\,\underline{V} - u. \end{aligned} \quad (41)$$

Rearranging, the seller's optimal investment decision can be written as:

$$c_b = \begin{cases} \bar{c} & \text{if } \frac{\bar{c}}{\bar{\gamma}} < \delta E\widetilde{V} + (1-\lambda)\,(1-\delta)\,\underline{V} \\ 0 & otherwise \end{cases}. \quad (42)$$

As $(1-\lambda)\,(1-\delta)\,\underline{V} > 0$, it can be seen by comparing expressions (42) and (3) that:

$$c_b > c_0 \iff \frac{\overline{c}}{\overline{\gamma}} \in \left[\delta E\widetilde{V},\ \delta E\widetilde{V} + (1-\lambda)\,(1-\delta)\,\underline{V}\right]. \quad (43)$$

9.2 Appendix B

9.2.1 Relaxing Assumptions

In Lemma 5 we did not pay attention to the parties' participation constraints and assumed $\Pi_{Total}^0 \geq \bar{u}$. In order to arrive at Proposition 1 we have to deal with these shortcomings.

For $u \geq \overline{u} \equiv E\widetilde{V} - \underline{V}$, which is the case in which the seller would offer $E\widetilde{V} - u$ the buyer's participation constraint (PC) is satisfied by assumption ($u \geq 0$). However, in order for the seller's PC to be satisfied, u must not exceed total payoff:

$$\Pi_{S1} \geq 0 \iff u \leq \Pi_{Total}^a = \Pi_{Total}^0. \quad (44)$$

We can therefore derive the following lemma:

Lemma 7 *Under the EDT regime, the seller will set price at $E\widetilde{V} - u$, which is the same price as under the the ED regime, if and only if*

$$\Pi_{Total}^0 > \overline{u} \wedge u \in \left[\overline{u},\ \Pi_{Total}^0\right]$$

with $\overline{u} = E\widetilde{V} - \underline{V} > 0$ *and* $\Pi_{Total}^0 = E\widetilde{V} - c_0 - (1-\gamma_0)\,\delta E\widetilde{V}$.

For $u < \overline{u}$ the seller prefers to offer $\underline{V}$ if $u \geq \overline{u} - \phi$ and P_b for $u < \overline{u} - \phi$. The buyer's PC is satisfied by definition if the seller chooses P_b (as $u \geq 0$). If the seller lowers the price to $\underline{V}$ this is true all the more. In this case the buyer's PC is not even binding, which means that the buyer receives a rent.

The seller's PC, however, is more problematic: If $u \geq \overline{u} - \phi$ and consequently $\underline{V}$ is preferred to P_b the following must hold:

$$\Pi_S^a(\underline{V}) \geq 0 \iff \underline{V} - c_0 - (1-\gamma_0)\,\delta E\widetilde{V} \geq 0 \iff \Pi_{Total}^0 \geq \overline{u}. \tag{45}$$

Taking into account that $\overline{u} - \phi$ may be negative we can write the following lemma:

Lemma 8 *Under the EDT regime, the seller offers $\underline{V}$, if and only if*

$$\begin{aligned} \Pi_{Total}^0 &\geq \overline{u} \wedge \overline{u} - \phi > 0 \wedge u \in [\overline{u} - \phi,\ \overline{u}) \\ \Pi_{Total}^0 &\geq \overline{u} \wedge \overline{u} - \phi \leq 0 \wedge u \in [0,\ \overline{u}) \end{aligned}$$

The seller voluntarily gives up bargaining power. This price leaves a rent to the buyer.

If $u < \overline{u} - \phi$ and, consequently, P_b is more attractive than $\underline{V}$ the following must hold:

$$\Pi_{S2}(P_b) \geq 0 \iff \Pi_{Total}^b - u = \Pi_{Total}^0 - \phi - u \geq 0 \iff u \leq \Pi_{Total}^0 - \phi. \tag{46}$$

Therefore the seller will choose $P = P_b$ if and only if $u < \overline{u} - \phi \wedge u \leq \Pi_{Total}^0 - \phi$. As $u > 0$ this is only possible if $\min[\overline{u} - \phi,\ \Pi_{Total}^0 - \phi] \geq 0$. Note that if $\overline{u} < \Pi_{Total}^0$, $u < \overline{u} - \phi$ implies $u < \Pi_{Total}^0 - \phi$, so that the PC of the seller is automatically satisfied. We can write the following lemma:

Lemma 9 *The seller will choose P_2 if and only if*

$$\begin{aligned} \overline{u} &< \Pi_{Total}^0 \wedge \ \overline{u} - \phi > 0 \wedge \ u \in [0,\ \overline{u} - \phi] \\ \vee \overline{u} &\geq \Pi_{Total}^0 \wedge \Pi_{Total}^0 - \phi > 0 \wedge u \in \left[0, \Pi_{Total}^0 - \phi\right]. \end{aligned}$$

Lemma 8 implies that it cannot happen that the seller voluntarily gives up bargaining power for $\Pi_{Total}^0 < \overline{u}$. To see this, consider that if $\underline{V}$ is preferred to P_b the seller's participation constraint will always be violated as stated in expression (45). But also $P_a = E\widetilde{V} - u$ will never be offered as follows from Lemma 7. Thus, if $\Pi_{Total}^0 < \overline{u}$, the seller either offers P_b or his PC is violated. On the other hand, for $\Pi_{Total}^0 \geq \overline{u}$ the participation constraint of the seller will hold for all cases of potential gains of trade, $u \in [0, \Pi_{Total}^0]$. We can therefore write the following corollary:

Corollary 1 *There will be no trade despite of potential gains of trade if and only if*

$$\begin{aligned} \Pi_{Total}^0 &\leq \overline{u} \wedge \Pi_{Total}^0 - \phi > 0 \wedge u \in \left[\Pi_{Total}^0 - \phi,\ \Pi_{Total}^0\right] \\ \vee \Pi_{Total}^0 &\leq \overline{u} \wedge \Pi_{Total}^0 - \phi \leq 0 \wedge u \in \left[0,\ \Pi_{Total}^0\right]. \end{aligned}$$

Therefore, if $\Pi_{Total}^0 \geq \overline{u}$ trade volume will always be efficient under the EDT regime.

9.2.2 Cases

If $\Pi^0_{Total} < 0$ there is no trade under EDT but neither under ED. This is not a problem as there are no potential gains of trade. If $\Pi^0_{Total} > 0$, it follows from lemma 7 - 9 that it is possible to distinguish four cases:

Case A: $\Pi^0_{Total} > \overline{u} \wedge \overline{u} - \phi \leq 0:$

$$P = \begin{cases} \underline{V} & \text{for } u \in [0,\ \overline{u}) \\ P_a = E\widetilde{V} - u & \text{for } u \in [\overline{u},\ \Pi^0_{Total}] \end{cases} . \tag{47}$$

Case B: $\Pi^0_{Total} > \overline{u} \wedge \overline{u} - \phi > 0:$

$$P = \begin{cases} P_b = \frac{E\widetilde{V} - u - \pi_T \underline{V}}{1 - \pi_T} & \text{for } u \in [0,\ \overline{u} - \phi) \\ \underline{V} & \text{for } u \in [\overline{u} - \phi,\ \overline{u}) \\ P_a = E\widetilde{V} - u & \text{for } u \in [\overline{u},\ \Pi^0_{Total}] \end{cases} . \tag{48}$$

Figure 7 shows cases A and B which share the property that $\Pi^0_{Total} > \overline{u}$. The shaded area shows the inefficiency that may arise.

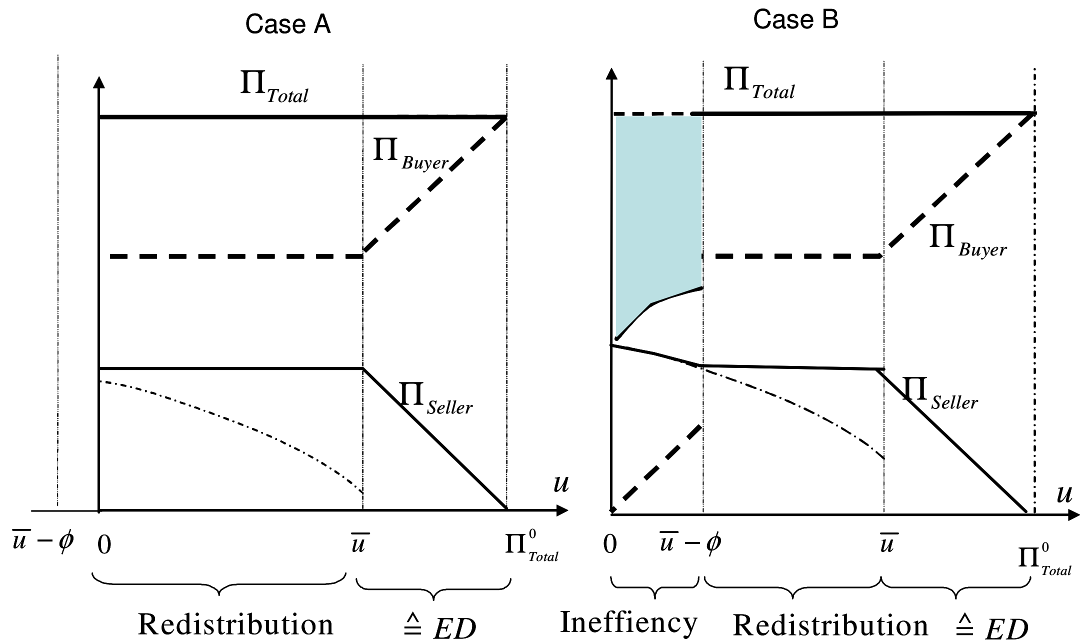

Figure 7: Cases for low devaluation due to non-conforming delivery.

Case C: $\Pi^0_{Total} \leq \overline{u} \wedge \overline{u} - \phi > 0.$

$$P = \begin{cases} P_2 = \frac{E\widetilde{V} - u - \pi_T \underline{V}}{1 - \pi_T} & \text{for } u \in [0,\ \Pi^0_{Total} - \phi) \\ \textit{no trade} & \text{for } u \in [\Pi^0_{Total} - \phi,\ \Pi^0_{Total}] \end{cases} \tag{49}$$

Case D: $\Pi^0_{Total} \leq \overline{u} \wedge \Pi^0_{Total} - \phi \leq 0$. In the extreme case, where $\Pi^0_{Total} - \phi \leq 0$ there is no trade at all.

Figure 8 shows cases C and D which share the common feature that $\Pi^0_{Total} \leq \overline{u}$. Not that the shaded area shows inefficiency. This time the inefficiency also arises from loss of trade volume.

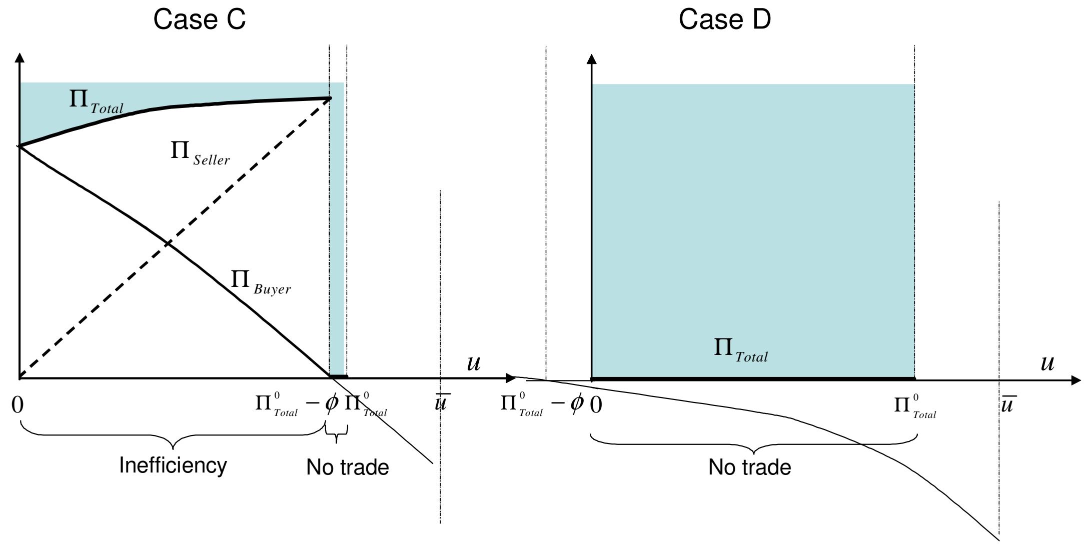

Figure 8:

9.2.3 Rewriting in terms of δ

So far our results would allow us to predict the impact of a shift from EDT to ED. By calculating Π^0_{Total}, $\bar{u}$ and ϕ we can predict the effect on investment, prices, allocative efficiency and trade volume for any given u. When it comes to general qualitative statements, however, a distinction of cases depending on the threshold values Π^0_{Total}, $\bar{u}$, $\bar{u} - \phi$ and $\Pi^0_{Total} - \phi$ is not very helpful unless one can give intuitive meaning to them. We will do so indirectly by writing the conditions for cases A, B, C and D in terms of δ which measures the devaluation due to non-conformity. Substituting Π^0_{Total}, $\bar{u}$ and ϕ in the above conditions and rearranging, we can derive the following lemma:

Lemma 10 *In terms of δ the above conditions can be written as:*

$$
\begin{aligned}
\text{Case A} &: \quad \Pi^0_{Total} > \overline{u} \wedge \overline{u} - \phi \leq 0 \iff \delta < \delta_{II} \wedge \delta \leq \delta_I, \\
\text{Case B} &: \quad \Pi^0_{Total} > \overline{u} \wedge \overline{u} - \phi > 0 \iff \delta < \delta_{II} \wedge \delta > \delta_I, \\
\text{Case C} &: \quad \Pi^0_{Total} \leq \overline{u} \wedge \ \Pi^0_{Total} - \phi > 0 \iff \delta \geq \delta_{II} \wedge \delta < \delta_{III}, \\
\text{Case D} &: \quad \Pi^0_{Total} \leq \overline{u} \wedge \ \Pi^0_{Total} - \phi \leq 0 \iff \delta \geq \delta_{II} \wedge \delta \geq \delta_{III} \\
\text{where} &: \\
\delta_I &\equiv \min\left[\max\left[0,\ \frac{[(1-\lambda)(1-\gamma_b) - \lambda(\mu-1)]\underline{V} + (c_b - c_0)}{[(1-\lambda)(1-\gamma_b) + (\gamma_b - \gamma_0)(1+\lambda\mu-\lambda)]\underline{V}}\right],\ 1\right], \\
\delta_{II} &\equiv \min\left[\max\left[0,\ \frac{\underline{V} - c_0}{(1-\gamma_0)E\widetilde{V}}\right],\ 1\right], \\
\delta_{III} &\equiv \min\left[\max\left[0,\ \frac{[\lambda\mu + \gamma_b(1-\lambda)]\underline{V} - c_b}{(1-\gamma_b)\lambda\mu\underline{V}}\right], 1\right].
\end{aligned}
$$

We can significantly simplify Lemma 10 by making use of the structure imposed by the investment decision of the seller. We can distinguish three cases depending on the efficiency of the quality assurance technology. If technology is very inefficient, the seller will neither invest under the ED nor under the EDT regime (i). For intermediate efficiency levels he will invest under the EDT but not under the ED regime (ii). If the technology is very efficient he will invest under both regimes (iii).

i) Low Efficiency: If

$$\frac{\overline{c}}{\overline{\gamma}} > \delta E\widetilde{V} + (1-\lambda)(1-\delta)\underline{V} \tag{50}$$

the quality assurance technology is very inefficient and the seller will not invest in quality even if he knows that termination is part of the buyer's equilibrium strategy:

$$c_0 = c_b = 0 \implies \gamma_0 = \gamma_b = 0. \tag{51}$$

Using (51) the following expressions simplify:

$$
\begin{aligned}
\phi_A &= 0 \qquad (52)\\
\phi_P &= (1-\lambda)(1-\delta)\underline{V} > 0 \\
\Pi^0_{Total} &= (1-\delta)E\widetilde{V}.
\end{aligned}
$$

We can proof the following lemma:

Lemma 11 *In the low efficiency case, $\delta^i_I < \delta^i_{II} = \frac{\underline{V}}{E\widetilde{V}} < \delta^i_{III} = 1$.*

Proof. Inserting (51) into the expression in Lemma 10 gives:

$$
\begin{aligned}
\delta^i_I &= \max\left[0,\ \frac{1-\lambda\mu}{1-\lambda}\right] = \max\left[0,\ 1 - \frac{\lambda(\mu-1)}{1-\lambda}\right], \qquad (53)\\
\delta^i_{II} &= \frac{\underline{V}}{E\widetilde{V}} = 1 - \frac{\lambda(\mu-1)}{1-\lambda+\lambda\mu} > 0, \\
\delta^i_{III} &\equiv 1.
\end{aligned}
$$

Using $\lambda\mu > 0$ one can derive $\delta_I^i < \delta_{II}^i$. From $\mu > 1 \implies \delta_{II}^i < 1$ follows, $\delta_{II}^i < \delta_{III}^i$. ■

ii) Intermediate Efficiency: If

$$\delta E\widetilde{V} < \frac{\overline{c}}{\overline{\gamma}} \leq \delta E\widetilde{V} + (1-\lambda)(1-\delta)\underline{V} \tag{54}$$

the efficiency level of the quality assurance technology is intermediate. The seller will *only* invest if termination will be part of the buyer's equilibrium strategy:

$$c_0 = 0 \implies \gamma_0 = 0 \wedge c_b = \overline{c} \implies \gamma_b = \overline{\gamma}. \tag{55}$$

Using (55) the following expressions can be simplified:

$$\begin{aligned} \phi_A &= \overline{c} - \overline{\gamma}\delta E\widetilde{V}, \\ \phi_P &= (1-\lambda)(1-\overline{\gamma})(1-\delta)\underline{V} > 0, \\ \Pi_{Total}^0 &= (1-\delta) E\widetilde{V}, \\ \bar{u} &= \lambda\left(\overline{V} - \underline{V}\right). \end{aligned} \tag{56}$$

We can prove the following lemma:

Lemma 12 *If the efficiency of the quality assurance technology is intermediate* $\delta_I^{ii} < \delta_{II}^{ii} = \frac{\underline{V}}{E\widetilde{V}} < \delta_{III}^{ii} = 1$.

Proof. The proof can be made in three parts:

$$\begin{aligned} 1.\ \delta_{II}^{ii} &= \delta_{II}^{i} = \frac{\underline{V}}{E\widetilde{V}} = 1 - \frac{\lambda(\mu-1)}{1-\lambda+\lambda\mu} < 1, \\ 2.\ \delta_{I}^{ii} &= \max\left[0, \frac{[(1-\lambda)(1-\overline{\gamma}) - \lambda(\mu-1)]\underline{V} + \overline{c}}{[(1-\lambda)(1-\overline{\gamma}) + \overline{\gamma}(1+\lambda\mu-\lambda)]\underline{V}}\right] < \delta_{II}^{ii}, \\ 3.\ \delta_{II}^{ii} &< \delta_{III}^{ii} = 1. \end{aligned} \tag{57}$$

The first claim can be immediately seen by plugging $c_0 = 0$ and $\gamma_0 = 0$ into the expressions in Lemma 10. Using (54) we can write:

$$\begin{aligned} & \frac{[(1-\lambda)(1-\overline{\gamma}) - \lambda(\mu-1)]\underline{V} + \overline{c}}{[(1-\lambda)(1-\overline{\gamma}) + \overline{\gamma}(1+\lambda\mu-\lambda)]\underline{V}} \\ < & \frac{[(1-\lambda)(1-\overline{\gamma}) - \lambda(\mu-1)]\underline{V} + \overline{\gamma}\delta E\widetilde{V} + \overline{\gamma}(1-\lambda)(1-\delta)\underline{V}}{[(1-\lambda)(1-\overline{\gamma}) + \overline{\gamma}(1+\lambda\mu-\lambda)]\underline{V}} \\ = & \frac{1-\lambda\mu(1-\overline{\gamma}\delta)}{1+\lambda(\overline{\gamma}\mu-1)} = 1 - \frac{\lambda(\mu-1) + \lambda\mu\overline{\gamma}(1-\delta)}{1-\lambda+\lambda\overline{\gamma}\mu} \\ < & 1 - \frac{\lambda(\mu-1)}{1-\lambda+\lambda\mu} = \delta_{II}^{ii} < 1 \end{aligned} \tag{58}$$

This gives us the second claim. For the third claim we plug $c_b = \overline{c} \implies \gamma_b = \overline{\gamma}$ into:

$$\delta_{III} \equiv \min\left[\max\left[0, \frac{[\lambda\mu + \gamma_b(1-\lambda)]\underline{V} - c_b}{(1-\gamma_b)\lambda\mu\underline{V}}\right], 1\right]. \tag{59}$$

Then, using (54), we can write:

$$\begin{aligned} & \frac{[\lambda\mu+\overline{\gamma}(1-\lambda)]\underline{V}-\overline{c}}{(1-\overline{\gamma})\lambda\mu\underline{V}} \\ > & \frac{[\lambda\mu+\overline{\gamma}(1-\lambda)]\underline{V}-\overline{\gamma}\delta E\widetilde{V}+\overline{\gamma}(1-\lambda)(1-\delta)\underline{V}}{(1-\overline{\gamma})\lambda\mu\underline{V}} \\ = & \frac{\lambda\mu\underline{V}-\overline{\gamma}\delta\left[E\widetilde{V}-(1-\lambda)\underline{V}\right]}{(1-\overline{\gamma})\lambda\mu\underline{V}}=\frac{\lambda\mu\underline{V}-\overline{\gamma}\delta\lambda\mu\underline{V}}{(1-\overline{\gamma})\lambda\mu\underline{V}} \\ = & \frac{1-\overline{\gamma}\delta}{1-\overline{\gamma}}>1 \text{ as } \overline{\gamma},\delta\in[0,\ 1]. \end{aligned} \tag{60}$$

This gives us the third claim. ■

iii) High Efficiency: If

$$\frac{\overline{c}}{\overline{\gamma}}\leq\delta E\widetilde{V} \tag{61}$$

the quality assurance technology is very efficient. This means that the buyer will always invest:

$$c_0=c_b=\overline{c}\implies\gamma_0=\gamma_b=\overline{\gamma}. \tag{62}$$

Using (62) the following expressions can be simplified:

$$\begin{aligned} \phi_A &= 0, \\ \phi_P &= (1-\lambda)(1-\overline{\gamma})(1-\delta)\underline{V}>0, \\ \Pi^0_{Total} &= E\widetilde{V}-\overline{c}-(1-\overline{\gamma})\delta E\widetilde{V}. \end{aligned} \tag{63}$$

We can proof the following lemma:

Lemma 13 *If the efficiency of the quality assurance technology is high* $\delta_I^{iii}<\delta_I^i<\frac{\underline{V}}{E\widetilde{V}}\leq\delta_{II}^{iii}\leq\delta_{III}^{iii}=1$.

Proof. The proof can be made in three parts:

$$\begin{aligned} 1)\ \delta_I^{iii} &= \max\left[0,\ \frac{[(1-\lambda)(1-\overline{\gamma})-\lambda(\mu-1)]}{(1-\lambda)(1-\overline{\gamma})}\right]<\delta_I^i<\delta_{II}^i, \\ 2)\ \delta_{II}^i &= \frac{\underline{V}}{E\widetilde{V}}\leq\delta_{II}^{iii}=\frac{\underline{V}-\overline{c}}{(1-\overline{\gamma})E\widetilde{V}}, \\ 3)\ \delta_{II}^{iii} &< \delta_{III}^{iii}=1. \end{aligned} \tag{64}$$

Plugging $c_0=c_b=\overline{c}\implies\gamma_0=\gamma_b=\overline{\gamma}$ into:

$$\frac{[(1-\lambda)(1-\gamma_b)-\lambda(\mu-1)]\underline{V}+(c_b-c_0)}{[(1-\lambda)(1-\gamma_b)+(\gamma_b-\gamma_0)(1+\lambda\mu-\lambda)]\underline{V}} \tag{65}$$

gives:

$$\delta_I^{iii} = \frac{[(1-\lambda)(1-\overline{\gamma})-\lambda(\mu-1)]}{(1-\lambda)(1-\overline{\gamma})} \tag{66}$$
$$= 1-\frac{\lambda(\mu-1)}{(1-\lambda)(1-\overline{\gamma})} < 1-\frac{\lambda(\mu-1)}{1-\lambda} = \delta_I^i < 1.$$

By Lemma 11 $\delta_I^i < \delta_{II}^i$. This vindicates the first claim. For the second claim, suppose the opposite:

$$\frac{\underline{V}}{E\widetilde{V}} > \frac{\underline{V}-\overline{c}}{(1-\overline{\gamma})E\widetilde{V}} \iff \frac{\overline{c}}{\overline{\gamma}} > \underline{V}. \tag{67}$$

If $\frac{\underline{V}}{E\widetilde{V}} > \frac{\underline{V}-\overline{c}}{(1-\overline{\gamma})E\widetilde{V}}$ there must exist $\delta \in \left[\frac{\underline{V}-\overline{c}}{(1-\overline{\gamma})E\widetilde{V}},\ \frac{\underline{V}}{E\widetilde{V}}\right]$. Using (61) and $\delta \leq \frac{\underline{V}}{E\widetilde{V}}$, which must hold for all δ of the interval we can write:

$$\frac{\overline{c}}{\overline{\gamma}} < \delta E\widetilde{V} < \frac{\underline{V}}{E\widetilde{V}}E\widetilde{V} = \underline{V}. \tag{68}$$

This contradicts (67) and gives us the second claim. The third claim follows from (59) and (60) from the proof of Lemma 12. Note, that $\frac{\overline{c}}{\overline{\gamma}} \leq \delta E\widetilde{V} + (1-\lambda)(1-\delta)\underline{V}$ is implied by (61). ■

Summing up, we can derive the following lemma which together with the case distinction from subsection (9.2.2) gives us Proposition 1:

Lemma 14 *As $\delta_I^x < \delta_{II}^x \leq \delta_{III}^x$, it is possible to considerably simplify lemma 10. Case D will never arise. Case A, B and C will occur depending on the value of parameter δ:*

Case A:	$\delta \in [0,\ \delta_I)$
Case B:	$\delta \in [\delta_I,\ \delta_{II}]$
Case C:	$\delta \in (\delta_{II},\ 1]$.

As $\delta_{II}^i = \delta_{II}^{ii} \leq \delta_{II}^{iii}$, $\delta < \frac{\underline{V}}{E\widetilde{V}}$ is a sufficient condition for $\delta < \delta_{II}$.

9.3 Appendix C: Devaluation due to non-conformity (δ)

Proof of Proposition 3. For $\delta \in [\delta_{II},\ 1]$ case C applies. We therefore rewrite equation (49):

$$P = \begin{cases} P_b = \frac{E\widetilde{V}-u-(1-\lambda)(1-\gamma_2)\underline{V}}{[1-(1-\lambda)(1-\gamma_2)]} & \text{for } u \in [0,\ u_I-\phi] \\ \textit{no trade} & \text{for } u \in (u_I-\phi,\ u_I] \end{cases}. \tag{69}$$

As

$$\frac{\partial}{\partial\delta}\phi_P = -(1-\lambda)(1-\gamma_2)\underline{V} < 0 \tag{70}$$

ex post inefficiency shrinks for rising δ (It follows immediately from expression (18) that in the limit case $\delta = 1$ it will be 0). ex ante inefficiency only arises in cases where investment levels differ depending on whether termination is part of the buyer's

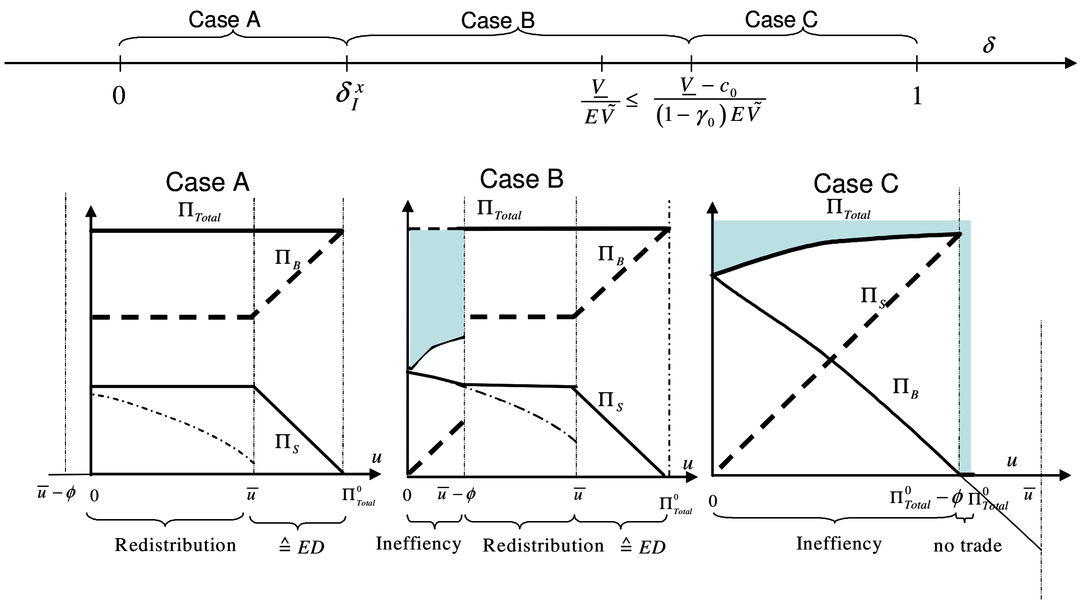

Figure 9:

equilibrium strategy or not. This is the case for intermediate efficiency of the quality assurance technology:

$$\delta E\widetilde{V} < \frac{\overline{c}}{\overline{\gamma}} \leq \delta E\widetilde{V} + (1-\lambda)(1-\delta)\underline{V}. \tag{71}$$

As δ rises the set of $\frac{\overline{c}}{\overline{\gamma}}$ for which this condition is fulfilled shrinks. (In the limit case for $\delta = 1$ it will be empty). ex ante inefficiency is non-increasing in δ as

$$\frac{\partial}{\partial \delta}\phi_A = \frac{\partial}{\partial \delta}(c_b - c_0) + (\gamma_0 - \gamma_b)\,\delta E\widetilde{V} = (\gamma_0 - \gamma_b)\,E\widetilde{V} \leq 0. \tag{72}$$

Therefore inefficiency $\phi = \phi_P + \phi_A$ will decrease in δ (will be 0 in the limit case $\delta = 1$) which implies that the no trade area $u \in (u_I - \phi,\ u_I]$ shrinks for rising δ (will be empty in the limit case $\delta = 1$). ■

Threshold δ_{II}:

Depending on the efficiency of the quality assurance technology, where index $x = i,\ ii,\ iii$ stands for low, intermediate and high efficiency, it follows from Lemma 10 that threshold value δ_{II}^x is given by:

$$\delta_{II}^{i} = \delta_{II}^{ii} = \frac{\underline{V}}{E\widetilde{V}} = \frac{\underline{V}}{\lambda\overline{V} + (1-\lambda)\underline{V}} \leq \delta_{II}^{iii} = \frac{\underline{V} - \overline{c}}{(1-\overline{\gamma})\,E\widetilde{V}}. \tag{73}$$

It will be high if the buyer's valuation in the low state $\underline{V}$ is not too small and the probability $1-\lambda$ that the buyer changes his mind about the product is high.

9.4 Appendix D: Consistency of Valuation (λ)

9.4.1 Conditions in terms of λ

Lemma 15 *We can write the conditions for case A, B, C in terms of λ:*[33]

$$
\begin{aligned}
\textit{Case A} &: \quad u_I > \bar{u} \wedge \bar{u} - \phi \leq 0 \iff \lambda < \lambda_{II} \wedge \lambda \leq \lambda_I, \qquad (74)\\
\textit{Case B} &: \quad u_I > \bar{u} \wedge \bar{u} - \phi > 0 \iff \lambda < \lambda_{II} \wedge \lambda > \lambda_I,\\
\textit{Case C} &: \quad u_I \leq \bar{u} \wedge u_I - \phi > 0 \iff \lambda \geq \lambda_{II} \wedge \lambda > \lambda_{III}\\
\textit{where} &: \\
\lambda_I &\equiv \min\left[\frac{(c_b - c_0) + (1-\gamma_b)(1-\delta)\underline{V}}{[(\mu-1) - \delta(\gamma_0 - \gamma_b)(\mu-1) + (1-\gamma_b)(1-\delta)]\underline{V}},\ 1\right],\\
\lambda_{II} &\equiv \min\left[\max\left[0,\ \frac{[1-\delta(1-\gamma_0)]\underline{V} - c_0}{\delta(\mu-1)(1-\gamma_0)\underline{V}}\right],\ 1\right],\\
\lambda_{III} &\equiv \min\left[\max\left[0,\ \frac{c_b - \gamma_b\underline{V}}{\underline{V}[(1-\delta+\gamma_b\delta)\mu - \gamma_b]}\right],\ 1\right].
\end{aligned}
$$

Depending on the efficiency of the quality assurance technology where superscripts i-iii refer to low, intermediate and high efficiency the threshold values are:

$$
\begin{aligned}
\lambda_I^i &\equiv \frac{1-\delta}{\mu-\delta},\ \lambda_I^{ii} = \lambda_I^{iii} \equiv \frac{\overline{c} + (1-\overline{\gamma})(1-\delta)\underline{V}}{(\mu-1) + \delta\overline{\gamma}(\mu-1) + (1-\overline{\gamma})(1-\delta)}\\
\lambda_{II}^i &= \lambda_{II}^{ii} \equiv \frac{(1-\delta)}{\delta(\mu-1)},\ \lambda_{II}^{iii} \equiv \frac{[1-\delta(1-\overline{\gamma})]\underline{V} - \overline{c}}{\delta(\mu-1)(1-\overline{\gamma})\underline{V}}
\end{aligned}
$$

Proof. Inserting into $u_I > \bar{u}$, one can write:

$$E\widetilde{V} - c_0 - (1-\gamma_0)\delta E\widetilde{V} > \lambda(\mu-1)\underline{V}. \qquad (75)$$

Rearranging gives us:

$$\lambda < \lambda_{II} \equiv \frac{[1-\delta(1-\gamma_0)]\underline{V} - c_0}{\delta(\mu-1)(1-\gamma_0)\underline{V}}. \qquad (76)$$

Inserting into $\bar{u} \leq \phi$, one can write:

$$(\mu-1)\underline{V} - (c_b - c_0) - (\gamma_0 - \gamma_b)\delta[1 + \lambda(\mu-1)]\underline{V} - (1-\lambda)(1-\gamma_b)(1-\delta)\underline{V} \leq 0. \qquad (77)$$

Rearranging gives us:

$$\lambda \leq \lambda_I \equiv \frac{(c_b - c_0) + (1-\gamma_b)(1-\delta)\underline{V}}{[(\mu-1) - \delta(\gamma_0 - \gamma_b)(\mu-1) + (1-\gamma_b)(1-\delta)]\underline{V}} > 0. \qquad (78)$$

Proof. Inserting into $u_I > \phi$, one can write:

$$E\widetilde{V} - c_0 - (1-\gamma_0)\delta E\widetilde{V} - (c_b - c_0) - (\gamma_0 - \gamma_b)\delta E\widetilde{V} - (1-\lambda)(1-\gamma_b)(1-\delta)\underline{V} > 0 \qquad (79)$$

■

[33] Case D does not have to be considered as was already proven in terms of δ in Lemma (14):

Rearranging gives us:

$$(1-\delta+\gamma_b\delta)\left[1+\lambda\left(\mu-1\right)\right]\underline{V}-c_b-(1-\lambda)\left(1-\gamma_b\right)\left(1-\delta\right)\underline{V}>0 \tag{80}$$

Solving for λ, we can write:

$$\lambda>\lambda_{III}\equiv\frac{c_b-\gamma_b\underline{V}}{\underline{V}\left[\left(1-\delta+\gamma_b\delta\right)\mu-\gamma_b\right]}. \tag{81}$$

■

9.4.2 Comparative statics for interval: $\lambda\in[0,\ \lambda_I]$

Lemma 16 $\frac{\partial}{\partial\lambda}\frac{\bar{u}}{u_I^i}=\frac{\partial}{\partial\lambda}\frac{\lambda(\mu-1)}{(1-\delta)[1+\lambda(\mu-1)]}>0$

Proof. The sign depends on the sign of the numerator of the first order derivative:

$$\begin{aligned} N &= (\mu-1)\left(1-\delta\right)\left[1+\lambda\left(\mu-1\right)\right]-\lambda\left(\mu-1\right)^2\left(1-\delta\right) \\ &= (\mu-1)\left(1-\delta\right)>0. \end{aligned} \tag{82}$$

which is positive. ■

Lemma 17 $\frac{\partial}{\partial\lambda}\frac{\bar{u}}{u_I^{ii}}=\frac{\partial}{\partial\lambda}\frac{\bar{u}}{u_I^i}>0.$

Proof. This is true because $\frac{\bar{u}}{u_I^{ii}}=\frac{\bar{u}}{u_I^i}$. ■

Lemma 18 $\frac{\partial}{\partial\lambda}\frac{\bar{u}}{u_I^{iii}}=\frac{\partial}{\partial\lambda}\frac{\lambda(\mu-1)\underline{V}}{[1-\delta(1-\overline{\gamma})]E\widetilde{V}-\overline{c}}>0.$

Proof. The numerator of the first order derivative is:

$$N=(\mu-1)\,\underline{V}\left[\left[1-\delta\left(1-\overline{\gamma}\right)\right]\underline{V}-\overline{c}\right]. \tag{83}$$

As $(\mu-1)\,\underline{V}$ is positive the sign of the numerator depends on the sign of $[1-\delta\left(1-\overline{\gamma}\right)]\,\underline{V}-\overline{c}$. As $\overline{c}<\overline{\gamma}\delta E\widetilde{V}$, we can write:

$$\begin{aligned} & [1-\delta\left(1-\overline{\gamma}\right)]\,\underline{V}-\overline{c} \\ > \; & [1-\delta\left(1-\overline{\gamma}\right)]\,\underline{V}-\overline{\gamma}\delta E\widetilde{V} \\ = \; & [1-\delta\left(1-\overline{\gamma}\right)-\overline{\gamma}\delta-\overline{\gamma}\delta\lambda\left(\mu-1\right)]\,\underline{V} \\ = \; & [1-\delta\left[1+\overline{\gamma}\lambda\left(\mu-1\right)\right]]\,\underline{V}. \end{aligned} \tag{84}$$

As $\underline{V}$ is positive the sign depends on the sign of $1-\delta\left[1+\overline{\gamma}\lambda\left(\mu-1\right)\right]$. As it must be true that $\delta<\delta_I^{iii}$ and $\delta_I^{iii}<\delta_I^i<\frac{\underline{V}}{E\widetilde{V}}=\frac{1}{1+\lambda(\mu-1)}$ by Lemma (13), we can write:

$$1-\delta\left[1+\overline{\gamma}\lambda\left(\mu-1\right)\right]>\left[1-\frac{1+\overline{\gamma}\lambda\left(\mu-1\right)}{1+\lambda\left(\mu-1\right)}\right]>0 \tag{85}$$

which proves the claim. ■

9.4.3 Comparative statics for interval: $\lambda \in [\lambda_I,\ \lambda_{II}]$

Lemma 19 $\frac{\partial}{\partial\lambda}\frac{\phi^i}{u_I^i} = \frac{\partial}{\partial\lambda}\frac{(1-\lambda)(1-\delta)\underline{V}}{(1-\delta)[1+\lambda(\mu-1)]\underline{V}} < 0.$

Proof. The numerator of the first order derivative can be written as:

$$N = -(1-\delta)^2\underline{V}^2[1+\lambda(\mu-1)] - (1-\delta)^2(\mu-1)(1-\lambda)\underline{V}^2 \tag{86}$$

It can easily be seen that this numerator will always be negative. ■

Lemma 20 $\frac{\partial}{\partial\lambda}\frac{\phi^{ii}}{u_I^{ii}} = \frac{\partial}{\partial\lambda}\frac{\overline{c}-\overline{\gamma}\delta[1+\lambda(\mu-1)]\underline{V}+(1-\lambda)(1-\overline{\gamma})(1-\delta)\underline{V}}{(1-\delta)[1+\lambda(\mu-1)]\underline{V}}.$

Proof. The numerator of the first order derivative can be written as:

$$\begin{aligned} & -(1-\delta)[1+\lambda(\mu-1)][\overline{\gamma}\delta(\mu-1)+(1-\overline{\gamma})(1-\delta)]\underline{V}^2 \\ & -[\overline{c}-\overline{\gamma}\delta[1+\lambda(\mu-1)]\underline{V}+(1-\lambda)(1-\overline{\gamma})(1-\delta)\underline{V}](1-\delta)(\mu-1)\underline{V} \\ = & -(1-\delta)[1+\lambda(\mu-1)][(1-\overline{\gamma})(1-\delta)]\underline{V}^2 \\ & -[\overline{c}+(1-\lambda)(1-\overline{\gamma})(1-\delta)\underline{V}](1-\delta)(\mu-1)\underline{V}. \end{aligned} \tag{87}$$

It can easily be seen that this numerator will always be negative. ■

Lemma 21 $\frac{\partial}{\partial\lambda}\frac{\phi^{iii}}{u_I^{iii}} = \frac{\partial}{\partial\lambda}\frac{(1-\lambda)(1-\overline{\gamma})(1-\delta)\underline{V}}{[1-\delta(1-\overline{\gamma})][1+\lambda(\mu-1)]\underline{V}-\overline{c}}$

Proof. As:

$$\begin{aligned} \frac{\partial}{\partial\lambda}\phi^{iii} &= -(1-\overline{\gamma})(1-\delta)\underline{V} \\ \frac{\partial}{\partial\lambda}u_I^{iii} &= [1-\delta(1-\overline{\gamma})](\mu-1)\underline{V} \end{aligned} \tag{88}$$

the numerator of the first order derivative can be written as:

$$\begin{aligned} N &= -(1-\overline{\gamma})(1-\delta)\underline{V}\{[1-\delta(1-\overline{\gamma})][1+\lambda(\mu-1)]\underline{V}-\overline{c}\} \\ & \quad -(1-\lambda)(1-\overline{\gamma})(1-\delta)\underline{V}\cdot[1-\delta(1-\overline{\gamma})](\mu-1)\underline{V} \\ &= -(1-\overline{\gamma})(1-\delta)\underline{V}\{[1-\delta(1-\overline{\gamma})]\underline{V}-\overline{c}\} \\ & \quad -(1-\overline{\gamma})(1-\delta)[1-\delta(1-\overline{\gamma})](\mu-1)\underline{V}^2 \\ &= -(1-\overline{\gamma})(1-\delta)\underline{V}\{[1-\delta(1-\overline{\gamma})]\mu\underline{V}-\overline{c}\}. \end{aligned} \tag{89}$$

As $-(1-\overline{\gamma})(1-\delta)\underline{V}$ is negative the sign of the numerator depends on the sign of $[1-\delta(1-\overline{\gamma})]\mu\underline{V}-\overline{c}$. Using:

$$u_I^{III} > 0 \iff [1-\delta(1-\overline{\gamma})][1+\lambda(\mu-1)]\underline{V} > \overline{c} \tag{90}$$

it can be written:

$$\begin{aligned} [1-\delta(1-\overline{\gamma})]\mu\underline{V}-\overline{c} &> [1-\delta(1-\overline{\gamma})]\mu\underline{V}-[1-\delta(1-\overline{\gamma})][1+\lambda(\mu-1)]\underline{V} \\ &= [1-\delta(1-\overline{\gamma})][(1-\lambda)(\mu-1)]\underline{V} > 0. \end{aligned} \tag{91}$$

Therefore the sign of the numerator will be negative. ■

9.4.4 Comparative statics for interval: $\lambda \in [\lambda_{II},\ 1]$

Lemma 22 $\frac{\partial}{\partial\lambda}\phi^{i} < 0,\ \frac{\partial}{\partial\lambda}\phi^{ii} < 0\,,\ \frac{\partial}{\partial\lambda}\phi^{iii} < 0$

Proof. As

$$\begin{aligned} \frac{\partial}{\partial\lambda}\phi^{i} &= \frac{\partial}{\partial\lambda}\phi^{i}_{P} = \frac{\partial}{\partial\lambda}\left[(1-\lambda)(1-\delta)\underline{V}\right] = -(1-\delta)\underline{V} < 0, \quad (92)\\ \frac{\partial}{\partial\lambda}\phi^{ii} &= \frac{\partial}{\partial\lambda}\phi^{ii}_{A} + \frac{\partial}{\partial\lambda}\phi^{ii}_{p} = \frac{\partial}{\partial\lambda}\left[\overline{c} - \overline{\gamma}\delta\left[1+\lambda(\mu-1)\underline{V}\right] + (1-\lambda)(1-\overline{\gamma})(1-\delta)\underline{V}\right]\\ &= -\overline{\gamma}\delta(\mu-1)\underline{V} - (1-\lambda)(1-\delta)\underline{V} < 0,\\ \frac{\partial}{\partial\lambda}\phi^{iii} &= \frac{\partial}{\partial\lambda}\phi_{P} = \frac{\partial}{\partial\lambda}\left[(1-\lambda)(1-\overline{\gamma})(1-\delta)\underline{V}\right] = -(1-\overline{\gamma})(1-\delta)\underline{V} < 0 \end{aligned}$$

the claim follows from equation 49. ■

9.4.5 Continuity

Lemma 23 *The function* $\phi(\lambda)$ *is continuous at* $\frac{\overline{c}}{\overline{\gamma}} = \delta E\widetilde{V} + (1-\lambda)(1-\delta)\underline{V}$ *and at* $\frac{\overline{c}}{\overline{\gamma}} = \delta E\widetilde{V}$

Proof.

$$\phi^{i} - \phi^{ii} = \overline{\gamma}(1-\lambda)(1-\delta)\underline{V} + \overline{\gamma}\delta E\widetilde{V} - \overline{c}. \quad (93)$$

Inserting $\overline{c} = \overline{\gamma}\delta E\widetilde{V} + \overline{\gamma}(1-\lambda)(1-\delta)\underline{V}$, we see that $\phi^{i} - \phi^{ii} = 0$.

$$\phi^{ii} - \phi^{iii} = \overline{c} - \overline{\gamma}\delta E\widetilde{V}. \quad (94)$$

Inserting $\overline{c} = \overline{\gamma}\delta E\widetilde{V}$, we see that $\phi^{ii} - \phi^{iii} = 0$. ■

9.4.6 Extreme cases: $\lambda = 0,\ \lambda = 1$

Lemma 24 *If* $\lambda = 0,\ \lambda = 1$*, the outcome under EDT is identical to the outcome under ED.*

Proof. If $\lambda = 0$, $\bar{u} = \lambda\left(\overline{V} - \underline{V}\right) = 0$. If $u_I > 0$ i.e. if there are potential gains of trade, this means that a degenerate case A applies, where the outcome under EDT is identical to the outcome under ED. If $\lambda = 1$, case C will apply. ex post inefficiency, however, will be 0. As $\delta E\widetilde{V} + (1-\lambda)(1-\delta)\underline{V} = \delta E\widetilde{V} = \delta\mu\underline{V}$, there will never be ex ante inefficiency. Therefore results under EDT will be the identical as under the ED regime. ■

Summarizing Lemmas (15)-(24) gives us Proposition (4).

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