Coase, externalities, property rights and the legal system[1]

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1. Introduction

The process of globalization is moving fast forward. Also the process of regional economic integration has considerably increased, as illustrated, for example, by the successful introduction of the Euro. At the same time increased competition on a global and local scale can be observed. These developments have led to a huge increase in factor-mobility and factor movements. Especially capital mobility and movements appear to have increased a lot. These processes are seen as favorable developments in order to increase overall economic efficiency and therefore also contributing to increasing welfare. At the same time the process of globalization, economic integration and increased competition is accompanied by many externalities (positive as well as negative); a striking example is provided by the global warming effect.

In line with the above, we have to consider how to deal with externalities in an efficient way, in order to contribute to overall welfare. One of the most important theorems of economics, with respect to externalities, is the "Coase" theorem (although Coase never formulated it as such). According to Coase it is possible to internalize external effects. If property rights are assigned and if they are tradable, then bargaining will result in an efficient solution, no government intervention is needed. Another important point is that it plays no role how the property rights are assigned to get this result. An important restriction is that transaction cost should be marginally low, otherwise the system will not function. Unfortunately, we always observe transaction costs in the real world. If we look at the trading of emission rights, transaction costs, in fact, it appears to be rather high. The consequence could be that it is difficult to apply the Coase theorem.

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If property rights are assigned, an enforcement mechanism is needed in case of violation. This enforcement is associated with cost of and investments in efforts in order to enforce these rights at court. Of course, if there are different legal systems the outcome could also be very different, depending on the actual legal system which forms a part of the institutional setting.

In most economic theories the institutional setting is taken for granted. However this assumption rarely corresponds to the facts of the real world. The differences in, for example, the EU countries with respect to the jurisdictional system are huge. Sometimes even within countries there are significant differences. In Germany, for example, many differences exist between the jurisdictional systems of the Bundeslaender. We also want to point out that the comparative advantage of countries and regions can be influenced by the institutional structure. Different institutional settings will lead to different approach to externalities. As a result, addressing the problems caused by externalities can vary quit a bit between countries and regions.

In this paper we investigate the possible consequences of different institutional settings (*in casu* the legal system) on externalities and their effect on the efficient allocation of externalities. We investigate whether the restriction of marginally low transaction costs can be relaxed if the legal system is efficient. In this context we define an efficient legal system as a system of rules such that the Coase theorem can be applied in the presence of non-marginally low transaction costs without loosing its efficiency properties. The basic idea is that a legal system should be such that a potential plaintiff has no incentive to enforce the law by going to court.

To analyze the consequences of different law systems, we split the paper into two parts. In the first part we start by summarizing the model of Schweizer (1988) on the Coase theorem as a kind of reference point. The advantage of Schweizer's (1988) model is that his interpretation is seen as clear and thorough. Therefore, this model will be used to highlight the important properties of the Coase's theorem.

We will extend the model in the following two ways. First we extend the model by incorporating incomplete contracts. That means we allow for ex-post renegotiating. Hereby we introduce the legal system as "the rules of the game". Disputes about contracts are resolved at court if a compromise cannot be found between the contractors. At first we assume that the legal system to resolve such disputes is costless for the plaintiff and defendant. We show that a credibility problem can emerge depending on how property rights are distributed. This credibility problem prevents an efficient solution to be reached through trading property rights. Second, we will we relax the above assumption and investigate the consequences if going to court is not costless.

In the second part of the paper we put some realistic features into our approach. We will analyze the two most prominent civil law systems; the Anglo Saxon (AS) and Roman (R) civil law system. One difference between the two systems is that in the AS system both plaintiff and defendant have to pay for their own efforts to win the lawsuit, whichever the result of the lawsuit will be. The efforts of winning a lawsuit are the costs of the lawyers, the costs of experts, costs of witnesses, *et cetera*. In contradiction to the AS system the R system is characterized by the fact that the loosing party at court has to bear all costs including the costs of the winning party.

2. The Coase Theorem

Our point of departure is the model developed by Schweizer (1988). Let us assume that there are two agents A and B. Agent A is involved in an activity x which generates a positive utility, and Agent B is involved in an activity y. Agent B, however, values agent A's activity x negatively; agent A's activity x causes a negative externality for Agent B. This can be expressed using the following utility functions. For simplicity, we assume that both players are risk neutral and that both utility functions are additively separable.

Agent A's utility function:

$$U = A(x) \tag{1}$$

Agent B's utility function:

$$V = B(y) - S(x, y) \tag{2}$$

The disutility (negative externality) of agent B resulting from agent A's activity x is represented in the function $S(x,y)$, where the function has the following properties: S is increasing in both variables x,y and for all x,y and the cross partial derivative $S_{xy}(x,y)$ is always positive. The functions A and B are concave and twice differentiable, so that:

$$A_x(x) > 0 \text{ for } x < x^* \text{ and } A_x(x) < 0 \text{ for } x > x^* \text{ and } A_{xx}(x) < 0 \text{ for } x > 0 \quad (3)$$

and

$$B_y(y) > 0 \text{ for } y < y^* \text{ and } B_y(y) < 0 \text{ for } y > y^* \text{ and } B_{yy}(y) < 0 \text{ for } y > 0$$

An efficient solution will be achieved when simultaneously the optimal levels of x and y are determined. This can be realized if both players cooperate, or if a benevolent dictator decides. In both cases this leads to the following maximization problem:

$$\underset{x,y}{Max}(U+V) \Rightarrow \underset{x,y}{Max}\{A(x)+B(y)-S(x,y)\} \quad (4)$$

The first order conditions of (4) are given by:

$A_x(x) - S_x(x, y) = 0$	The activity level of A in $x = x^E$
$B_y(y) - S_y(x, y) = 0$	The activity level of B in $x = x^E$

where the efficient levels of x and y are given by x^E and y^E respectively. There is no guarantee that the two agents will cooperate, an incentive for cooperation is missing. If agent A maximizes his own utility, this exceeds the cooperative outcome and there is no incentive for cooperation. Then a non-efficient outcome is the result.

Next we turn to Coase's solution. At first property rights have to be assigned. There are two possibilities. Agent A is not liable (n) for the externality which means that agent A owns the property rights. The other possibility is that Agent A is liable (l) for the externality. In this situation agent B owns the property rights. If the property rights are tradable, the same efficient solution can be achieved.

3. Trading property rights

We start with Agent A owning the property rights (n). In this situation agent A is not liable for causing externalities. Let us first introduce the **reservation** utility of agent A, the utility the agent can achieve by fully making use of his property rights. This is, clearly, the activity level which maximizes agent A's utility and where $A_x(x^n) = 0$ holds. The reservation utility than amounts to

$\overline{U} = A(x^n)$. (We shall use the superscript A to indicate that agent A owns the property rights.)

If agent B proposes agent A to reduce his activity $(x = x^A)$ in return for compensation (Z^A) than the outcome, U for agent A, should be equal to or exceed the reservation utility:

$$U = A(x^A) + Z^A \geq \overline{U} \tag{5}$$

Agent B evidently wants to maximize his utility and as such minimize the compensation to be paid to A. This means that equation (5) strictly holds. We can derive the compensation from equation (5):

$$Z^A = A(x^n) - A(x^A) \tag{6}$$

To maximize his utility, agent A has to take into account his own activity level and the compensation to be paid which depends on the activity levels of x and y. This leads to the following optimization problem of agent B:

$$\underset{x,y}{Max} V = B(y) - S(x,y) - [A(x^n) - A(x)] \tag{7}$$

It should be noted that activity level x^n is given. In this situation, agent B determines both activity levels. This process can be described as a game consisting of 3 stages. Below we have written out the 3 stages:

Stage 1 — ***B*** proposes a contract to ***A*** for payment Z^A if A reduces his activity to $x = x^A$ £ x^n

Stage 2 — A makes a decision about the contract:
Accept and reduce activity level to $x = x^A$
If Z^A ³ $[A(x^n) - A(x^A)]$
Reject and keep activity level $x = x^n$
If $Z^A < [A(x^n) - A(x^A)]$

Stage 3 — B makes a decision about his activity level y depending on the action of A in stage 2 (best response function):
If A decides $x = x^n$ than $y = y^n$ otherwise
If A decides $x = x^A$ than $y = y^A$

Above we have assumed that $B(y)\text{-}S(x,y)\text{-}[A(x^n)\text{-}A\ (x^A)] > B(y^n)\text{-}S(x^n,\ y^n)$, otherwise there would be no trading in property rights[2]. Using the first order condition of equation (7) we get:

$-S_x(x, y) + A_x(x) = 0$	The activity level of A is $x = x^A = x^E$ and
$B_y(y) - S_y(x, y)$	The activity level of B equals $y = y^A = y^E$

We immediately see that the results of x and y coincide with the efficient solution. Notice that there are distributional differences compared with the efficient solution.

We will now look at the case where agent B owns the property rights. In this situation agent A is liable for causing the externality. The same approach is applied as before. In this case agent A will have to compensate agent B for causing the externality due to the activity x. The reservation utility of agent B equals $\overline{V} = B^y(y^l)$ where $B^y(y^l) = 0$. Agent B is willing to accept the proposal for compensation if the following condition is satisfied:

$$V = B(y) - S(x,y) + Z^B \geq \overline{V} \tag{8}$$

Because agent A is minimizing the compensation, equation (5) strictly holds the optimal compensation for agent A then becomes:

$$Z^B = B(y^l) - \left[B(y) - S(x,y)\right] \tag{9}$$

Notice that the compensation depends on x,y and y^l where the last one is given. Agent A then faces the following maximization problem:

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[2] By cooperation between the agents, a "surplus" is created. Because, depending on the assignment of property rights, one of the Agents receives a reservation utility and therefore we have a Pareto improvement. If there would be no surplus creation possible the situation is apparently efficient. Bargaining will not take place. After assigning the property rights one of the agents will stop its economic activities. In this case we have reached a corner solution. These kinds of possibilities are not taking into account in this paper. A related problem which prevents from "Coasian" bargaining namely the income effects, which we do not address in this paper. For a treatment of these kind of effects see for example Milgrom & Roberts (1992) 35-39.

$$\underset{x,y}{Max}\,U = A(x) - [\,B(y^{l}) - \{B(y) - S(x,y)\}\,] \tag{10}$$

Like before we describe the 3 stages of the game below:

Stage 1 — *A* proposes a contract to *B* to pay Z^B so that B allows A to increase A's activity level $x^B \geq x^l$.

Stage 2 — B decides about the contract:
Accept if $Z^B \geq [B(y^l) - \{B(y) - S(x,y)\}]$, and reduce his activity to $y = y^B < y^l$ and allow A to increase his activity to $x = x^B > x^l$;
Reject if $Z^B < [B(y^l) - \{B(y) - S(x,y)\}]$ and keep activity $y = y^l$ and stick to Agent A keeping his activity level to $x = x^l$.

Stage 3 — A decides about his activity level *x* depending on the action of B in stage 2:
If agent B decides in favor of activity level $y = y^l$ than $x = x^l$;
If agent B decides in favor of activity level $y = y^B < y^l$ than $x = x^B > x^l$.

Starting at stage 3, A has to decide about his activity level *x* and *y* and the resulting compensation Z^B (the best response function of *A*). The compensation Z^B is therefore endogenous. This results in the following first order condition of the maximization problem (equation (10)) of A:

$A_x(x) - S_x(x, y) = 0$	The activity level of *A* is $x = x^B = x^E$
$B_y(y) - S_y(x, y)$	The activity level of *B* equals $y = y^B = y^E$

Assigning property rights to agent *B* and trading thus leads to an efficient allocation.

We see that whichever way the property rights are distributed, when they are tradable, an efficient allocation (solution) will result. The outcome with respect to the activity levels resembles the outcomes of the previous case and the cooperative solution. The assignment of property rights, however, as noted before, has distributional consequences.[3]

[3] In case agent A owns the property rights (*A*) we have $U^A = A(x) + [A(x^n) - A(x^E)]$ and $V^A = B(y^E) - S(x^E, y^E) - [A(x^n)\text{-}A(x^E)]$. When B owns the property rights (B) $U^B = A(x^E) - [B(y^l)\text{-}\{B(y^E) - S(x^E, y^E)\}]$ and $V^A = B(y^E) - S(x^E, y^E) + [B(y^l) - \{B(y^B) - S(x^E, y^E)\}]$. On aggregate they are the same. Depending on the assignment of the property rights the distribution (of utility) changes.

4. Incomplete contracts

If property rights are assigned, the legal system should supply proper safeguards and guarantee enforcement of property rights. Now suppose that the agreements between the agents of the previous section are laid down in a contract. It contains the bargained activity levels and the compensation. The question than is, will the contract hold? (We assume that any dispute will be solved through the legal system). Suppose now that the contracts which are accepted by the agents are incomplete. This means that renegotiations ex-post cannot be excluded. We assume that the agents make use of the existing legal system when there is a conflict regarding the contract on property rights. For both agents the contractual agreements are observable, but they are not verifiable before the Court. The outcome of the lawsuit, in case of a dispute, is on forehand uncertain for the agents. We assume that going to court to enforce a contract is costless. Later on we will relax this assumption.

Due to the possibility of renegotiation, the following question arises; are the contracts credible ex-post, or, in other words, is there a moral hazard problem?

Below we shall investigate this credibility problem for the two different assignments of property rights namely:

- I Agent A owns the property rights.
  Will agent B then ex post pay Z^A to agent A?
- II Agent B owns the property rights.
  Will agent A then ex post pay Z^B to agent B?

It can be seen that the credibility of the contracts is highly depending on the distributional effects.

Ad I

In the first case where agent A owns the property rights a moral hazard problem does not arise. If agent B does not stick to the agreement, agent A will increase his activity to $x = x^n$ instead of $x = x^A$. This is the “not liable” solution which is not in the interest of agent B. There in no incentive to breach the contract. Formally, there are two options for agent B ex-post:

a) Pay the compensation
b) Do not to pay the compensation

The game ends if agent B chooses to pay the compensation (a). The contractual agreements are held by both agents. This is the efficient (ex-ante) solution of the previous section. If agent B does not pay the compensation and breaches the contract, agent A can react in the following way:

b1) He can decide not to go to court but increase his output to $x = x^n$, which maximizes his pay-off.

b2) He can keep the activity level at $x = x^A$ and go to court to enforce the payment Z^A.

To find out which alternative is preferred, we compare the expected pay-offs of all strategies. Let us first consider a). The pay-offs can be calculated by inserting the respective activity levels x^A and y^A in the utility functions of both agents, where we keep in mind that the activity levels $x = x^A$ and $y = y^A$ coincide with the efficient outcome of the previous section. The pay-offs are respectively:

$$U^{A*} = A(x^A) + Z^A \text{ and} \tag{11A}$$

$$V^{A*} = B(y^A) - S(x^A, y^A) - Z^A, \text{ where } Z^A = [A(x^n) - A(x^A)] \tag{11B}$$

We have used the superscript $A*$ to indicate that this is an efficient solution in case agent A owns the property rights. Next we turn to b). Agent B does not pay the agreed compensation, so we have $Z^A = 0$. If agent B does not stick to the ex-ante agreement, agent A has no reason to keep his part of the agreement. Agent A will increase his activity level to x^n because that increases his utility. Agent's B best reaction is to choose activity level y^n. (The reader may notice that this is the "no liable" case.) Using the utility functions of the two agents we find the following pay-offs:

$$U^A = A(x^n) \text{ and} \tag{12A}$$

$$V^A = B(y^n) - S(x^n, y^n) \tag{12B}$$

What remains is looking at the last possibility, b2). Because we assume that the outcome of a lawsuit is uncertain we must know the probabilities of the agents to win their case for the court. Let P^A be the probability that agent A wins the lawsuit in the case of a dispute. We take this probability exogenously given. Later on we will relax this assumption. Obviously we have $0 < P^A < 1$ and $P^B = (1-P^A)$ where P^B is the probability that agent B wins the case for the court. Taking this into account we have the following expected pay-offs for the two agents:

$$EU^A = A(x^A) + P^A Z^A \quad \text{and} \tag{13A}$$

$$EV^A = B(y^A) - S(x^A, y^A) - P^A Z^A \tag{13B}$$

It is easy to see that the (expected) pay-offs now also depend on the court's decision. This is the probability to get the compensation assignment through court, or, in other words, the expected compensation. Notice that in principle this also leads to an efficient allocation. Below we have represented the game in the extensive form. This will facilitate us to solve the game.

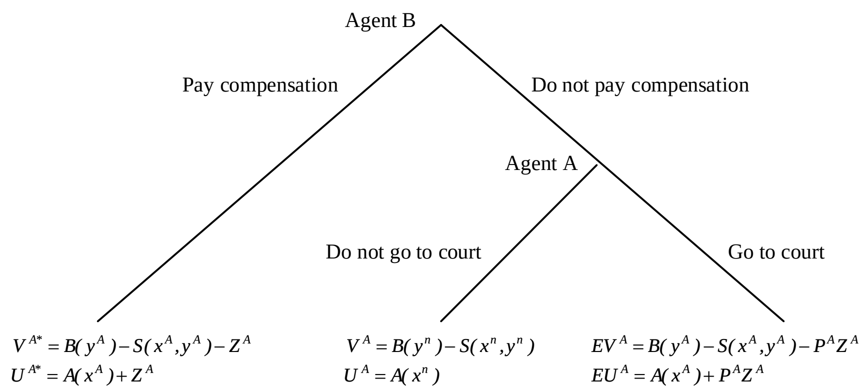

Figure 1: The game if A owns the property rights

We now know the pay-offs, so we can solve the game. First compare for agent B the pay-offs of not going to court (b1) with going to court (b2). We rewrite equation (13A) as $EU^A = (1-P^A)A(x^A) + P^A A(x^n)$.[4] Because of $x^A < x^n$, we see that $EU^A(x^A) < U^A(x^n)$. If agent B does not pay, A chooses not to go to court (b2). Knowing this, agent B can choose between a pay-off of V^{A*}, by keeping the ex-ante contract or a pay-off of V^A, by not paying the compensation. Because of $V^{A*} > V^A$ agent B will choose to pay the compensation (a).Because previously we assumed that, $B(y^A)-S(x^A,y^A)-[A(x^n)-A(x^A)] > B(y^n)-S(x^n, y^n)$, it is obvious that agent A is willing to pay (otherwise there is no willingness to trade property rights).

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[4] $EU^A = A(x^A) + P^A[A(x^n) - A(x^A)] = (1-P^A)A(x^A) + P^A A(x^n)$.

We can conclude that agent A will not go to court if agent B does not pay, but will increase his activity level up to $x = x^n$. In the case where agent A owns the property rights there is no moral hazard and no credibility problem.

Ad II

In the second case where agent B owns the property rights, we also have to investigate if there is a moral hazard problem. Ex-post agent A has two options:

c) Pay the compensation
d) Not to pay the compensation

If agent A chooses c) then the game ends and an efficient allocation is the result. If not, and agent A chooses d) then there are two possibilities for agent B:

d1) Agent B does not go to court and accepts the contract breech or
d2) Agent B goes to court and tries to enforce the contract

The decision, naturally, depends on the expected pay-offs. The pay-offs of c) we already know from the previous sections. They are, respectively,

$$U^{B*} = A(x^B) + Z^B \quad \text{and} \tag{14A}$$

$$V^{B*} = [B(y^l) - B(y^B) - S(x^B,y^B) + Z^B \quad \text{where}$$
$$Z^{B*} = [B(y^l) - B(y^B) - S(x^B,y^B)] \tag{14B}$$

Activity levels x^B and y^B represent again an efficient outcome, as we have seen in the previous section. The superscript $B*$ is used to indicate that B owns the property right and that this is an efficient solution.

In case A does not pay the compensation, agent B can decide not go to court (d1) and than $Z^B = 0$. If both agents maximize their utility, we find the following pay-offs for agent B and A:

$$V^B = B(y^B) - S(x^B,y^B) \quad \text{and} \tag{15A}$$

$$U^B = A(x^B) \tag{15B}$$

This coincides with the “liable” solution of section 3.

The other possibility is that agent A goes to court (d2).Going to court results in an expected pay-off (utility) for agents B and A of:

$$EV^B = B(y^B) - S(x^B, y^B) + (1\text{-}P^A)Z^B \quad \text{and} \tag{16A}$$

$$EU^B = A(x^B) - (1\text{-}P^A)Z^B \tag{16B}$$

To solve the game we compare the pay-offs of the two strategies (d1 and d2) Looking at equation (16A) we see that $EV^B = V^B + (1\text{-}P^A)Z^B$. That means that $EV^B > V^B$ and as a result, agent B chooses to go to court (d2). Knowing this, agent A has to decide which action to take. This depends on the expected pay-off of the two alternatives, c and d. Again we compare the expected pay-offs of the two strategies. Rearranging equation (16B) gives us $EU^B = U^{B*} + P^A Z^B$ so we have $EU^B > U^{B*}$. Agent A chooses d) and so ex-post agent A does not stick to the contractual agreement to pay Z^B. We resume the game in extensive form below. The previous solution can be easily be verified using the game tree.

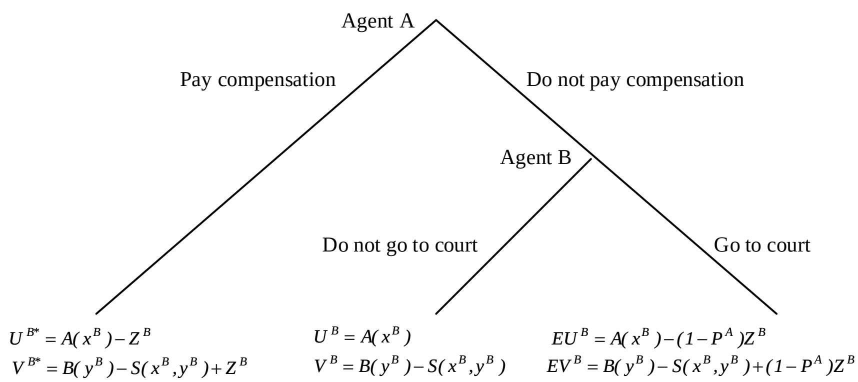

Figure 2: The game if B owns the property rights

This result can have serious implications for the ex-ante decisions. If agent B knows that ex-post the contract will not hold he will not accept an agreement ex-ante. That means that there will be no trading of property rights and a possible efficient solution will not be reached. It also means that this property rights assignment leads to a hold up situation.

Proposition 1
If contracts are incomplete, the assigning of property rights does have an influence on efficient allocation, through trading property rights, in case of externalities.

We have shown that if contracts are incomplete, and renegotiations cannot be excluded, then it matters how property rights are distributed for an efficient allocation of externalities. In the next section we do one more step forward. There we investigate the effect of costs associated with going to court to resolve disputes concerning property rights. That is we assume positive transaction costs.

5. Costly law suits

Now we relax the assumption that going to court to enforce the contract is costless. If agents go to court to resolve contractual problems, all kinds of cost will emerge like paying lawyers, et cetera. If the agents decide to go to court, they also have to take into consideration what effort to invest to win the case for the court. We assume that the higher the relative effort of an agent, the higher is his probability to win the lawsuit. To model these features we take a look at the economic theory of conflict.

The probability to win the lawsuit
We assume that the probability that agent A will win the lawsuit, depends on how much effort he is willing to invest and also on the effort level of his opponent. The probability for an agent to win the lawsuit is endogenously determined by the effort levels of the competing agents. We can write the probability function as follows: $p^A = p(e^A, e^B)$, where the variables e^A and e^B are the efforts levels (respectively the costs of going to court) of agent A and agent B.[5] If a player owns the property rights we assume that that agent has a comparative advantage before court. We use the following contest success function to take care of these features:

$$p^A\left(e^A, e^B\right) = \frac{\theta e^A}{\theta e^A + e^B}, \tag{17}$$

[5] Here we follow Tullock (1980).

where q, is a parameter which reflects the burden of the proof.[6] As we noticed above, this probability also depends on the distribution of the property rights. Because of the fact that the property rights are assigned to agent B, agent A carries the burden of proof and therefore we have the following restriction: $0 < q < 1$.[7]

The polluter pays principle

We have seen in the previous section that a credibility problem occurs when agent A is liable and when B owns the property rights. The agent who causes the externality has to compensate for the externality. This situation is sometimes called "the polluter pays" principle. Because of the presence of a credibility problem we will restrict our attention to the polluter pays principle. Next to that we investigate whether it is possible that the legal system is able to resolve the credibility problem.

So the question is: do different rules lead to different outcomes of a game? To keep the problem manageable we distinguish two different civil law systems:

1) The Anglo Saxon (AS) civil law system (every agents pays for his own) and
2) Roman (R) civil law (the losing agent has to pay all the costs).

The approach is exactly the same as in the previous section. The extension is that going to court is costly. The agents have to incorporate these costs in their decision process. Furthermore the probability is now endogenous depending on the efforts of the agents.

6. The Anglo Saxon Civil Law system (AS)

Both legal systems which are subject to investigation, agent B is the one who owns the property rights Let us start with investigating the Anglo Saxon Civil Law System, where we us the superscript (*AS*) indicates the legal system under which decisions are made. If agent B owns the property rights, there are two again options for agent A. Notice that the activity levels (x, y)

[6] This formulation was introduced by Grossman & Kim (1996).

[7] The more q is going to zero the harder it will become for agent A to win the lawsuit. If q is one, the burden of proof is equally distributed between agent A and B.

are fixed ex-ante and are laid down in the contractual agreements. For convenience we summarize the possible options for both agents. For agent A we have the following:

c) Pay the compensation
d) Do not pay the compensation (which results in contract breech)

If agent A chooses d) agent B has two options:

d1) He does not go to court and accepts the contract breech,
d2) He goes to court, and tries to enforce the contract.

Regarding option c, pay the compensation, there is no problem. The pay-offs can be found in equation (14A) and (14B) Also for option d1, where agent A does not pay the compensation, the pay-offs are already known. They can be found in equation (15A) and (15B). When agent A does not pay and agent B decides to go to court (d2) the applied alternative legal system makes a difference. Whether agent B goes to court depends on the expected pay-off. The expected pay-off (utility) of agent B is then given by:

$$EV^{AS} = B(y^B) - S(x^B, y^B) + (1- p^A)Z^B - e^B = V^B + \left(\frac{e^B}{\theta e^A + e^B}\right)Z^B - e^B \qquad (19)$$

If agent A wins the lawsuit, agent B will not receive compensation. If agent A looses the lawsuit, agent B will receive the compensation. Next to that, agents A and B will invest in effort to win the lawsuit, which is costly. We also need to find the pay-offs of agent A if B goes to the court. The pay-off of agent A is:

$$EU^{AS} = A(x^B) - (1\text{-}p^A)Z^B - e^A = U^B - \left(\frac{e^B}{\theta e^A + e^B}\right)Z^B - e^A \qquad (20)$$

The pay-off depends on the probability to win the lawsuit and the associated costs in terms of effort. The probability is influenced by both the effort levels (e^A, e^B) and the distribution of the burden of proof (q). This can be seen if we look at the second and third term of the equations (19) and (20). Before we can compare the pay-offs, we have to find the effort levels agents are willing to invest to win the lawsuit. Both agents maximize their expected pay-offs. Differentiating equation (19) and (20) with respect to the efforts results in the following FOC's :

$$\frac{\partial EV^{AS}}{\partial e^{B}} = \frac{\theta e^{A} Z^{B}}{\left(\theta e^{A} + e^{B}\right)^{2}} - 1 = 0 \text{ and,} \tag{21}$$

$$\frac{\partial EU^{AS}}{\partial e^{A}} = \frac{\theta e^{A} Z^{B}}{\left(\theta e^{A} + e^{B}\right)^{2}} - 1 = 0 \tag{22}$$

By using equations (21) and (22), we are able to calculate the optimal efforts of both agents. After some manipulations we get:

$$e^{A} = e^{B} = \frac{\theta Z^{B}}{(1+\theta)^{2}} \tag{23}$$

If the optimal effort level is determined, the pay-offs can be calculated. Inserting (23) in (19) and (20) results in:[8]

$$EV^{AS} = V^{B} + Z^{B}\left(\frac{1}{(1+\theta)}\right)^{2} \quad \text{and}^{9} \tag{24}$$

$$EU^{AS} = U^{B} - Z^{B}\left(\frac{1}{(1+\theta)}\right)^{2} \tag{25}$$

The decision of agent A, whether or not to pay the compensation depends on what agent B will do in the two cases. For agent B it is beneficial to go court. The expected pay of going to court exceeds that of not going to court. Using equation (24) with the fact that $0 < q < 1$, this is easy to verify because:

$$EV^{AS} > V^{B}. \tag{26}$$

Agent B will go to court if agent A does not pay the compensation. Agent A knows this and as a result will choose d. This can be seen by comparing the pay-offs:

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[8] $EV^{AS} = V^{B} + \left(\frac{e^{B}}{\theta e^{A} + e^{B}}\right)Z^{B} - e^{B} = V^{B} + \left(\frac{1}{1+\theta}\right)Z^{B} - \frac{\theta}{(1+\theta)^{2}} Z^{B}.$

[9] $EV^{AS} = U^{B} - \left(\frac{e^{B}}{\theta e^{A} + e^{B}}\right)Z^{B} - e^{A} = U^{B} - \left(\frac{\theta e^{A}}{\theta e^{A} + e^{B}}\right)Z^{B} - e^{A} = U^{B} - \left(\frac{1}{1+\theta}\right)Z^{B} - \frac{\theta}{(1+\theta)^{2}} Z^{B}$

$$EU^{AS} > U^{B*}. \tag{27}$$

Despite the fact that agent A knows that agent B goes to court if the compensation will not be paid, there is an incentive for agent A to breech the contract. This is due to the fact that there is still a probability for agent A to win his case for court, resulting from contract incompleteness. The above solution can easily be verified with the help of the game tree and using back ward induction to solve it.

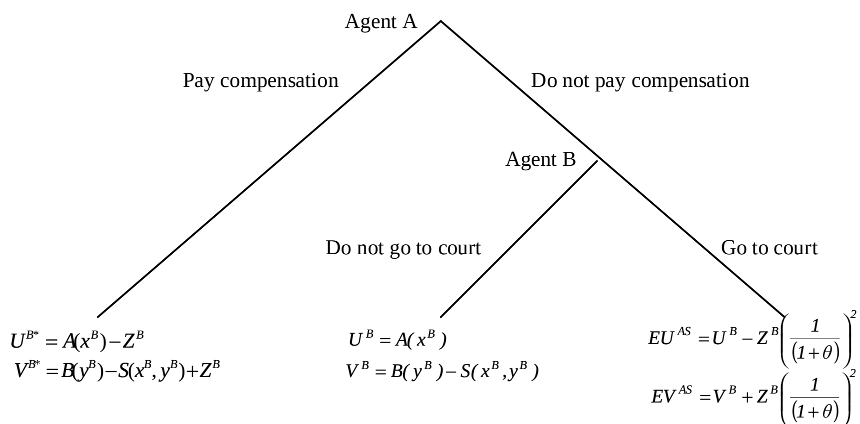

Figure 3: The game under AS legal system in extensive form

Apparently the AS legal setting does not provide sufficient safeguards. This leads to the proposition below:

Proposition 2
The Anglo Saxon legal system (where agents have to pay for their own costs) does not resolve the credibility problem in case of the polluter pays principle.

We can conclude that there will be no trading of property rights and therefore an efficiency loss is the result. In the case of the AS legal system we can speak of a hold up situation. The AS legal system does not protect the agents against opportunistic behavior.

7. The Roman Civil Law System (R)

After having looked at the Anglo Saxon system we turn to the Roman Civil Law System (R). The big difference is that the agent who looses the lawsuit must pay for all costs of the lawsuit, including the costs of his opponent. Notice that compared with the AS legal system, only the pay-offs of the strategy going to court (d2) if agent A refuses to pay the compensation, will be different.

Whether agent A under the Roman legal system goes to court depends on the expected pay-offs. We use the superscript R to indicate that we are dealing with the Roman legal system. The expected utility of agent B going to court is given by:[10]

$$EV^R = V^B + Z^B - \left(\frac{qe^A}{qe^A + e^B}\right)(Z^B + e^A + e^B) \tag{29}$$

If agent A wins the lawsuit, agent B will not receive a compensation. Additional to that, agent B has to pay not only for his own efforts but also for the efforts of his opponent. If agent A looses the lawsuit, agent B will receive the compensation. Next to that agent A must pay for the entire costs of the efforts of both players. In this way the AS legal system differs from the R legal system. Naturally, the expected pay-offs of both agents are also different. If agent A does not pay and agent B goes to court his expected pay-off amounts to[11]:

$$EU^R = U^B - \left(\frac{e^B}{\theta e^A + e^B}\right)(Z^B + e^A + e^B) \tag{30}$$

If agent A wins the lawsuit all costs of the efforts will be reimbursed by agent B. If agent A looses the lawsuit he must pay the compensation to agent B and for the cost of the efforts of both players.

Now agents not only have to decide whether or not they go to court, they also have to decide how much they invest in the efforts, if a lawsuit will

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[10] $EV^R = V^B - p^A(e^A + e^B) + (1-p^A)Z^B = V^B + Z^B - p^A(Z^B + e^A + e^B)$.

[11] $EU^R = U^B - (1-p^A)(Z^B+e^A+e^B)$.

take place. Maximizing their expected utility functions leads to the following FOC's, which are derived from (29) and (30):

$$\frac{\partial EV^R}{\partial e^B} = \frac{-\theta e^A\left(\theta e^A + e^B\right) + \theta e^A\left(e^A + e^B + Z^B\right)}{\left(\theta e^A + e^B\right)^2} = 0 \quad \text{and} \tag{31}$$

$$\frac{\partial EU^R}{\partial e^A} = \frac{-e^B\left(\theta e^A + e^B\right) + \theta e^B(Z^A + e^A + e^B)}{\left(\theta e^A + e^B\right)^2} = 0 \tag{32}$$

From (31) we see that, $(qe^A + e^B) = (e^A + e^B + Z^B)$ which results in:

$$e^A = \frac{-1}{(1-\theta)} Z^B. \tag{33}$$

Taking into account the assumption $0 < q < 1$, we get the result that $e^A < 0$. Because of the fact, that only non-negative effort levels are allowed, we end up in a corner solution namely:

$$e^A = 0 \tag{34}$$

From the other second order condition we can see that; $(qe^A + e^B) = q(Z^B + e^A + e^B)$. The optimal effort level becomes:

$$e^B = \frac{\theta}{(1-\theta)} Z^B. \tag{35}$$

Now the pay-off of the different strategies can be compared. If we insert (34) and (35) in (29) we find that:

$$EV^R = V^B + Z^B \tag{36}$$

If we compare we see that, $EV^R > V^B$. Agent B will go to court if agent A breeches the contract, or if agent A chooses d, agent B will opt for d1. With this information we can compare the pay-off of paying the compensation (c) and not paying the compensation (d) for agent A. Substituting the optimal effort levels in equation (30) gives us:

$$EU^R = U^B - \frac{1}{(1-\theta)} Z^B \tag{37}$$

Knowing that agent B owns the property rights and therefore $0 < q < 1$ and as a result we have $\frac{1}{(1-\theta)} > 1$, and we conclude that $EU^R < U^{B*}$.

Once more we summarize and write the game in extensive form. The above solution can be verified using the game tree.

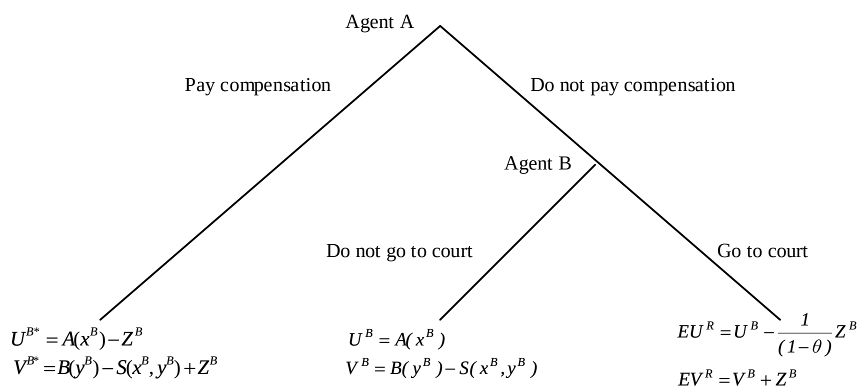

Figure 4: The game under R legal system in extensive form

If we look at the results we can conclude that **the R legal system has resolved the credibility problem of the polluter pays principle**. Both agents will stick to the ex-ante contract and there will be no hold up. That means that Coasian bargaining will lead to an efficient solution of externalities. This leads to the proposition below.

Proposition 3

The Roman legal system (where the losing agent has to pay for the costs) does resolve the credibility problem in case of the polluter pays principle; through Coasian bargaining an efficient solution can be attained.

In contrast to the AS legal system, in the R legal system there is no incentive for agent A to breech the contract. There is no ex-post opportunistic behavior. This is the result of the fact that the looser has to pay all the cost. There will be no hold up and an efficient solution is possible by trading property rights.

7. Conclusion

In this paper, we revisited the "Coase" theorem. As point of departure we took a game theoretic setting following the model of Schweizer (1988). Additionally we assumed that contracts are incomplete, and that renegotiations cannot be excluded. This opens the door to possible opportunistic behavior. Normally the legal system tries to prevent as much as possible this kind of behavior. We showed that depending on the distribution of property rights agents behave opportunistically. In the case where the agent which causes the externality is liable, a credibility problem appears; this is the polluter pays principle. The outcome is a hold up situation, no property rights are traded ex-ante due to ex-post opportunistic behavior. This then prevents reaching an efficient solution by trading property rights. The other possibility, where the agent who causes the externality is not liable, gives rise to a credibility problem. As a result the efficient allocation will be reached by trading property rights.

We continued with an investigation whether a legal system is able to solve the credibility problem of the polluter pays principle. A distinction was made between the Anglo Saxon (AS) legal system and the Roman (R) legal system. Given the AS system, each of the agents has to pay for his own costs incurred during the lawsuit concerning conflicts of property rights. In case of the Roman system the losing agent has to pay the entire costs. We showed that in case of the Anglo Saxon legal system, the credibility problem cannot be solved. The Roman system resolves the credibility problem due to the rule that the losing agent has to pay the entire costs. From that we could conclude that the Coase theorem works better under the Roman legal system than under the Anglo Saxon legal system.

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